

Structure and Diversity of Natural-Anthropogenic Landscapes of Konkakinh-Konchurang Conservation Area, Vietnam

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Abstract: Studying the characteristics of landscape structures is an important content in determining territorial division, especially in the monsoon tropics, where there is a strong division of non-zonal rule as in the Central Highlands of Vietnam. Konkakinh-Konchurang conservation area is located in the north-eastern part of Gia Lai province with a special geographic location. There is a profound division of components, natural and human factors. The humid tropical climate is simultaneously influenced by the climate of the Central Highlands and the Central Coast. Natural-anthropogenic landscapes are quite differentiated from one system, one subsystem, three classes, five subclasses, 13 types and 87 kinds. The diversity in the landscape structure is evident in the elevation law through subclasses. In particular, subclass has the highest level of diversity is subclass on plateau with 3 types and 22 kinds; subclass on plain has the lowest level of diversity with only two types and 13 kinds. The diversity of landscape in Konkakinh National Park is much higher than in Konchurang Natural Reserve because of the differentiation of landscape forming components as well as long-standing farming practices of indigenous ethnic groups - Bana.

Key words: landscape, diversity, conservation area, Konkakinh - Konchurang

1. Introduction

Structure and diversity are the basic properties of the landscape in general, natural-anthropogenic landscapes in particular. These characteristics show characteristics of differentiation and hierarchy on a specific area [1-3]. Researching and analyzing structure characteristics of landscape allows to determine the characteristics and roles of each component, each landscape unit, the interaction of the constituent components, especially the anthropogenic component and factors [4-7] according to vertical and horizontal structure at a defined time, and it is the base for forecasting the changes, adjustments by themselves or under external factors of landscape in the future [1, 2, 8-11]. In the

physical geographic conditions of Vietnam, these properties are even more evident through the differentiation of tectonics — topography and marine — continental properties [9, 12]. This not only provides knowledge and awareness about the nature and natural resources of Vietnam's tropical ecosystems, but also a scientific base for forest management and development associated with biodiversity conservation.

Konkakinh-Konchurang conservation area occupies a significant part of Gia Lai province with mainly natural forests, highly representative of the tropical forest ecosystems of the Central Highlands, Vietnam. This area contains great values of biodiversity, the ability to regulate the environment, especially the hydrological environment.

So far, there have been studies on landscape for the whole Central Highlands region (Ecological landscape

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map of the Central Highlands, in 1988 at the rate of 1:250,000). Some other research results are still very general, lack of detailed description of the structure and differentiation of the area. Moreover, researches, investigations of ecosystem components, complex studies of features and spatial differentiation have hardly been conducted.

The paper presents the results of research on the diverse characteristics of the natural-anthropogenic landscape with the establishing of a landscape map at the scale of 1: 50,000; clarifying the spatial structure and landscape diversity, the causes of the diversity according to the taxonomic hierarchy and the regions of the Konkakinh-Konchurang conservation area.

2. Material and Methods

2.1 Studied Area

Konkakinh-Konchurang conservation area is located in the area of K'Bang district, northern part of Mang Yang district and a small part of Dak Doa district, located in the Central Highland of Vietnam (Fig. 1). It is the starting area of the river system containing four rivers: Ba, Se San, Srepok and Con. In the manner of administrative geography, this area is divided by the East Truong Son route, nearby the National Highway 19 in the south, adjacent to Highway 24 in the north and the vast forest of Kon Plong, Kontum province, forming a valuable natural ecosystems under preservation in the central of Truong Son forest.

