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Effects of land use on floristic composition and diversity of woody vegetation in the commune of Enampore, Senegal

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The diversity of woody vegetation is threatened by intensified land use and soil chemistry. However, the effects of land use and soil chemistry on woody vegetation are not well known. The objective of this study was to determine the influence of land use classes (upland, uncultivated lowland, cultivated lowland, and tans) on the diversity and structure of woody vegetation in the commune of Enampore. To do this, an inventory was conducted in two sites (Essyl and Selecky). A total of 80 plots for vegetation surveys were conducted, 10 in each land use (The plots were circular in size, ranging from 15 to 100 m in radius depending on the land use class. In each plot, the chemical properties (pH and salinity) of the soil, diversity, density, abundance, regeneration, and growth parameters (height and diameter) of the woody plants were determined. Soil chemical properties varied significantly ($p<0.05$) according to land use. Uncultivated lowlands and tans had lower pH (pH≤4.62) and higher electrical conductivities (EC≥580µs/cm). A total of 33 species belonging to 31 genera from 17 families were recorded across all land use types. The most represented families were *Fabaceae*, *Apocynaceae*, and *Combretaceae*. Land use significantly ($p<0.05$) influenced woody diversity, abundance, and density. The uplands had more diversity than the other land use types. Salinity had a strong influence on the vegetation located in the tans and uncultivated lowlands. Vertical and horizontal structures had an "L" shape typical of a stand dominated by young trees. The diversity and density of woody plants in the commune of Enampore are influenced by land use and soil chemical properties.

Keywords: Land use, pH, Salinity, Woody vegetation, Diversity, Structure.

INTRODUCTION

Human use of vegetation has a long tradition in semi-arid West Africa, and local people highly value the goods and

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services provided by woody plants in the Sudano-Sahelian region of Senegal. Forests and woodlands surrounding rural habitats provide vast natural resources such as firewood and timber, food, medicine, and fiber (Shackleton and Gumbo, 2010). Local people regard woody plants as a key resource that provides many functions and use them intensively (Ganaba and Guinko, 1995). Woody vegetation is a key component of the savannah ecosystem and an indicator of ecosystem condition and health (Lawesson, 1990; Tappan et al., 2004). Trees play an important role in the functioning of savannah ecosystems (Sankaran et al., 2008) maintaining soil chemistry and nutrient cycling (Schlesinger and Gramenopoulos, 1996; Reid et al., 1999). They also provide habitat for wildlife and a range of ecosystem services that directly support livelihoods. Woody plants are also coppiced for fodder (Le Houérou, 2002) and therefore play an important role in the pastoral economy. In Lower Casamance, woody plants play an extremely important role in the life of rural populations (Rabiou et al., 2014). They help to mitigate extreme climatic events. Several woody species of ecological, socio-economic, and cultural interest are deliberately conserved in the crop fields (Sambou et al., 2017).

Despite its importance, woody vegetation is under strong pressure causing its degradation. In Senegal, the degradation of woody vegetation is very advanced in the agroecological zones. Woody species are subject to degradation caused by several natural, climatic, and anthropogenic factors (Samaké et al., 2011; Diatta et al., 2016). Climatic factors have contributed to the disappearance of certain woody species locally. Among the most cited causes of vegetation regression in Senegal are overexploitation of resources, land use change, bushfires, climate change, deterioration of soil properties (salinization and pH), and erosion (Brandt et al., 2014; Sambou et al., 2016). Similarly, salinization and acidification of soils create imbalances in the ecosystem and would cause significant damage to wildlife, pastures, habitats, and vegetation cover (Mbow et al., 2000). The problem of salinity has been present for a long time in the uncultivated lowlands, especially in Lower Casamance (Sadio, 1991). However, knowledge of the spatial distribution of woody vegetation diversity and density across landscape classes is still limited (Foley et al., 2005). In particular, more information is needed on woody vegetation diversity and distribution in agricultural areas compared to other parts of the landscape (Augusseau et al., 2006; Raebild et al., 2007). This research aimed to study the spatial distribution of woody species and its determining factors according to land use types in the commune of Enampore in Lower Casamance.

MATERIALS AND METHODS

Study area

The study was conducted in the localities of Selecky (12° 31'37'' N, 16° 27'56'' W and Essyl (12° 31'10'' N, 16° 25'34'' W) located in the Lower Casamance region of Ziguinchor, Senegal (Figure 1). The climate is characterized by the coastal South Sudanese type (Sagna, 2005) and is dominated by two seasons: a dry season from November to May and a rainy season from June to October, during which agricultural activities are conducted. The average annual temperature is 27°C with a maximum (of 35°C) in April and a minimum (of 15°C) in December (Sagna, 2005). The study area is characterized by vegetation dominated by the species *Elaeis guineensis, Borassus akeassii, Ceiba pentandra, Parkia biglobosa, Adansonia digitata, Khaya senegalensis, Anacardium occidentale, Mangifera indica*, etc. The mangrove ecosystem is still colonized by two tree species (*Avicennia germinans* and *Rhizophora mangle*) (PDC, 2021).

Sampling and data collection

Google Earth imagery was combined with a visual interpretation of Landsat imagery for exploratory assessment before fieldwork. Classification of satellite imagery was based on the landscape classes (Sambou et al., 2016; Dewan et al., 2012; Cui et al., 2013; Dieng et al., 2014). Four land use classes (upland, uncultivated lowland, cultivated lowland, and Tans) were identified. After the selection of sites (Selecky and Essyl) and land use classes, a prospective visit was organized to validate the classification, mapping, and delineation of the land use classes using GPS. Based on the classification of land use classes, stratified sampling was carried out. Within each land use, 10 plots were randomly selected by choosing geographic coordinates (Figure 2). A total of 80 plots, 40 in each site, were selected. To obtain an approximately similar number of trees in each plot, circular plots of varying size were adopted according to land-use types, that is, 15 m radius for upland and tans and 100 m radius for uncultivated lowland and cultivated lowland. In each plot, all woody species were identified and counted, and diameter and height were measured. All individuals with a diameter greater than 5 cm were measured at 1.30 m using a tree caliper. In addition, all individuals with a diameter of less than 5 cm were counted systematically. The total height of each individual was measured with a Blum leiss. In each plot, a 500 g sample of soil was taken with an auger from several randomly selected locations. Soil samples were taken from the 0-30 cm horizon. Composite samples were made by mixing different samples for sites that appeared heterogeneous. Soil samples were taken to the Laboratory of Agroforestry and Ecology (LAFE) at the Assane Seck University in Ziguinchor to determine pH and electrical conductivity (EC).

