THE IMPACTS OF SOIL AND LOCAL HUMANS ON PLANT DISTRIBUTION AND DIVERSITY IN THE FLUVIAL FLOODPLAIN, AN GIANG PROVINCE

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Abstract

Four types of alluvial soils in the fluvial floodplain of An Giang province were characterized by silt, porosity, slight acidity, and high nutrients. The results recorded 230 plant species of 80 wild plants and 150 cultivated plants, mainly medicinal and edible plants. Fabaceae, Poaceae, Asteraceae, and Cucurbitaceae were the most diverse families. Woody diversity was the highest in Orthofluvic fluvisols. The source of herbs was richest in Orthofluvic fluvisols but most diverse in Gleyic fluvisols. The RDA analysis showed that soil and humans played an equal role in plant diversity (relatively 7.0% explanatory variables by soil, 6.1% by human activities, and 12.6% by the combination of soil and humans). Porosity and silt affected the diversity in Anofluvic and Orthofluvic fluvisols while clay affected the diversity in Gleyic and Cambic fluvisols. Local people's planting habits and hobbies increased woody diversity while weed control and tillage decreased herbaceous diversity.

Keywords: *An Giang ecological area, distribution, diversity, the fluvial floodplain, plant.*

NHỮNG TÁC ĐỘNG CỦA ĐẤT VÀ NGƯỜI DÂN ĐỊA PHƯƠNG ĐẾN SỰ PHÂN BỐ VÀ ĐA DẠNG THỰC VẬT, VÙNG ĐỒNG LỤT VEN SÔNG, TỈNH AN GIANG

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Tóm tắt

Đặc điểm đặc trưng của bốn loại đất phù sa ở vùng đồng lụt ven sông của tỉnh An Giang là hàm lượng phù sa và độ xốp cao, nhiều dinh dưỡng và chua nhẹ. Nghiên cứu đã ghi nhận 230 loài thực vật gồm 80 loài hoang dã và 150 loài được trồng, các loài này chủ yếu là cây thuốc và cây ăn được. Họ Fabaceae, Poaceae, Asteraceae, Cucurbitaceae là những họ đa dạng nhất. Các loài cây gỗ đa dạng nhất ở đất phù sa bồi, trong khi các loài thân thảo có sự giàu loài nhất ở đất phù sa không được bồi nhưng đa dạng nhất ở đất phù sa gley. Phân tích RDA cho thấy đất và con người tác động gần như là ngang nhau đến hiện trạng đa dạng thực vật (7,0% biến giải thích là đất, 6,1% là do hoạt động của con người và 12,6% là do sự kết hợp giữa yếu tố đất và người). Độ xốp và lượng thịt ảnh hưởng đến sự đa dạng thực vật ở đất phù sa bồi và đất phù sa không được bồi, trong khi lượng sét ảnh hưởng đến sự đa dạng ở đất phù sa gley và đất phù sa có tầng loang lỗ. Tập tính canh tác và sở thích trồng cây của người dân địa phương làm tăng sự đa dạng của cây thân gỗ trong khi các biện pháp kiểm soát cỏ dại và làm đất đã làm giảm sự đa dạng của cây thân thảo ở vùng đồng lụt ven sông.

Từ khóa: *Khu vực sinh thái An Giang, phân bố, đa dạng, vùng đồng lụt ven sông, thực vật.*

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1. Introduction

Plant diversity is an interesting topic for scientists because of its important roles in ecosystem functions and services. However, it is undergoing a strong decline worldwide due to human-induced environmental changes. The diversity and distribution of plants in many communities, for example rangeland, are not accidental but determined by climate, soil, water, and human factors (Abbasi-kesbi et al., 2017). In the same climatic condition, the soil was a filter to prevent the presence of plant species that lacked essential physiological characteristics for survival. The physicochemical properties of soil have influenced the distribution and diversity of flora. Especially, the texture, pH and nutrients were the main factors generating the change of vegetation in different areas (Dado and Jiwen, 2014). Based on the topographical features, the depth of inundation in the flood season, and soil characteristics, three main ecological areas in An Giang province were determined, namely mountainous area, the fluvial floodplain, and the opened depression of floodplain. The fluvial floodplain formed along Tien and Hau rivers with the depth of inundation over 0.5 m (Nguyen et al., 2012). Alluvial soils are the main soil types (ca. 48.60% of the area) and classified into four categories, i.e. Anofluvic and Orthofluvic fluvisols, Gleyic and Cambic fluvisols. The area of agricultural production is 209,364.06 ha (ca. 74.05% of the land use) (An Giang Statistical Office, 2016). Plant diversity plays an important role in terms of ecology and social-economy. In this region, this is the key component of agroecosystems. Many plant species are resources providing medicine, goods and ecological services for local humans. According to Gall & Orians (1992), agricultural practices were one of the most important human activities critically affecting the present status of biodiversity. From the above views, it is shown that the flora's distribution and abundance in the fluvial floodplain have often been related to physicochemical soil characteristics and local human activities. Although there were many studies on the An Giang flora in the mountainous area, very few ones were carried out in the fluvial floodplain. Besides, the ecological factors that affected the diversity and distribution of vegetation in this area have not been mentioned in the previous researches. Concerning the importance of plant diversity in managing resources, this paper aims to assess and identify the influences of human and soil factors regarding plant distribution and diversity in the fluvial floodplain, An Giang province.