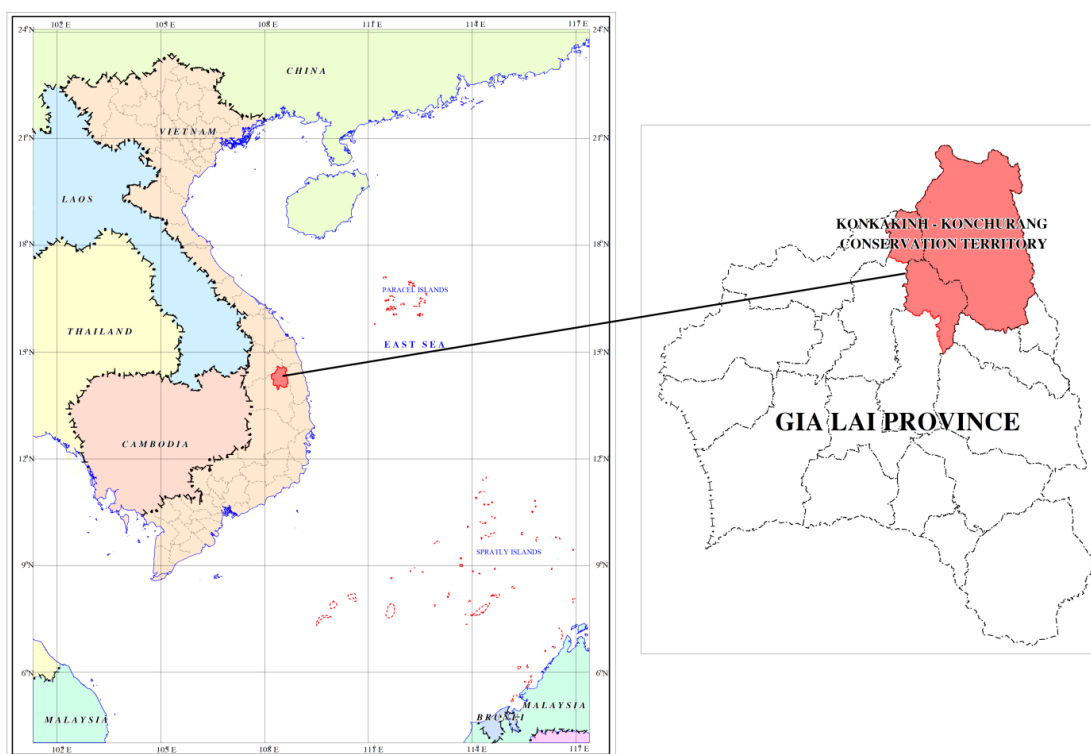


Fig. 1 Location of the studied area.

2.2 Data Collection

Based on topographic map and preliminary landscape map, we selected plots and routes to investigate. Survey results by plots and routes in different types of terrain were recorded to describe natural characteristics, human activities and their

spatial differentiation. The boundaries of landscape units were checked, especially the boundaries of different types and kinds of landscapes.

2.3 Editing and Establishing Maps

To perform the research, we have edited component

maps and developed natural-anthropogenic landscape map of the studied area (2017). The MapInfo Pro 15, ArcGIS 10.2, ENVI 5.3 and satellite images SPOT 5 were used to build maps. Component maps were edited and built at the scale of 1:50000. Map of natural-anthropogenic landscape of Konkakinh-Konchurang conservation area was established at the scale of 1:50000 based on overlapping and analyzing the combination of component maps and field survey results. The method

of overlaying map layers with program Arcgis 10 (License ESU006984479, ArcGIS Desktop Basic) was used; execute the Intersect command. Selected 6-range taxonomic systems contain: System → Subsystem → Class → Subclass → Type → Kind (Table 1).

Due to the homogeneity of the system and subsystem in taxonomic range, the legend of natural – anthropogenic landscape map does not represent these two ranges (Fig. 3).

Table 1 Taxonomic ranges and classification criteria for the landscape in Konkakinh-Konchurang conservation area.

	Taxonomic range	Classification criteria
1	System of landscape	The decisive role of the atmospheric circulation regime in the process of climate formation in the belt
2	Subsystem of landscape	The decisive role of atmospheric circulation regime and the regulation of ecological regions of flora
3	Class of landscape	Relief configuration, which determines the homogeneity of two large processes, namely erosion and accumulation, in the real cycle
4	Subclass of landscape	The peculiarity of large relief forms manifests the property of non-border based on the combination of relief and typical geomorphological processes
5	Type of landscape	Bio-climate and anthropogenic activities determine the formation of vegetation
6	Kind of landscape	The natural – anthropogenic differentiation of vegetation on different soil types

2.3 Data analysis and Evaluation

A comprehensive landscape assessment was used to determine the status of landscape components, including the identification of plants within forested areas, agricultural areas and grass and shrub landscapes. The comprehensive assessment of collected data was conducted with reference to remote sensing data and biological and ecological characteristics of crops in tropical monsoon conditions of Vietnam.