Data processing and analysis

At the end of data collection, other parameters of the woody vegetation such as density, diversity, and structure were calculated. The density is the number of individuals per unit area. It is expressed in a number of individuals/ha. The observed or real density (D) is obtained by the following formula:

$$D = \frac{N}{S}$$

D: density (number of individuals per hectare); N: total number of individuals; S: area (ha).

To assess the floristic composition and diversity of woody vegetation by land use class, Menhinick's richness, Shannon's diversity indices, Pielou's evenness, and Jaccard's dissimilarity were determined. The Menhinick (DMn) richness index (Rh, 1977) was determined from the formula:

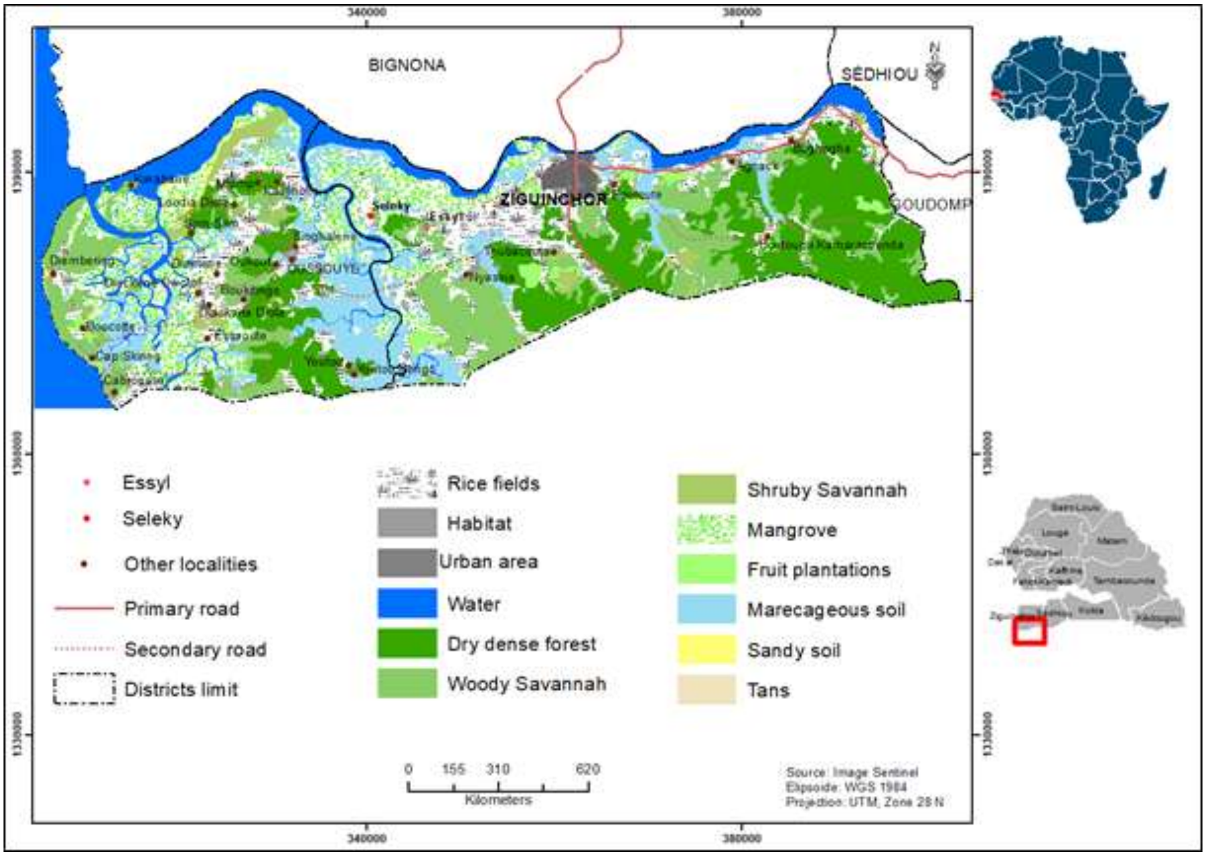


Figure 1. location of the study sites.
Source: Authors

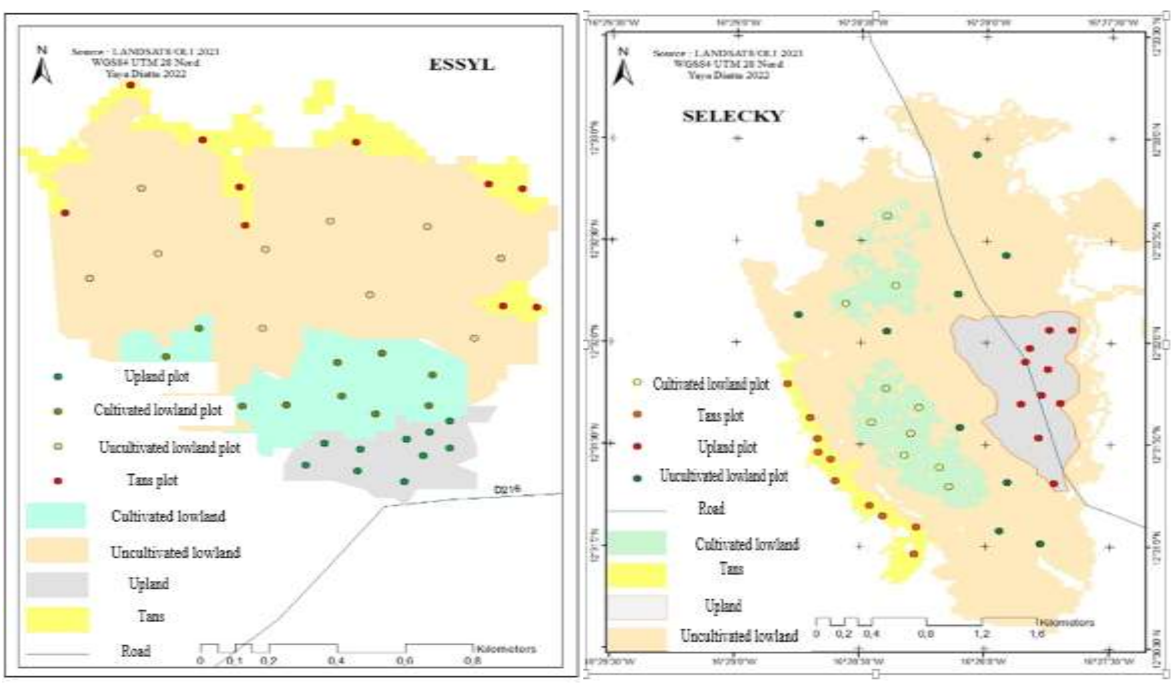


Figure 2. Location of inventory plots by occupancy type at both sites.
Source: Authors

Table 1. Variation in soil pH and EC according to land use classes in the two sites.