2. Materials and methods

2.1. Study area

An Giang province covers an area of 353,675.89 ha at the geographical longitude of 104°47'20''E to 105°35'10''E and latitude of 10°10'30''N to 10°37'50'N. The fluvial floodplain is located along the Tien and Hau rivers and has a depth of inundation over 0.5 m with salinity thresholds from 0-2 g/l (Nguyen et al., 2012). The climate condition has the mean annual temperature from 25°C to 26°C, the mean annual precipitation from 1200 mm to 1700 mm and the mean annual humidity from 81% to 84%. Two types of soil that were alluvial soil and deep active acid sulfate soil with sulfuric materials present depth in soil (>50 cm) were formed, but the alluvial soil has the largest area in An Giang province (165,547 ha). The alluvial soil is classified into four categories, namely Anofluvic and Orthofluvic fluvisols, Gleyic and Cambic fluvisols (Sub-NIAPP, 2003). These had high natural fertility, slight acidity, and no limiting factors for many crops. Exploitation has been performed in this rangeland to date and plant coverage is appropriate to study the diversity. This study was aimed to investigate the impacts of soil and local humans on plant diversity and distribution from 2017 to 2018.

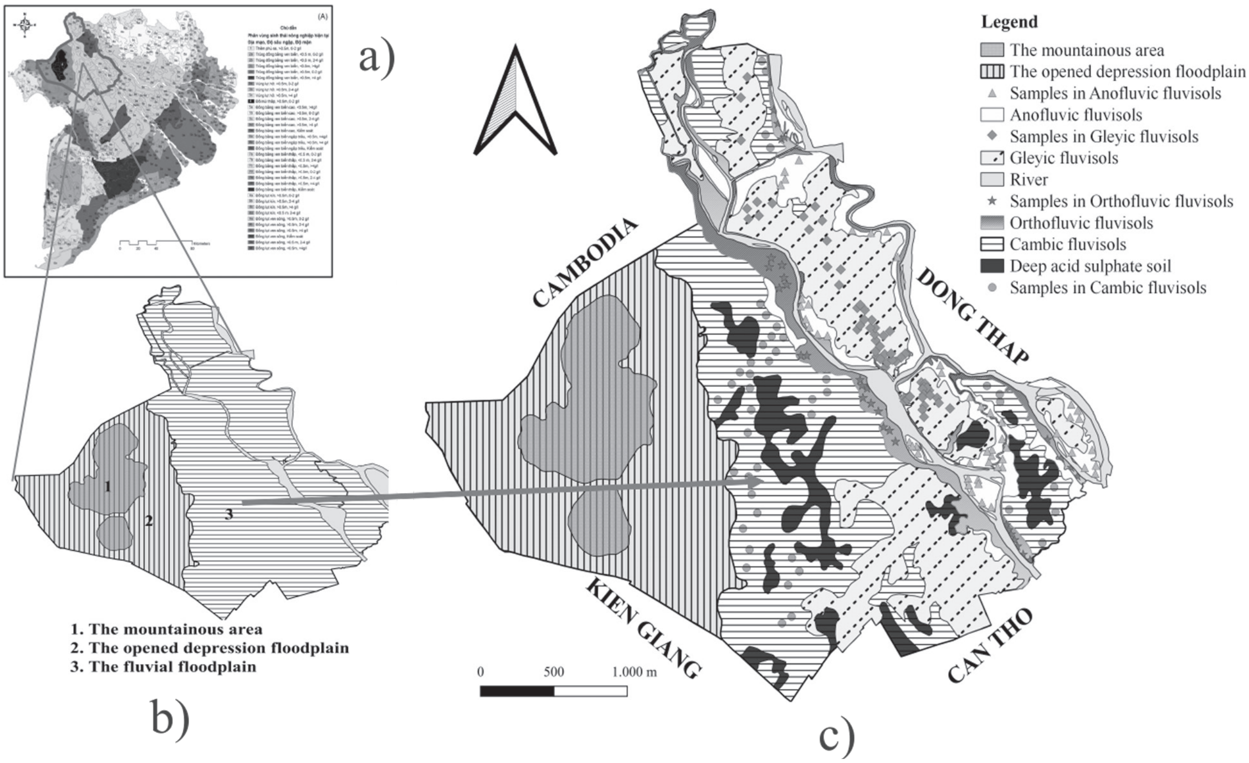

Figure 1. (a) The agro-ecological zones map in Mekong Delta (Nguyen et al., 2012); (b) The agro-ecological zones map in An Giang province; (c) The position of quadrats in the fluvial floodplain

2.2. Methods

Table 1. The number of quadrats in the fluvial floodplain

Types of soil	The number of quadrats (100 m^2)	The number of quadrats (1 m^2)
Anofluvic fluvisols	35	90
Orthofluvic fluvisols	30	80
Gleyic fluvisols	40	80
Cambic fluvisols	50	160