The diversity of the landscape is determined by the statistics, comparing richness, abundance and area of the landscape units according to the taxonomic rang. Similarly, comparison and assessment the diversity of landscapes according to the core areas of the conservation area: Konkakinh National Park and Konchurang Natural Reserve.

3. Results and Discussion

3.1 Characteristics of Landscape Forming Components: Vertical Structure of the Landscape

The studied area consists of various geological

formations and petrographic compositions with 21 different geological complexes. Basaltic and granite bedrocks distribute widely, creating characteristic terrains. Accordingly, the regional topography gradually decreases from North to South and from West to East, creating numerous plateaux. The plateau topography has average height of 900-1000 m a.s.l., gradually lowers from the North (1300 m a.s.l.) to the South (600 m a.s.l.), slightly protrudes in the middle and gently slopes to the two valley sides of Ba river and Con river. This terrain is typical with the process of surface erosion. Besides, the cubic-sized mountains on the pristine background is strongly divided with slope of 30-35°, forming deep valleys of Se San (Dak Pnè) and Ba rivers. Alternatively, the topography of semi-plains, plains and valleys distributed in the south of the studied area are characterized by exogenous activities of denudation – accumulation, accumulation – erosion [1, 14].

In the studied area, the typical humid tropical is influenced simultaneously by climate circulation in the Central Highlands and Central Coast [15], which

contains a various combination of terrains, including mountains, highlands, valleys and plains. The average temperature is 21-23°C. Rainy season lasts from May to December with heavy rainfalls of over 2000 mm, while as dry season is short (3-4 months) and drought situation is not as serious as which has been happening in the South and West [14, 15]. The hydrological system in this area is highly developed, including the mainstream and tributaries of the rivers Ba, Se San, Srepok and Con. The flow with thick density is relatively evenly distributed, averaging 0.34 km/km². Because of well-preserved vegetation, the plant density in the north is often higher than in the south.

According to the soil classification of FAO/UNESCO, there are six main soil groups with 14 soil types in this area [1, 16], highlighted by Rhodic Ferralsols on basalt in the eastern region and Ferralic Acrisols soil formed by different rocks under weather change in the western region of the studied area. In this area, several types of highland tropical vegetation are formed. They are evergreen forest and mixed forest (broadleaf and coniferous) concentrated in low and medium mountains of Konkakinh National Park, Konchurang Nature Reserve and surrounding areas [1, 17]. The vegetation processes a primitive structure with many layers of canopy and thick cover. The anthropogenic vegetation is mainly plantation forest, exploited for planting agricultural and industrial crops such as coffee, rubber, pepper, sugarcane, rice and many other crops.

The population of the studied area is not much and unevenly distributed. According to the statistics of Gia Lai province, the population of K'Bang district in 2019 is 80,130 people, the average density is 45 people/km² (Gia Lai People's Committee, 2019). The population is predominated by Ba Na ethnic (70%). Besides, there are other ethnic minorities and migrant peoples such as Tay, Nung, Hmong, Dao... Kinh people live in Mang Yang district and the center of K'Bang district, distribute along the main road connecting communes.

Economic activities are mainly agricultural

production, including cultivation and livestock. The southern region has a developed livestock industry. Shifting cultivation is the common habit and a food source for indigenous people. According to the survey results, up to 50% of households interviewed produce agricultural products on forest land with extensive culture. Most ethnic households in the buffer zone of the national park and reserved nature are lack of food for several months in a year. People often collect forest products for eating, borrow or sell unripe agricultural products for living and hold expectation for government aid.

3.2 Structural Characteristics of Landscapes: Horizontal Structure of the Landscape

Research results show that, the studied area consists of 1 system, 1 subsystem, 3 classes, 5 subclasses, 13 types and 87 kinds of landscape (Fig. 2 and Fig. 3).

System and subsystem of landscape: The studied area belongs to the tropical monsoon landscape system. The influence of southwest and Southeastern highland monsoon resulted in a subsystem of tropical monsoon landscape.