Site	Land use classes	pH	EC (µs/cm)
Selecky	Uncultivated lowland	4.25±0.33[c]	1497±1195[b]
	Upland	5.3±0.43[a]	62±19.23[c]
	Tans	4.25±0.07[c]	5280±707.1[a]
	Cultivated lowland	4.66±0.36[b]	292±248.89[c]
	Probability	0.00028	9,71E-08
Essyl	Uncultivated lowland	4.62±0.7[bc]	580±1030.11[b]
	Upland	5.48±0.71[a]	62.22±52.14[b]
	Tans	4.48±0.48[c]	6479.75±709.25[a]
	Cultivated lowland	5.27±0.75[ab]	416±846.89[b]
	Probability	0.011	2.00E-16

Values in the same column with the same letters are not statistically different (Fisher LSD test, 5% threshold).
Source: Authors

$$DMn = \frac{S}{\sqrt{N}}$$

DMn: Menhinick richness index; S: species richness, which is the total number of species in the stand considered in a given ecosystem (Erard, 2003); N: total abundance.

The Shannon index is a diversity index that measures the species composition of a stand by taking into account the species richness and equitability of the species (Felfili et al., 2004). The Shannon index (H') is calculated from the formula:

$$H' = -\Sigma pi lnpi$$

H': Shannon index; pi: relative abundance.

Piélou's evenness (Pielou, 1966) also known as Shannon's equitability translates the way individuals are distributed across species and allows us to say if space is dominated by any species (Adjakpa et al., 2013). Pielou's evenness (J') was calculated from the formula:

$$J' = {H'}/{lnS}$$

H': Shannon index; S: species richness

To determine the difference in species composition between land use classes, Jaccard's dissimilarity, clustering, and principal component analysis (PCA) were performed. Jaccard's dissimilarity (Colwell and Coddington, 1994) or Jaccard's ecological distance (J) was calculated from the equation:

$$J = 1 - \frac{\Sigma mini\,(ai, bi)}{\Sigma \max\,(ai, bi)}$$

With *ai*: the abundance of species i in site A and *bi*: the abundance of species i in site B.

The data in the form of community and environment matrices were analyzed with BiodiversityR (3.5.0) to compare floristic diversity and composition between land use classes. The difference between land use classes was tested by analysis of variance (ANOVA) followed by Fisher's multiple comparison test at the 0.05 threshold. Data on growth parameters were grouped into diameter and height classes to characterize the horizontal and vertical structure of the woody vegetation. Frequencies for each diameter and height class were plotted for the woody species. Similarly, the diameter and height structure was plotted against land use classes.

To examine the parameters influencing woody species diversity, regression analyses were used to identify explanatory variables for species distribution, using the following model:

Y= Land use+CE+pH

Where Y is the response variable (Menhinick index, abundance, density, and Shannon index).

RESULTS

Soil characteristics

The analysis of pH and electrical conductivity (EC) according to land use classes showed significant differences (P<0.05) in the two sites (Table 1). The soil pH in both sites varied between 4.25 and 5.48 and was significantly different between land use classes (P<0.05). Indeed, the highest pH was obtained in upland (5.3±0.43 and 5.48±0.71 respectively in Selecky and Essyl) and cultivated lowland (4.66±0.36 and 5.27±0.75). These two land use classes were also characterized by low salinity. EC varied between 62 and 6479.75 µs/cm in the study area. Thus, the tans recorded the highest EC (5280±707 and 6479.75±709.25µs/cm) followed by uncultivated lowland (1497±1195 and 580±1030.11µs/cm) and cultivated lowland (292±248.89 and 416±846.89µs/cm). The lowest EC were recorded in upland with 62±19.23 and 62.22±52.14µs/cm respectively in Selecky and Essyl.

Floristic composition and diversity

The inventory recorded 33 tree species, belonging to 17 families. A total of 31, 9, 8, and 4 tree species were recorded in the upland, cultivated lowland, uncultivated lowland, and tans respectively. Fabaceae, Apocynaceae, Combretaceae, and Moraceae were families mostly taxonomic diversified. *Faidherbia albida* was found in all land use classes. However, some species such as

Lannea acida, Mangifera indica, Uvaria chamae, Holarrhena floribunda, Landolphia heudelotii, Saba senegalensis, Voacanga africana, Alchornea cordifolia, Cassia sieberiana, Dialium guineense, Ficus sycomorus Ficus sur, Ficus vogelii, Morinda citrifolia, Fagara zanthoxyloides, Allophilus africanus, Cola cordifolia, and *Gmelina arborea* were only found at upland. For the Tans, species such as *Conocarpus erectus* and *Rhizophora racemose* were characteristics (Table 2). The floristic composition varied according to the land use classes for both sites. 22 and 18 species belonging to 22 and 17 genera, and 13 and 12 families were recorded at the uplands of Essyl and Selecky respectively. The land use classes have significantly influenced most of the studied parameters in the two sites. The analysis of variance on diversity, abundance, and density parameters showed a significant difference ($P<0.05$) between land use classes. The richness index did not vary significantly ($P>0.05$) between land use classes. Comparing the species diversity in land use classes, uplands were more diversified than cultivated and uncultivated lowlands and tans. Abundance and density varied significantly between land use classes. The uplands were the only category that differed significantly from the other land use classes, having higher abundance and density (Table 3).