Survey transect is identified by satellite images of Google Earth and soil maps. One hundred-fifty-five quadrats (100 m^2) were surveyed in a part of the floodplain along the Hau River and Tien River, namely Cho Moi, Phu Tan, Tan Chau, Chau Thanh and Chau Phu districts. The quadrats were located in four alluvial soil types of Anofluvic and Orthofluvic fluvisols, Gleyic and Cambic fluvisols (Table 1). For each transect, the quadrats of 100 m^2 were random-systematically established for trees with ($DBH_{1,3}$) ≥ 6 cm and shrubs. In the quadrats of 100 m^2, three sub-quadrats of 1 m^2 were arranged for herbaceous plants diagonally. In the field and the agricultural ecosystem, the study was established on any three quadrats of 1 m^2. The numbers of required quadrats were determined by the species accumulation curve methods, using GPS to determine coordinates of quadrats. In the quadrats, data were collected with (i) the number of plant species; (ii) the number of individuals (the number of root for shrubs and herbs, the number of stems for climbing herbs) and the DBH diameter of tree (Le, 2005). The local people were interviewed for useful values of flora, frequency of changes in crop, cutting down and planting, herbicide spraying, weed cleaning, fertilizer application and tillage. The number of households were surveyed in this region as n=92 (woods) and n=108 (herbs). The morphological comparison method was applied to determine the species's name based on An Illustrated Flora of Viet Nam – Vol.1,2,3 (Pham Hoang Ho, 1999). The uses of plants were investigated in the local communities and searched from Dictionary of medicinal plants in Viet Nam (Vo Van Chi, 2018).

2.3. Method of diversity assessment

+ *Determinating of rare and precious species* based on the Vietnam Red Book - Part II (Plant).

+ *Diversity assessment by alpha diversity indices* (Table 2):

Table 2. The alpha diversity indexes

Index	Formulas		Meaning
Margalef (d)	d=(S-1)/logeN	S: total species N: total individual	A measure of the abundance of species present for a given number of individuals.
Pielou's (J')	J'=H'/logeS	H': Shannon index	A measure of degree of evenness in species abundances.
Shannon (H')	H'= $-\sum Pi * \log(Pi)$	Pi: Ni/N	A measure of species diversity in a community.
Simpson (λ')	$\lambda' = \{\sum Ni(Ni-1)\}/\{N(N-1)\}$	Ni: total individual of species i	A measure of species dominance in a community.

+ Important value index (IVI): For woods, IVI = RD + RF + RBA (Le Quoc Huy, 2005) and for herbs and shrubs, IVI = RD + RF. RD (%) is relative density, RF (%) is the relative occurrence frequency and RBA (%) is the relative basal area.

+ Assessing the similarity of flora through Sorensen index: S=2c/(a+b). S: Sorensen index (from 0 to 1); a: number of species of community A; b: number of species of community B; c: the number of species in common of two communities A and B.

2.4. Methods of soil survey and assessment

In quadrats 100 m^2 & 1 m^2, the soil samples at 4 corners and center were collected and mixed approximately 0.5 kg. A shovel was used to reach a depth of 50 cm and a small knife was used to mark and take soil samples at layer 0-20 cm and layer 20-50 cm. Soil samples were brought to the laboratory and dried at room temperature, and crushed through a sieve with a diameter of 2 mm. The soil parameters were analysised on texture (Robinson method), bulk density (soil are taken in a 100 cm^3 box and then dried at 105°C for 24 hours), particle density (Pycnometer method), porosity, pH_{KCl} (soil: KCl = 1:5), EC (soil: wate = 1:5), and OM (Walkley Black method). N total (digestion with salicylic acid + H_2SO_4 98% + $CuSO_4$ + K_2SO_4) and N available (extracted by KCl 1N) were distillated by Kjeldahl method. P total (digestion with H_2SO_4 98%+$HClO_4$) and P available (extracted by H_2SO_4 0.1N) were showed color of phosphomolybdate and colorimetric on spectrophotometer at 880nm. K total (digestion with HF–$HClO_4$) and K available (extracted by CH_3COONH_4 1N) were measured by AES method. Ca^{2+} and Mg^{2+} were extracted by $BaCl_2$ and measured by AAS method (Doan et al., 1998).

2.5. Statistical analysis

Identifying diversity indexes and species accumulation curves by Primer Ver.6. Data of diversity indexes and soil were analyzed by ANOVA method and Tukey/Tamhana's Test in the SPSS package ver.22, at 5% significance level. The relationship between plant and soil factors was analyzed by CCA method in Canoco software ver.4.5. The relationship between plant and human factors was analyzed by regression analysis method in the SPSS package ver.22. Quantitative analysis of the contribution of soil and human factors to the diversity status was analyzed by the RDA method in Canoco software 4.5.

3. Results and discussion

3.1. Physicochemical characteristics of soil in the fluvial floodplain

The types of alluvial soils in this area were mainly silty clay soil that had a high level of silt and clay. In both layers 0-20 cm and 20-50 cm, the porosity in all soil types was high but these values were not significantly different (p>0.05) (Table 3).