Class and subclass of landscape: Konkakinh-Konchurang conservation area is divided into 3 classes: plateaus, mountains (medium and low), and the class of valley and hollow between the mountain. In particular, the class of mountain is classified into 2 subclasses: medium mountain with elevation over 1,000 m a.s.l. and low mountain with elevation from 600 to 1,000 m a.s.l. The class of valley and hollow between the mountain includes subclass of valley erosion and accumulation and subclass of terraces and plains accumulate-invasion with the aluvi-deluvi process.

Type of landscape: Accordingly, the studied area has 13 types of landscape belonging to 3 groups: group of evergreen tropical forests and natural-anthropogenic shrubs, grasslands; group of anthropogenic vegetation (annual crops and plants in residential areas); and group of aquatic landscape.

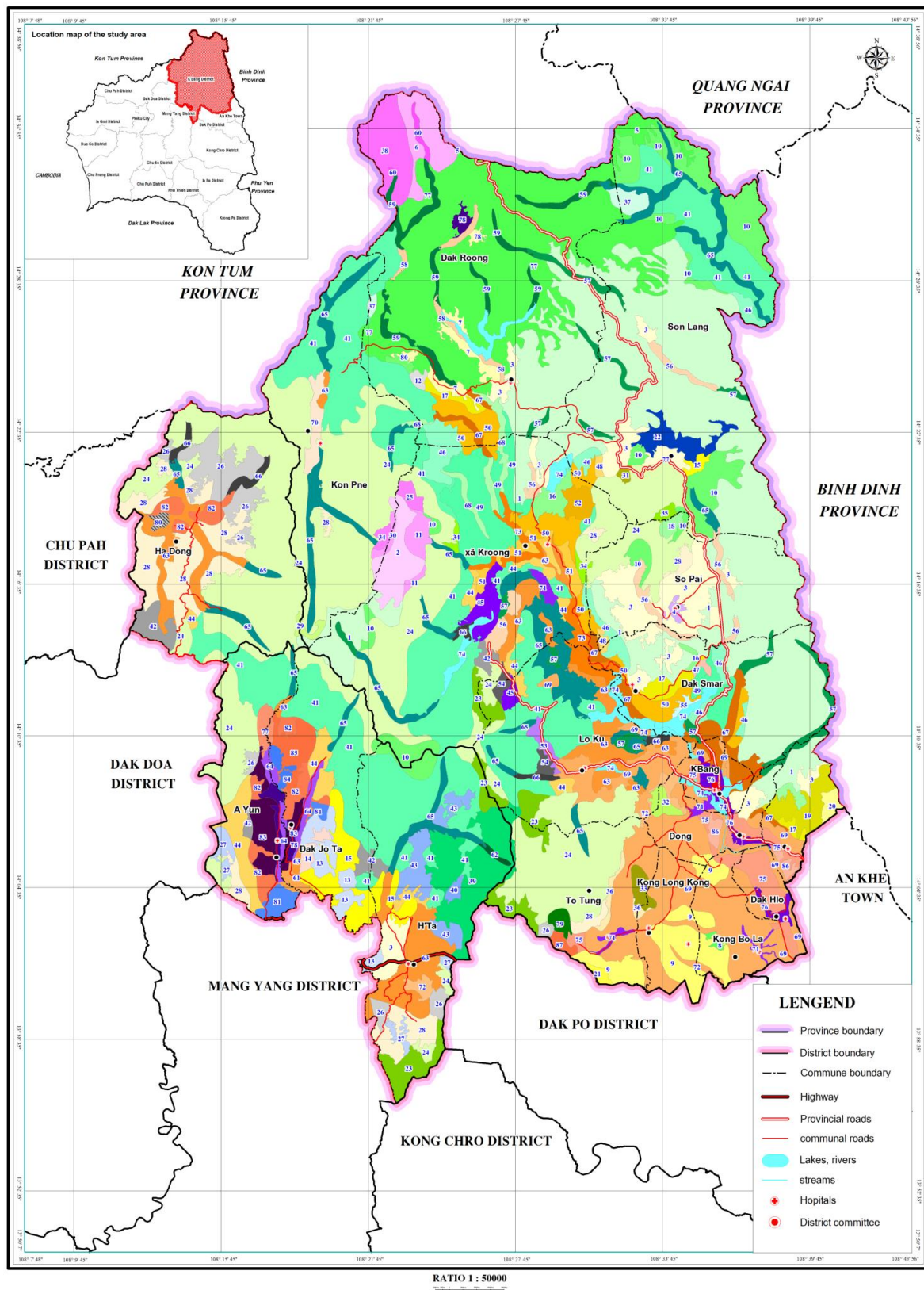


Fig. 2 Map of the natural – anthropogenic landscape in the Konkakin – Konchurang conservation area.