Difference in species composition

Analysis of dissimilarity between land use classes at both sites showed ecological distance greater than 58% (Table 4). The largest ecological distances were noted between tans and other land use classes. Clustering and principal component analysis showed different groups between land use classes (Figures 3 and 4). For Selecky, the analysis revealed two distinct groups. The first group (upland) was characterized by *Lannea acida, Uvaria chamae, Saba senegalensis, Dialium guineense, Ficus sycomorus, Ficus sur, Ficus vogelii, Fagara zanthoxyloides, Allophilus africanus, Ceiba pentandra, Elaeis guineensis, Borassus akeassii,* and *Adansonia digitata*. The second group (cultivated and uncultivated lowlands) was characterized by the presence of specific species such as *Faidherbia albida, Azadirachta indica*, and *Neocarya macrophylla*. For Essyl, the analysis based on land use discriminated three groups (upland, tans, and cultivated and uncultivated lowlands) according to their influence on floristic composition, abundance, and diversity. Characteristic species for upland were *Mangifera indica, Uvaria chamae, Holarrhena floribunda, Landolphia heudelotii, Saba senegalensis, Alchornea cordifolia, Cassia sieberiana, Dialium guineense, Ficus sur, Morinda citrifolia, Cola cordifolia, Gmelina arborea, Terminalia macrophylla, Anonychium africanum, Combretum micranthum, Faidherbia albida, Ceiba pentandra, Piliostigma thonningii, Borassus akeassii, Elaeis guineensis,* and *Parkia biglobosa*. Tans were characterized by *Conocarpus erectus and Rhizophora racemosa*, whereas *Neocarya macrophylla, Azadirachta indica, Adansonia digitata,* and *Acacia nilotica* were characteristic species for both cultivated and uncultivated lowlands. Based on soil chemical properties, tans, and uncultivated lowlands were associated with high salinity characterized by high electrical conductivity (EC) values, whereas higher soil pH was a characteristic value for upland. The analysis showed an opposition between pH and Electrical Conductivity (EC) in both sites.

Structure of woody vegetation

Diameter structure

The analysis showed that individuals with a diameter between 5 and 50 cm represented 30 and 40% of individuals in Essyl and Selecky respectively (Figure 5). The proportions of individuals with a diameter between 5 and 50 cm were 0, 24, 33.33, and 29.66% in tans, cultivated and uncultivated lowland, and upland respectively at Selecky, whereas 100, 31.25, 31.67, and 33% at Essyl. Individuals with a diameter greater than 50 cm were poorly represented in both sites. However, the stand of individuals was not balanced in sites and land use classes with an "L" structure characteristic of a young and stable stand. The pattern of the L-shaped distribution at Essyl in the cultivated lowland and upland revealed some stability in the stand.

Height structure

The analysis showed that individuals with a height between 2 and 8 m were represented by 17 and 23%of individuals located at Selecky and Essyl respectively. In Selecky, individuals with a height between 4 and 14 m constituted 29.47 and 27.21% in the uncultivated and cultivated lowland respectively. On the other hand, individuals with a height between 10 and 12 m were represented by 24% in upland. In Essyl, the proportion of individuals with a height between 2 and 8m was 28, 24, 12.5, and 35% of the individuals in upland, uncultivated, and cultivated lowland and tans respectively. At Selecky, individuals with a height between 10 and 12m were represented by 24% of individuals in the upland. Generally, individuals with a height greater than 20 m were weakly found at Essyl and Selecky. The height structure was globally balanced in both sites (Figure 6).

Influence of environmental factors (pH, EC, and land use classes) on woody vegetation parameters.

Multiple regression analyses showed significant effects of

Table 2. Species occurrence according to land use classes and sites.

Families	Genera	Species	Land use classes			
			Upland	Cultivated lowlands	Uncultivated lowland	Tans
Anacardiaceae	Lannea	*Lannea acida*	+			
	Mangifera	*Mangifera indica*	+			
Annonaceae	Uvaria	*Uvaria chamae*	+			
Apocynaceae	Holarrhena	*Holarrhena floribunda*	+			
	Landolphia	*Landolphia heudelotii*	+			
	Saba	*Saba senegalensis*	+			
	Voicanga	*Voacanga africana*	+			
Arecacea	Borassus	*Borassus akaessii*	+	+	+	
	Elaeis	*Elaeis guineensis*	+	+	+	
Chrysobalanaceae	Neocarya	*Neocarya macrophylla*	+		+	+
Combretaceae	Combretum	*Combretum micranthum*	+			
	Conocarpus	*Conocarpus erectus*				+
	Terminalia	*Terminalia macroptera*	+	+		
Euphorbiaceae	*Alchornea*	*Alchornea cordifolia*	+			
Fabaceae	Acacia	*Acacia nilotica*	+		+	
	Cassia	*Cassia sieberiana*	+			
	Dialium	*Dialium guineense*	+			
	Faidherbia	*Faidherbia albida*	+	+	+	+
	Parkia	*Parkia biglobosa*	+	+	+	
	Piliostigma	*Piliostigma thonningii*	+	+	+	
	Anonychium	*Anonychium africanum*	+			
Malvaceae	Adansonia	*Adansonia digitata*	+	+		
	Ceiba	*Ceiba pentandra*	+	+		
Meliaceae	Azadirachta	*Azadirachta indica*	+	+	+	
Moraceae	Ficus	*Ficus sycomorus*	+			
		Ficus sur	+			
		Ficus vogelii	+			
Rhizophoraceae	Rhizophora	*Rhizophora racemosa*				+
Rubiaceae	Morinda	*Morinda citrifolia*	+			
Rutaceae	Fagara	*Fagara zanthoxyloides*	+			
Sapindaceae	Allophilus	*Allophilus africanus*	+			
Sterculiaceae	Cola	*Cola cordifolia*	+			
Verbenaceae	Gmelina	*Gmelina arborea*	+			

Source: Authors

Table 3. Test of differences for vegetation structure and diversity for land cover types at both sites, with mean values for each variable within each land cover type.

Site	Land use classes	Abundance	Menhinick Index	Shannon	Density
Essyl	Uncultivated lowland	18±16.01^{b}	0.79±0.25^{a}	0.68±0.27^{b}	0.001±000^{b}
	Upland	54±24.62^{a}	0.87±0.39^{a}	1.05±0.46^{a}	0.07±0.03^{a}
	Tans	7,5±8.07^{b}	0.60±0.27^{a}	0.05±0.12^{c}	0.011±0.01^{b}
	Cultivated lowland	16±16.12^{b}	0.86±0.39^{a}	0.69±0.39^{b}	0.001±0.00^{b}
	Probability	3.43E-05	0.44	0.00013	1.17E-09
Selecky	Uncultivated lowland	4±3.4^{b}	0.93±0.56^{a}	0.35±0.4^{a}	0.0001±0.00^{b}
	Upland	24.4±23.6^{a}	0.83±023^{a}	0.73±0.25^{a}	0.0346±0.03^{a}
	Cultivated lowland	4.9±4.4^{b}	0.88±0.34^{a}	0.37±0.45^{a}	0.0002±0.00^{b}
	Probability	0.038	0,89	0.098	0.0093

Values in the same column with the same letters are not statistically different (Fisher LSD test, 5% threshold).
Source: Authors

Table 4. Dissimilarity matrix between land use classes in the two sites.