Table 3. Physical properties of soils

Soil properties	Layer (cm)	Types of fluvisols			
		Anofluvic	Orthofluvic	Gleyic	Cambic
Sand (%)	0-20	14.71±2.61^{a}	12.14±1.99^{a}	3.73±0.28^{b}	11.09±1.99^{a}
	20-50	10.67±1.09^{a}	10.23±1.70^{a}	5.77±0.24^{ab}	4.41±0.77^{b}
Silt (%)	0-20	57.95±1.02^{a}	53.26±0.58^{b}	47.60±1.40^{c}	45.25±2.45^{c}
	20-50	59.97±0.49^{a}	54.08±0.53^{b}	51.45±0.79^{b}	53.87±1.15^{b}
Clay (%)	0-20	30.97±1.85^{c}	34.60±1.59^{bc}	48.67±1.39^{a}	40.04±4.05^{b}
	20-50	29.36±0.95^{c}	35.69±1.40^{bc}	42.78±0.78^{a}	41.71±2.8^{ab}
Bulk density (g/cm^3)	0-20	0.88±0.04^{a}	0.96±0.04^{a}	0.89±0.07^{a}	0.84±0.02^{a}
	20-50	0.95±0.03^{a}	0.99±0.04^{a}	0.96±0.07^{a}	0.91±0.06^{a}
Particle density (g/cm^3)	0-20	2.33±0.03^{a}	2.35±0.04^{a}	2.24±0.11^{a}	2.29±0.08^{a}
	20-50	2.22±0.05^{a}	2.14±0.06^{a}	2.15±0.08^{a}	2.14±0.06^{a}
Porosity (%)	0-20	63.43±2.97^{a}	62.69±1.66^{a}	58.95±1.76^{b}	58.41±3.75^{b}
	20-50	57.65±2.71^{a}	57.12±1.24^{a}	53.34±1.45^{a}	54.35±3.92^{a}

Note: Values followed by dissimilar letters (a,b,c) under the same row are significantly different at p<0.05.

The amount of sand and silt of Anofluvic fluvisols were higher than that of clay and at the same time higher than the amount of the other three soil types (p<0.05) because this soil was formed by young river sediments and distributed in natural levees, sandbars along the Tien and Hau rivers. Although Orthofluvic fluvisols had particle size composition like Anofluvic fluvisols, its clay was higher because the distribution was farther from the Tien and Hau rivers. Gleyic fluvisols and Cambic fluvisols were distributed in low areas, behind the natural levees and far from the river, so the physical properties of these soils have changed significantly. In particular, in the 0-20 cm and 20-50 cm layers, the content of sand and silt decreased but the amount of clay increased to the highest level in the 0-20 cm layer of Gleyic fluvisols (48.67 ± 1.39%) (p<0.05). Similarly, the porosity of these two soil types also decreased in the layer 0-20 cm meaningfully (p<0.05). The research results were similar to those of Sub-NIAPP (2003) that these soils were principally silty, high porosity and good drainage.

Compared with the characteristics of soil in the mountainous area and opened depression of floodplain in An Giang, these alluvial soils in the fluvial floodplain were characterized by slight acidity with the value of pHKCl from 5.29±0.11 to 5.95±0.16 (p<0.05) and decreased with depth, except for Orthofluvic fluvisols. In contrast, EC tended to increase with depth in all four soil types and reached the highest value in Cambic fluvisols. The content of OM, nitrogen, phosphor, potassium, Ca^{2+} and Mg^{2+} were assessed as the medium to rich nutrients and tended to decrease with depth. The high contents were analyzed on Anofluvic fluvisols and Orthofluvic fluvisols apart from available nitrogen (Table 4). In general, these features of soils in the fluvial floodplain were formed by some reasons that they were distributed in the locations near rivers, annually deposited alluvium, without any pyrite materials. Also, the high proportions of available nutrients in the alluvial soils were due to the application of fertilizers to improve the soil nutrient in crops by farmers. At present, the whole region is exploited to cultivate fruit trees, rice and vegetables and it becomes an important food supply area of An Giang province.