LANDSCAPES CLASS	LANDSCAPES SUB-CLASS	LANDSCAPES TYPE		Tropical monsoon highland climate, average humid of 81%, average temperature of 22°C Total annual rainfall fluctuates: 1500 - 2800 mm, slightly lacking in moisture The rain season lasts 8-9 month, the dry season is 3-4 month short							
		LANDSCAPES KIND	Natural vegetation			Anthropogenic vegetation				Reservoir	
			Evergreen tropical forest	Wood and bamboo mixed forest	Grasslands and shrubs	Plantation forest	Industrial crops	Annual Crops	Plant in residential areas		
Plateau	<i>High plateau with surface washing process</i>	Rhodic Ferralsols	1	2				3	4		
		Xanthich Ferrasols	5	6				7			
		Haplic Lixisols	8					9			
		Ferralic Acrisols	10	11	12	13	14	15			
		Lithic Luvisols	16					17			
		Gleyic Luvisols	18					19			
		Lithic Leptosols						20			
		Haplic Lixisols						21			
Mountain	<i>Medium mountains with erosion, erosion processes dominate</i>	Reservoir									22
		Gleyic Acrisols	23								
		Ferralic Acrisols	24	25	26	27		28			
		Rhodic Ferralsols	29	30				31			
		Lithic Leptosols	32					33			
		Lithic Luvisols	34								
	<i>Low mountain invasion, landslide and leaching processes dominates</i>	Gleyic Luvisols	35					36			
		Xanthich Ferrasols	37	38							
		Gleyic Acrisols	39			40					
		Ferralic Acrisols	41		42	43		44	45		
		Rhodic Ferralsols	46				47	48			
		Lithic Luvisols	49					50			
		Plinthic Acrisols						51			
		Gleyic Luvisols						52			
		Haplic Lixisols						53			
		Haplic Acrisols			54						
		Reservoir									55
Valley and hollow between the mountain	<i>Valley erosion and accumulation</i>	Rhodic Ferralsols						56			
		Xanthich Ferrasols	57					58			
		Gleyic Acrisols	59	60				61			
		Ferralic Acrisols	62					63	64		
		Lithic Luvisols	65		66			67			
		Haplic Lixisols	68					69			
		Umbric Fluvisols						70	71		
		Lithic Leptosols						72			
		Plinthic Acrisols						73			
		Reservoir									74
	<i>Terraces and plains accumulate - invasion with the aluvi - deluvi process</i>	Haplic Lixisols						75	76		
		Gleyic Acrisols						77	78		
		Ferralic Acrisols	79		80	81		82	83		
		Haplic Acrisols				84		85			
		Eutric Fluvisols						86			
		Xanthich Ferrasols						87			

Fig. 3 Legend of natural – anthropogenic landscape map in the Konkakinh – Konchurang conservation area.

- Group of evergreen tropical forests and natural-anthropogenic shrubs, grasslands: these types of landscape were influenced by human activities at different levels. They basically retained the properties and development under natural rule. In some places, they were disturbed by the strong and frequent human impacts (shown in the types of shrubs and grasslands).
- Group of anthropogenic vegetation are landscapes that have a component or coating surface built by humans. They have at least one component created by humans and tend to grow in the direction of human impact. In the group, there are 4 types of landscape: plantation forest, industrial crops, agricultural crops and plants in residential areas.
- Group of aquatic landscape: include the lakes which are mainly built by humans on regular

flows such as irrigation lakes, hydroelectric reservoirs or multi-purpose lakes.