Site	Land use classes	Uncultivated lowlands	Upland	Tans
Essyl	Upland	0.883914		
	Tans	0.925287	0.993007	
	Cultivated lowlands	0.582160	0.834739	0.985149
Selecky	Upland	0.969432		
	Cultivated lowlands	0.920000	0.929461	

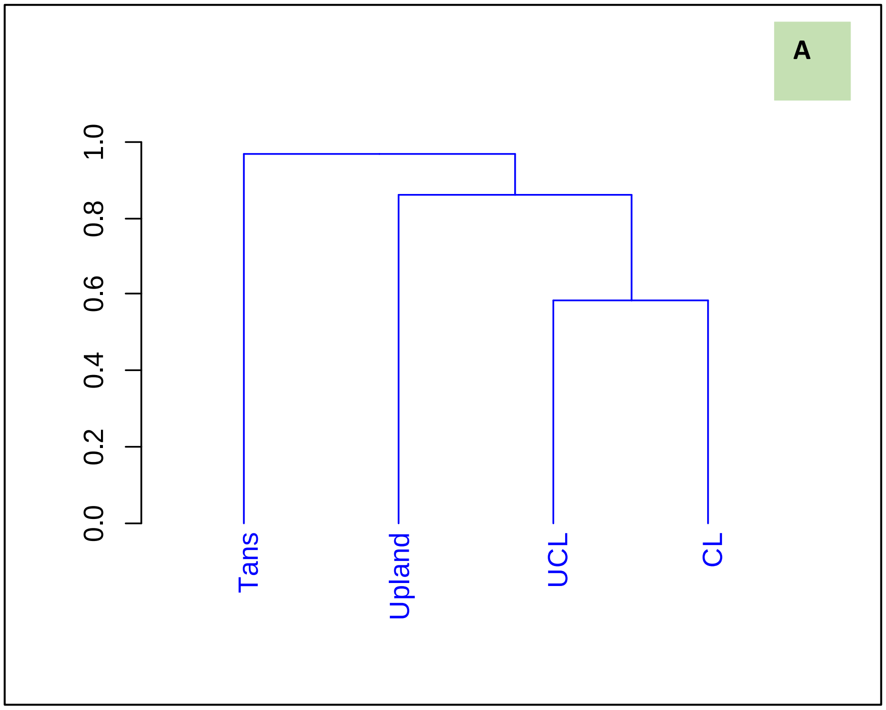
Source: Authors

land use classes on woody vegetation parameters (Table 5). Land use class influenced density, Shannon index, and abundance. At Essyl, all of these parameters were significantly greater at the plateau level (P<0.05). The same observation was noted at Selecky. Soil salinity expressed as EC and pH influenced Menhinick and Shannon index at Essyl, abundance, and density at Selecky. The negative slope indicates that vegetation parameters decrease with increasing salinity. Finally, soil pH positively influences species density and abundance at both sites.

DISCUSSION

Floristic composition and diversity of woody species

In all the study sites, 33 woody species were encountered. These species belong to 31 genera of 17 botanical families. The most represented families are Fabaceae, Apocynaceae, and Combretaceae. These results corroborate those of (Coly et al., 2005) who obtained 35 species in the fields of the Nema watershed, in Niombato in the Saloum. However, the area is moderately rich in species. Plant species are more represented in the upland and less in the uncultivated lowlands, cultivated lowlands, and tans. Thus, the dominance of species in the uplands may be because in this area the species are predominantly conserved. However, their low presence in the cultivated lowland and the uncultivated lowland would be due, on the one hand, to the fact that these areas are relatively dedicated to rice cultivation and producers tend to eliminate certain species to the detriment of others, and, on the other hand, to the significant presence of salt in these areas. This trend is general in the Sudano-Sahelian zone, where uncultivated lowlands have been intensively farmed in recent decades because of their fertile soils and hydromorphic character (Souberou et al., 2017, 2018; Talla et al., 2020). The exploitation of uncultivated lowlands is one of the adaptation strategies of farmers to climate change. This explains the low wealth in this area. The results obtained on the distribution of classes according to their frequency and specific contribution are in line with those observed by (Arshad, 2003) for the distribution of vegetation according to edaphic factors in the Cholistan desert (Pakistan). The diversity indices (Shannon and Menhinick) confirm the low richness in this area and according to the land use classes. These indices are more important in the upland. However, they are lower in the cultivated lowlands, the uncultivated lowlands, and especially in the tans. These low indices noted in the uncultivated lowlands and the tans would be due to the negative effect of salt on woody vegetation.