Table 4. Chemical properties of soils

Soil properties	Layer (cm)	Types of fluvisols			
		Anofluvic	Orthofluvic	Gleyic	Cambic
pHKCl	0-20	5.68±0.17^{a}	5.60±0.12^{a}	5.73±0.10^{a}	5.33±0.09^{a}
	20-50	5.62±0.11^{ab}	5.95±0.16^{a}	5.65±0.11^{ab}	5.29±0.11^{b}
EC	0-20	101.39±17.32^{a}	115.52±19.12^{a}	102.65±9.33^{a}	159.92±24.57^{a}
(µS/cm)	20-50	100.24±20.46^{c}	136.18±22.62^{b}	106.15±17.20^{c}	198.89±27.01^{a}
OM	0-20	3.56±0.17^{a}	3.71±0.24^{a}	3.11±0.15^{a}	3.50±0.28^{a}
(%OM)	20-50	2.63±0.16^{a}	2.85±0.28^{a}	2.50±0.19^{a}	1.81±0.17^{b}
N total	0-20	0.20±0.02^{a}	0.23±0.01^{a}	0.17±0.007^{a}	0.19±0.009^{a}
%N	20-50	0.13±0.002^{a}	0.14±0.004^{a}	0.09±0.008^{a}	0.10±0.01^{a}
N available	0-20	6.84±0.53^{b}	7.57±0.50^{b}	10.36±0.63^{a}	10.04±0.88^{a}
(mg/100 g)	20-50	6.39±0.46^{c}	7.35±0.39^{bc}	9.68±0.70^{a}	9.34±0.65^{ab}
P total	0-20	0.14±0.001^{a}	0.11±0.004^{a}	0.07±0.005^{a}	0.09±0.008^{a}
(%P_2O_5)	20-50	0.06±0.007^{a}	0.06±0.009^{a}	0.05±0.009^{a}	0.07±0.008^{a}
P available	0-20	23.89±2.43^{a}	18.89±3.13^{ab}	13.17±2.66^{b}	10.38±1.75^{b}
(mg/100 g)	20-50	14.64±1.42^{ab}	15.83±2.83^{a}	4.89±0.67^{c}	6.89±0.85^{bc}
K total	0-20	1.16±0.03^{a}	1.15±0.04^{a}	0.96±0.05^{a}	0.94±0.07^{a}
%K_2O	20-50	0.81±0.03^{a}	0.78±0.04^{a}	0.64±0.05^{a}	0.65±0.07^{a}
K available	0-20	2.70±0.35^{a}	2.77±0.27^{a}	1.32±0.28^{b}	0.91±0.12^{b}
(meq/100 g)	20-50	2.34±0.34^{a}	2.72±0.28^{a}	1.40±0.34^{ab}	0.85±0.11^{b}
Ca^{2+}	0-20	9.12±0.46^{a}	9.67±0.88^{a}	4.79±0.37^{b}	5.34±0.40^{b}
(meq/100 g)	20-50	8.67±0.40^{a}	9.48±0.81^{a}	5.34±0.42^{b}	5.80±0.43^{b}
Mg^{2+}	0-20	2.03±0.15^{b}	3.24±0.22^{a}	1.80±0.18^{b}	1.57±0.19^{b}
(meq/100 g)	20-50	2.17±0.17^{b}	3.05±0.26^{a}	1.62±0.17^{b}	1.69±0.21^{b}

Note: Values followed by dissimilar letters (a,b,c) under the same row are significantly different at p<0.05.

3.2. The flora distribution in the fluvial floodplain

To estimate the number of quadrats that need to be investigated in different soil types, the study analyzed the relationship between species cumulation and the number of quadrats (Figure 3). The Sobs (the observed species) value of woody species in Anofluvic and Orthofluvic fluvisols increased rapidly and balanced when the number of quadrats increased from 20 to 35. Although the species cumulative curve of Gleyic and Cambic fluvisols has yet to reach an equilibrium clearly, the last quadrats's Sobs values were nearly equal, ranging from 13.56

to 13.87 and from 21.50 to 21.81, respectively. For herbaceous species, Anofluvic fluvisols was more diverse than the other three soil types with the last quadrats's Sobs values from 53.72 to 54, while this value of the other three soil types were only 33.43 to 34. In general, the number of surveyed quadrats was reliable to assess the diversity of woody and herbaceous species in the fluvial floodplain.

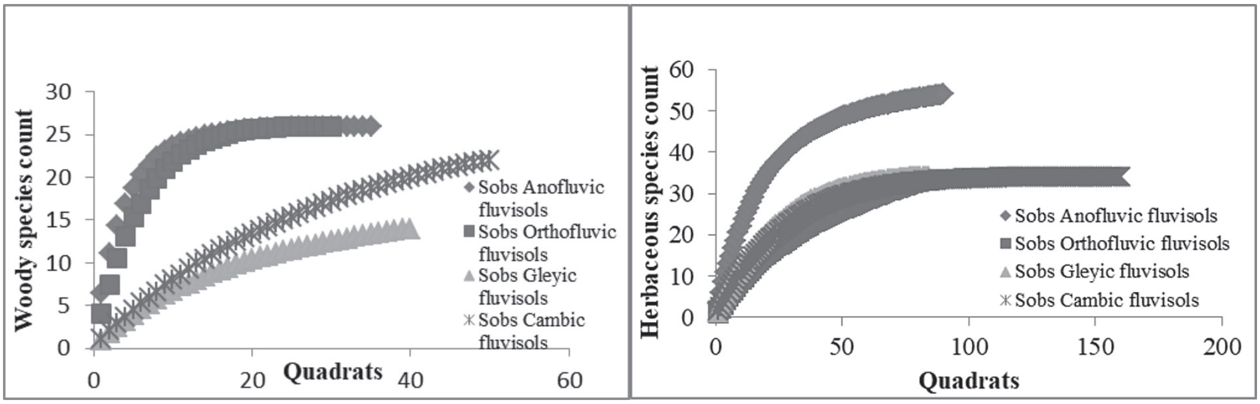

Figure 2. The species cumulative curve of woody and herbaceous species in the fluvial floodplain

Table 5. Species diversity of plant families in the fluvial floodplain

Families	The number of species			
	Anofluvic fluvisols	Orthofluvic fluvisols	Gleyic fluvisols	Cambic fluvisols
Fabaceae	20	18	17	17
Poaceae	18	15	18	18
Asteraceae	16	9	10	11
Cucurbitaceae	12	11	11	10
Euphorbiaceae	11	8	10	9
Cyperaceae	10	9	9	10
Lamiaceae	7	7	7	7
Rutaceae	6	6	0	0
Brassicaceae	5	6	6	6
Moraceae	5	5	4	4
Myrtaceae	5	4	3	3
Solanaceae	5	5	6	6

The results recorded 230 plant species and 173 genera which belong to 73 families, Polypodiophyta and Magnoliophyta. Among them, 80 wild species belong to 20 families and 150 cultivated species belong to 53 families. The Anofluvic soil had the most diversity of families, genera, and species. Table 5 showed the 12 of recorded families that were common distribution and high diversity in all four alluvial soil types. The most diverse family was Fabaceae, followed by Poaceae, Asteraceae and Cucurbitaceae.

3.3. The diversity of useful species

There were 221 useful species recorded in the fluvial floodplain (accounting for 96.09%). The medicinal and edible plants constituted the majority of the useful species group; of 150 planted species, 98 ones were fruit trees, food, and vegetable crops. The families were widely grown in crops, namely Poaceae, Fabaceae, Cucurbitaceae, Rutaceae, Solanaceae, Asteraceae, and Brassicaceae. Anofluvic and Orthofluvic fluvisols were with many valuable species distributed (Table 6).

Table 6. The diversity of useful species in the fluvial floodplain

Group of appication	Anofluvic fluvisols		Orthofluvic fluvisols		Gleyic fluvisols		Cambic fluvisols	
	Species	%	Species	%	Species	%	Species	%
Medicine (M)	191	94.6	154	91.1	149	89.8	145	91.2
Edible (Ed)	136	64.8	104	59.1	103	59.2	96	57.8
Timber (T)	13	6.2	12	6.8	9	5.2	9	5.4
Essential oils (Or)	9	4.3	9	5.1	8	4.6	8	4.8
Ornament (Eo)	10	4.8	5	2.8	9	5.2	6	3.6
Oil	1	0.5	2	1.1	1	0.6	1	0.6
Handicraft (H)	1	0.5	1	0.6	1	0.6	1	0.6
Others (U)	9	4.3	7	4.0	9	5.2	9	5.4
Total of useful species	202	96.2	169	95.5	166	95.4	159	95.8

The features of Anofluvic and Orthofluvic fluvisols were high nutrients and slight acidity due to deposit alluvium annually. Besides, the texture of the two soil types was principally silty (more than 53% particle size composition), so they were porous and their drainage ability was good. These areas were filled with many garden ecosystems of many perennial plants. The main species components were fruit trees of *Dimocarpus longan, Mangifera indica, Artocarpus heterophyllus, Citrus* sp., *Citrus grandis, Citrus aurantifolia, Prunus salicina*, and especially many varieties of *Mangifera indica* were mostly planted by farmers. The annual plants were mainly grown with vegetables. The most diverse family was Fabaceae of *Arachis hypogaea, Glycine max, Pachyrrhizus erosus, Psophocarpus tetragonolobus, Phaseolus vulgaris, Vigna radiata*, and *Vigna unguiculata*. Next, Cucurbitaceae was also a diverse family planted by farmers, namely *Cucumis melo, Luffa cylindrica, Lagenaria siceraria, Citrullus lanatus, Benincasa hispida, Cucumis sativus,* and *Momordica charantia*. The species compositions of Brassicaceae were *Brassica integrifolia, Brassica oleracea,* and *Brassica juncea* while Solanaceae was of *Capsicum frutescens, Lycopersicum esculentum*, and *Solanum melongena*.

Gleyic fluvisols and Cambic fluvisols were distributed in backswamp that lied behind the natural levees, so they were low and often inundated from the beginning of the rainy season (Nguyen, 1993). Therefore, the features of Gleyic fluvisols and Cambic fluvisols were high clay content, heavier soil, less porosity and drainage, so the main cultivation system was rice triple crop and rice double crop. Especially, *Diospyros mollis* belonging to the Ebenaceae family was only rare species recorded in the fluvial floodplain. It was listed in Vietnam Red Book (2007) at endangered levels (EN A1c, d, B1+2a). At present, *D. mollis* Griff. was planted in Tan Chau district for fruits. The weaver extracted black liquid from these fruits to dye cloth fabric. The traditional village of Lanh My A has attached *D. mollis* Griff. to Lanh My cloth fabric, which is glossy and durable over time. Currently, because of the increasing demand for using Lanh My cloth fabric, a lot of local people quit their weaving jobs and *D. mollis* Griff. was no longer planted or protected. Currently, only a few households still preserve it to represent the traditional beauty of Tan Chau people.