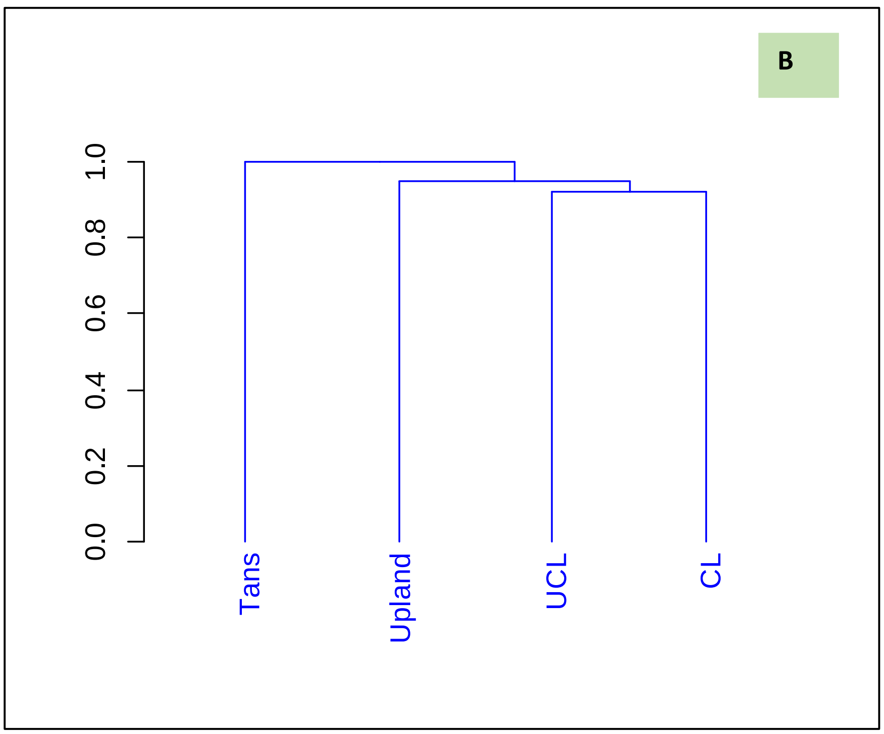
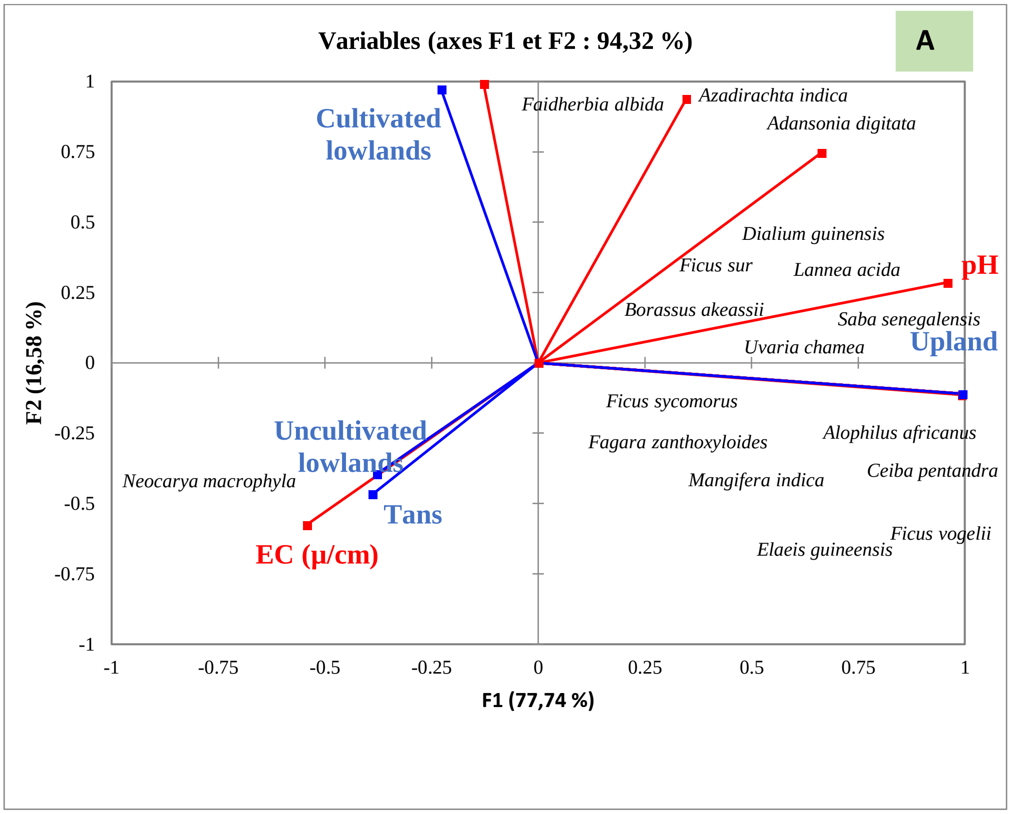


Figure 3. Cluster dendrogram of land use classes in Essyl (A) and Selecky (B). UCL, Uncultivated lowlands; CL, Cultivated lowlands.
Source: Authors

These results are in line with the work of (Amar et al., 2022) who noted a repressive effect of salinity on floristic diversity. These authors noted the lowest numbers of species in the most saline areas. Thus a dissimilarity of floristic diversity according to the salinity gradient was also reported by these authors.



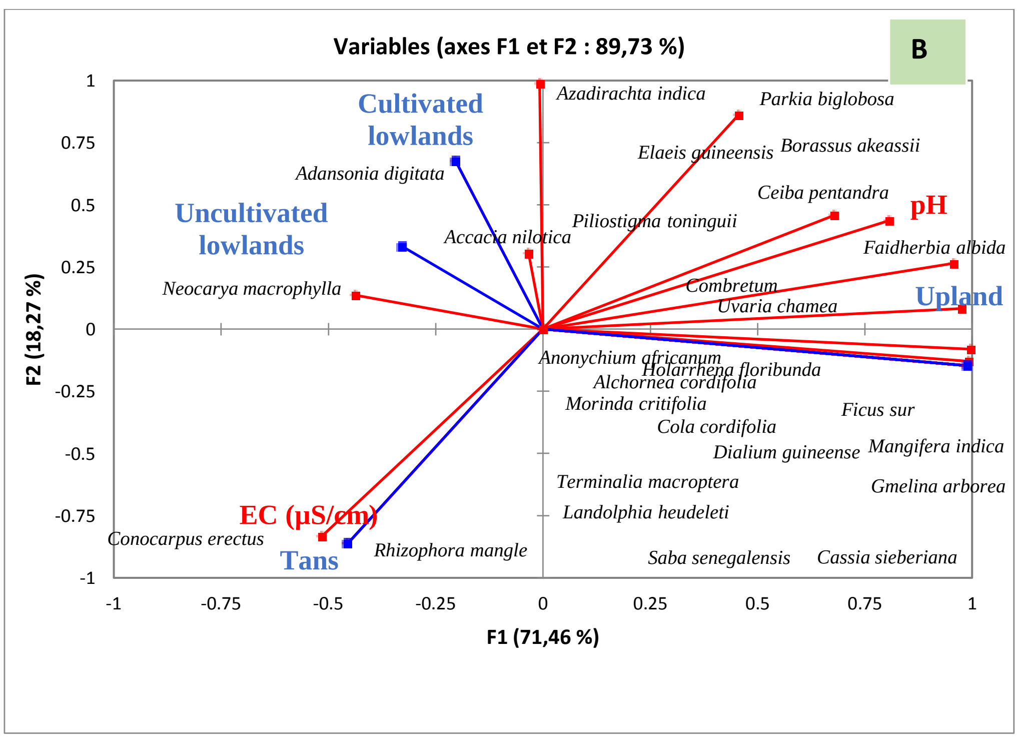
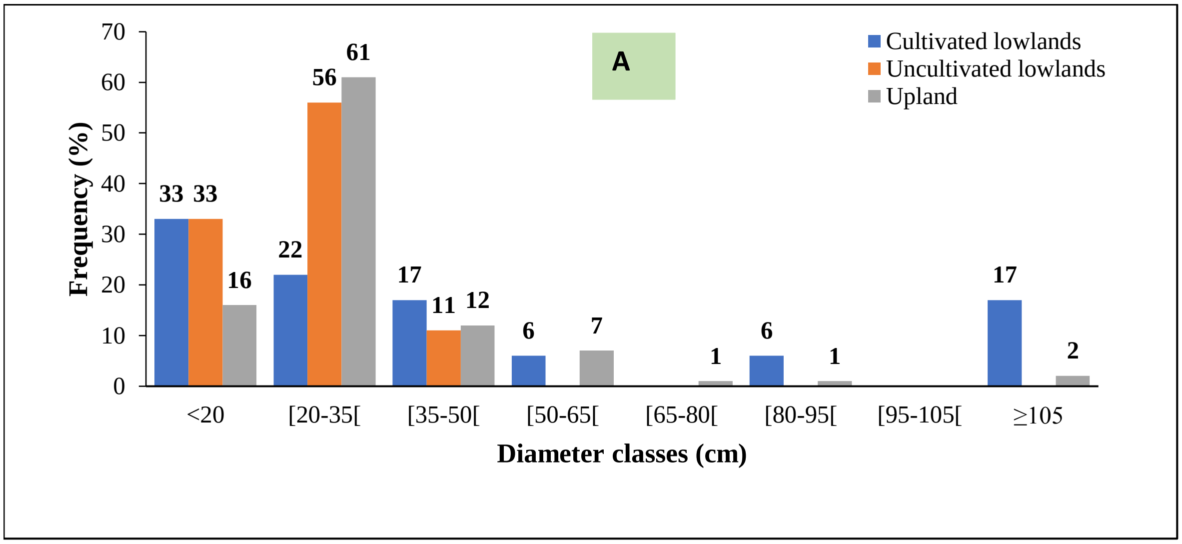