3.4. Diversity assessment in the fluvial floodplain

The similarity of plants was assessed

through Sorensen index. The flora of alluvial soil types had a very close relationship (S>0.82), of which the most similar plant composition was the flora of Gleyic and Cambic fluvisols (S=0.89). Influenced by freshwater all year round, rich nutrients due to sedimentation, these four alluvial soils virtually had no limitations in their distribution and diversity of plants, especially crops. Besides, the Anofluvic fluvisols were found along the Hau and Tien River, forming natural levees. Because of occupying a high position and well-drainage place, most of the garden ecosystems were formed mainly in the Anofluvic fluvisols. Therefore, the flora here was a little different from those in the other soil types.

The plant diversity was assessed through alpha diverse indexes. For wood, the value of indexes (d, J' and H') were the highest in Orthofluvic fluvisols ($p<0.05$) because of species diversity at home gardens with many fruit trees and other plants such as *Calophyllum inophyllum, Hopea odorata*, and *Samanea saman*. Although the most herbaceous abundance was in Orthofluvic fluvisols (d=2.29±0.07), the most diversity and evenness were in Gleyic fluvisols (Table 8).

Table 7. The similarity of plant compositions in the fluvial floodplain

	Anofluvic fluvisols	Orthofluvic fluvisols	Gleyic fluvisols
Anofluvic fluvisols	1	-	-
Orthofluvic fluvisols	0.85	1	-
Gleyic fluvisols	0.83	0.86	1
Cambic fluvisols	0.82	0.87	0.89

Table 8. The value of diversity indexes in the fluvial floodplain

Types of alluvial soil	The diversity indexes of woody plants			
	Margalef (d)	**Pielou (J')**	**Shannon-Wiener (H')**	**Simpson (λ')**
Anofluvic fluvisols	1.93±0.19^{b}	0.87±0.02^{a}	1.62±0.09^{b}	0.22±0.02^{b}
Orthofluvic fluvisols	3.48±0.24^{a}	0.92±0.02^{a}	2.18±0.08^{a}	0.10±0.02^{a}
Gleyic fluvisols	1.47±0.07^{bc}	0.74±0.03^{b}	1.26±0.04^{c}	0.36±0.03^{c}
Cambic fluvisols	1.27±0.08^{c}	0.73±0.02^{b}	1.22±0.05^{c}	0.39±0.02^{c}
The diversity indexes of herbaceous plants				
Anofluvic fluvisols	2.13±0.13^{ab}	0.91±0.007^{b}	1.92±0.04^{c}	0.13±0.005^{a}
Orthofluvic fluvisols	2.29±0.07^{a}	0.92±0.01^{ab}	2.05±0.05^{bc}	0.14±0.008^{a}
Gleyic fluvisols	1.94±0.09^{b}	0.94±0.002^{a}	2.24±0.05^{a}	0.12±0.007^{a}
Cambic fluvisols	1.81±0.10^{b}	0.93±0.004^{ab}	2.14±0.04^{ab}	0.13±0.005^{a}

Note: Values followed by dissimilar letters (a,b,c) under the same column are significantly different at p<0.05.

The Shannon-Wiener index of herbaceous plants in Anofluvic fluvisols with the lowest value proved that its diversity was also the lowest because the canopy cover of trees combined with chemical spraying many times had limited weed growth in the garden farming model. According to (Gall & Orians, 1992), besides local natural characteristics, the type of cultivation was also an important factor affecting the diversity and distribution of weeds. Some research results found the number of species in the mountainous areas richer than those in the fluvial floodplain and the opened depression of floodplain (Nguyen & Nguyen, 2017; Nguyen et al., 2018). However, the quantitative assessment through the alpha indices showed that the fluvial floodplain had the average value of (d), (J') and (H') indexes were higher, but (λ') was lower than the mountainous areas and the opened depression of floodplain. Thus, in different ecological regions, soil characteristics have affected the distribution and diversity of vegetation.

3.5. The role of soil and local humans in flora diversity

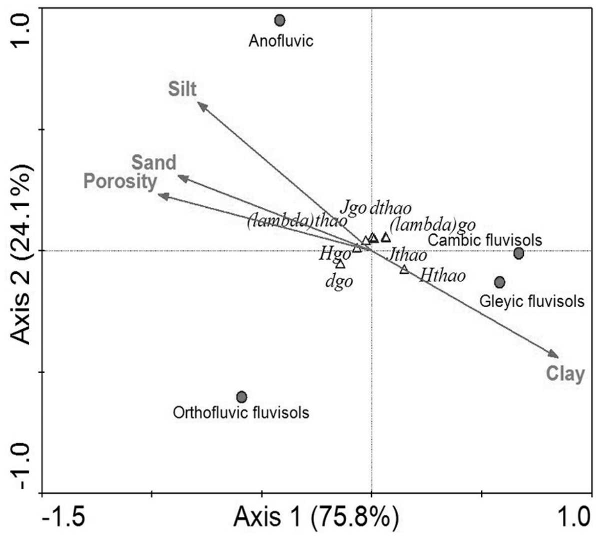

Figure 3. Influence of soil factors on the diversity indexes in the fluvial floodplain. d_{go}, J_{go}, H_{go}, $(Lambda)_{go}$ are the woody indexes; (d, J’, H’ and λ'); d_{thao}, J_{thao}, H_{thao}, $(Lambda)_{thao}$ are the herbaceous indexes (d, J’, H’ and λ')