Figure 4. Relationship between vegetation parameters, land use classes, and soil chemical properties in Selecky (A) and Essyl (B).
Source: Authors



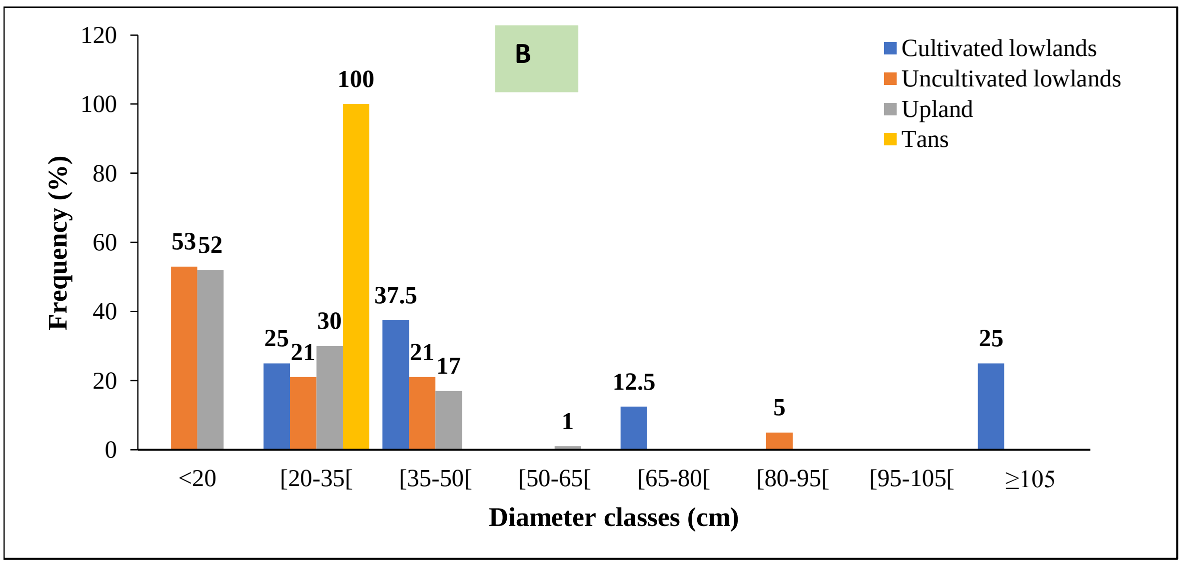


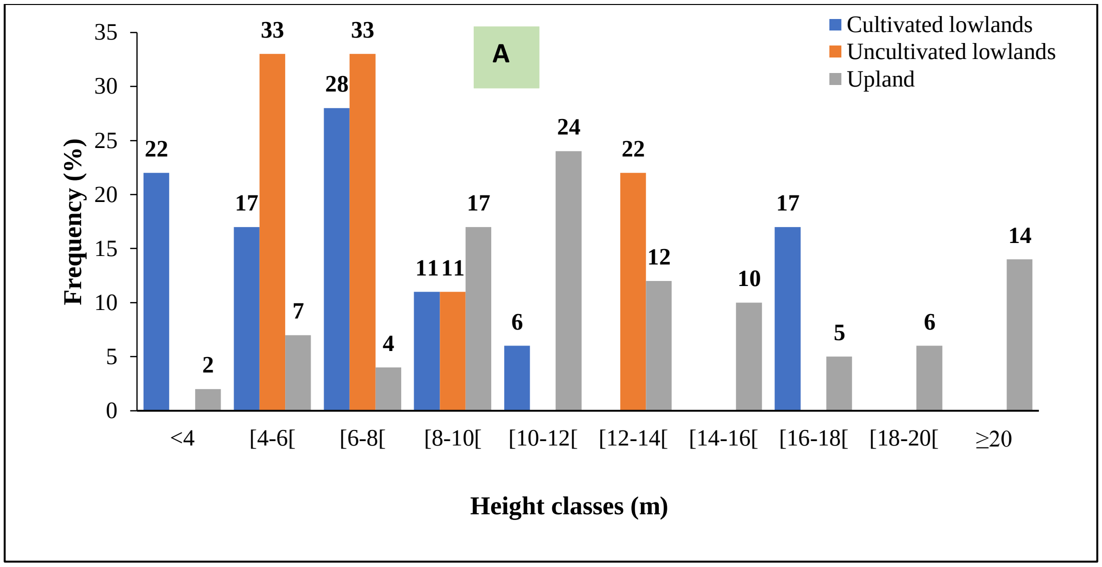
Figure 5. Distribution of individuals of the woody stand of the different land use by diameter classes in Selecky (A) and Essyl (B).
Source: Authors