The result of CCA analysis proves that physical soil factors affected plant diversity. The right side of Axis 1 describes the characteristics of Gleyic and Cambic fluvisols. The correlation score of clay is 0.847 and represents a positive correlation with the diverse indexes of herbaceous plants. The left side of Axis 1 also describes the features of Anofluvic and Orthofluvic fluvisols characterized by the high level of porosity, sand, and silt. These factors represent a positive correlation with the diversity indexes of woody plants, of which correlation score for each factor was r=-0.969 (porosity), r=-0.880 (sand) and r=-0.791 (silt), respectively. Axis 1 had the explanatory variable of 75.8% and the correlation coefficient was 0.643 ($p<0.05$). In Axis 2, the explanatory variable was 24.1% and the correlation coefficient was 0.449 ($p<0.05$) (Figure 3).

With the advantages of climate, alluvial soil and irrigation systems, the fluvial floodplain was one of the areas with the highest population and largest agricultural area in An Giang province. Therefore, local people's influence on the distribution and diversity of plants in this ecoregion should also be considered and assessed. Human activities have also created a positive correlation with some diverse indexes of woody plants and a negative correlation with some indexes of herbaceous plants. The planting habits and hobbies of the local people increased the diversity status of woods, but weed control and tillage practices also caused a decrease in herbaceous diversity in agricultural ecosystems (Table 9).

Table 9. Human impact on the diversity of flora in the fluvial floodplain

Indexes		R	R^2	P	Indexes		R	R^2	P
Wood	d	0.77	0.59	0.000	Herb	d	-0.655	0.429	0.000
	J’	0.65	0.43	0.000		J’	-0.138	0.019	0.08
	H’	0.76	0.57	0.000		H’	-0.814	0.662	0.000
	λ’	-0.65	0.43	0.000		λ’	0.754	0.569	0.000

Agricultural practices are one of the most important human activities critically affecting the present status of herbaceous diversity. Although weed species play an important role in the agricultural ecosystem, traditional farming practices of removing weed species from farmland, regardless of their ecological impacts; thus declining biodiversity in agricultural ecosystems. At present, the farming practices of the local farmers tend to eliminate weeds from agricultural ecosystems, especially in rice and crop fields. Interviewed results showed that in the fluvial floodplain, the frequency of weed control was picked up (4.22 times/crop) and they used both manual weeding and herbicide spraying. However, the application of herbicides was widely used because it was less labor-intensive and more effective. Also, traditional tillage methods limited weeds in rice fields. In contrast, the demand for food and economic development had led local farmers to plant many useful species around their home gardens. Currently, when the price of agricultural products fluctuates, a model of intercropping many species of fruits on the same garden is being developed by the farmers to diversify agricultural products and limit price risks. Besides, local people also plant and conserve a variety of trees for many other purposes such as religion, ornament, shade and preventing landslips. The contribution of soil and human factors to the current state of plant diversity was assessed with the same importance in the fluvial floodplain (Table 10). Soil factor explained for 7.0% of the diversity status (accounted for 27.24%) while human impact explained for 6.1% of the diversity (accounted for 23.74%). The rest was determined by the combination of soil and local people impacts making 12.6% of the diversity (accounting for 49.02%). Thus, in the fluvial floodplain, the role of soil and human factors in the diversity of vascular plants was almost equal.

Table 10. The contribution of soil and human factors to diversity in the fluvial floodplain

Explanatory variables	The contribution of explanatory variables for diversity data (%)	P-value
Total variables	25.7	0.002
Soil	7.0	0.002
Impact of human	6.1	0.01
Soil and impact of human	12.6	-

4. Conclusion

In the fluvial floodplain, the soil properties were characterized by the main silty component, slight acidity, and rich nutrients as OM, nitrogen, and potassium. The results recorded 230 plant species and 173 genera which belong to 73 families, of which 80 species of 20 families were wild species and 150 species of 53 families were planted by the local human. The Anofluvic soil was the most diverse of families, genera, and species. In the fluvial floodplain, both soil and local people played an equal role in the diversity status of plants. The porosity, sand, and silt affected the flora in Anofluvic and Orthofluvic fluvisols while clay affected them in Gleyic and Cambic fluvisols. The planting habits and hobbies of the local people positively affected the diversity status of woods while weed control and tillage practices caused a decrease in herbaceous diversity in agricultural ecosystems. To increase the diversity of plant resources, it is necessary to plan the development of fruit tree diversity in Anofluvic fluvisols and Orthofluvic fluvisols while herbaceous species should be developed in Gleyic fluvisols and Cambic fluvisols. Local people should be encouraged to diversify crops in home gardens and farming fields, limit monoculture and over-control weeds when unnecessary.

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