Effect of soil physical characteristics on woody species composition

For the soil parameters (pH and Salinity), the analyses showed that the tans recorded the highest salinity values and the most acidic pH. These parameters negatively influenced the specific diversity of the stand. The latter shows a strong relationship between woody vegetation and soil parameters. The work of (Jafari et al., 2004) on vegetation-soil relationships in the Hoz-e-Soltan region (Iran) revealed the existence of a specific relationship between soil characteristics and vegetation distribution. In our study, we targeted salinity and pH as variables. This has been adopted by several authors to see the relationships between soil characteristics and halophytic vegetation (Caballero et al., 1994; AHMAD, 1995; Thiam et al., 2015). These authors found that the distribution of vegetation in a given area is a function of soil salinity. Abu-Ziada (1980) was able to demonstrate a strong relationship between vegetation distribution with salinity and moisture in the soil.

Effect of land use types on woody species structure

In terms of stand structure, the analyses showed that this area is characterized by small individuals with heights between 2 and 8 meters and diameters ranging from 5 to



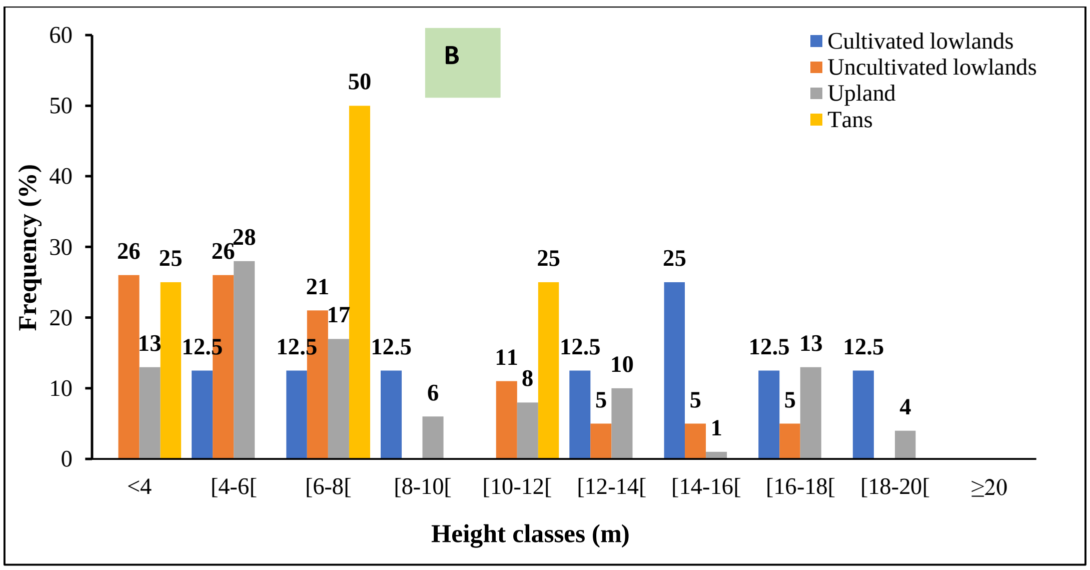


Figure 6. Distribution of individuals of the woody stand of the different land use classes by height classes in Selecky (A) and Essyl (B).
Source: Authors

Table 5. Regression analysis of the influence of landscape classes of soil pH and EC on vegetation composition, structure, and distribution.

Site	Variable	Explanatory variable	Estimate	T-value	Pr(>[t])	R2
Essyl	Abundance	Upland	31.68	3.278	0,00265**	57.56
		pH	2.67	0.569	0,57	57.56
		EC	-0.0044	-1.020	0,315	57.56
	Density	Upland	7.50E-02	7.022	8,36e-8***	77.1
		pH	1.35^{e}-03	0.261	0,796	77.1
		EC	4.180^{e}-07	0.088	0,931	77.1
	Menhinick Index	Tans	-1.598e-01	-0.292	0.77277	52.1
		pH	-1.284e-01	-1.374	0.18068	52.1
		EC	-9.253e-06	-0.106	0.91608	52.1

Table 5. Contd.

Selecky	Shannon	Tans	-5.89^{e}-01	-1.053	0,301	52.32
		Upland	4.51^{e-01}	2.311	0,028*	52.32
		pH	-1.584^{e}-01	-1.686	0,1032	52.32
		EC	-1.151^{e}-05	-0.132	0,89	52.32
	Abundance	Upland	15.73	3.201	0.00323**	49.71
		pH	-4.528	-1.262	0.216	49.71
		EC	-0.00077	-0.454	0.652	49.71
	Density	Upland	2.41E-02	3.804	0.000652***	58.91
		pH	-5.249^{e}-03	-1.136	0.264	58.91
		EC	-6.531^{e}-07	-0.298	0.7675	58.91

Source: Authors

50 cm. Individuals with diameters greater than 50 cm are poorly represented at both sites and across all land use types. These results are not in phase with the work of (Coly et al., 2020) who found a predominance of individuals with a diameter between 5 and 25 cm. However, the stand of individuals is not balanced across sites and occupancy types with an "L" structure characteristic of a young and stable stand. These results are similar to those of (Kebenzikato et al., 2014)in an *Adansonia digitata* park in Togo and (Ali et al., 2017) in the *Diospyros mespiliformis* park in central Niger.

Conclusion

The study of the diversity and structure of woody species in the commune of Enampore contributed to the understanding of their distribution according to land use types. The results show that the study area had an important taxonomic diversity. However, the study area was characterized by low diversity. Land use influenced the floristic composition, diversity, distribution, and structure of woody vegetation. Uplands, with their high pH and electroconductivity (EC), had the highest species diversity. In contrast, high salinity in the tans, uncultivated and cultivated lowlands had negative effects on tree diversity and density. In these different areas, few tree species are retained by producers. These areas are generally used for rice cultivation. Any reduction in forest area is likely to reduce tree diversity. Trees can act to cope with salinization. Thus, farmers should conserve and restore soil fertility through the use of trees, but also through the use of available organic amendments.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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