3.3 Diversity in Classes of Landscape

3.3.1 Diversity According to the Landscape Classes

(1) Diversity in Class of Plateaus

The class of the plateaus only has 1 subclass which is basalt plateaus, differentiated into 3 types with 22 kinds. In particular, the type of evergreen tropical forests and shrubs, grasslands has 10 kinds. Among them, the evergreen tropical forest landscapes consist

of 6 kinds with a total area of 60,683.36 ha. The type of anthropogenic vegetation on basalt plateaus is observed with 11 kinds. The landscape kind with the largest area in this landscape type is the evergreen closed forest landscape on Rhodic ferralsols soil (number 1), with a total area of 34,201.19 ha (Table 2), accounting for 53% of the total landscape area of landscape type, distribute concentrate in Kon Ha Nung plateau and a part of Konkakinh mountain.

Table 3 Area of landscape kinds of Konkakinh - Konchurang conservation area.

Landscape number on the map	Area (ha)	Number of contour	Landscape number on the map	Area (ha)	Number of contour	Landscape number on the map	Area (ha)	Number of contour
1	34,201.19	5	31	99.75	1	61	248.27	1
2	1,469.46	1	32	305.97	1	62	98.36	1
3	6,497.69	13	33	371.14	1	63	6,851.89	14
4	165.59	1	34	385.66	3	64	691.37	3
5	523.37	3	35	138.60	1	65	8,241.25	22
6	1,438.89	1	36	285.22	2	66	716.97	5
7	756.68	3	37	494.89	2	67	2,242.11	6
8	92.04	1	38	1,913.37	1	68	879.71	4
9	3,215.23	4	39	3,394.12	1	69	12,184.04	10
10	6,220.76	14	40	148.01	1	70	574.59	1
11	579.07	2	41	29,520.14	21	71	600.30	4
12	131.52	1	42	1,280.25	4	72	723.64	4
13	1,344.06	4	43	1,424.19	3	73	1,352.54	2
14	276.53	2	44	2,984.95	10	74	2,572.64	9
15	2,244.79	3	45	902.69	2	75	2,188.12	7
16	628.21	2	46	2,346.08	7	76	841.41	3
17	855.57	3	47	83.65	1	77	19,322.62	5
18	375.70	2	48	202.93	2	78	661.18	4
19	1,057.62	1	49	3,808.11	4	79	252.21	1
20	248.49	1	50	3,233.06	8	80	213.39	2
21	151.85	1	51	716.69	4	81	750.56	3
22	922.18	1	52	456.05	1	82	1,800.32	8
23	2,846.20	5	53	291.10	1	83	1,308.56	3
24	38,310.81	15	54	339.89	2	84	251.64	2
25	261.27	1	55	89.73	1	85	893.34	1
26	2,857.94	8	56	1,579.91	6	86	318.36	2
27	593.04	4	57	2,262.69	12	87	191.81	1
28	5,819.05	14	58	478.55	4	The total area of 87 kinds: 242,933.00 ha		
29	175.24	1	59	1,832.87	7			
30	163.56	1	60	167.94	2			

The most dominant and diverse one is the annual crops with 8 kinds, covering 90% of the total natural area. The type of aquatic landscape is not differentiated. There is only one kind (number 22), with an area of 922.18 ha and appearance frequency of one time. This is a valuable kind and very important in the basalt plateaus. It is the water supply and conditioner for the area, especially for annual crops and plants in residential areas.

(2) Diversity in Class of Mountain

Subclass of medium mountain: differentiated into 2 types, with 14 kinds of landscape. The type of tropical forests and shrubs, grasslands has 9 kinds with a total area of 45,445.25 ha. The landscape kind with the largest area in this landscape subclass is the evergreen closed forest landscape on Ferralic Acrisols soil (number 24), with a total area of 38,310.81 ha (Table 2). This subclass also possesses the highest frequency of appearance, with 15 times. Several other kinds have a frequency of only 1 time (number 25, 29, 30... on the map). These kinds are distributed in the western part of the study area, belonging to 5 communes, including Kon Phe, Ha Dong, Kroong, A Yun and To Tun. The type of anthropogenic vegetation on medium mountain has lower diversity, including 5 different kinds, scattered throughout the study area.

Subclass of low mountain: divided into 3 types with 19 kinds, widely distributed across the region. The type of evergreen tropical forests and shrubs, grasslands is quite diverse with 8 kinds with a total area of 33,622.26 ha. The landscape kind with the largest area in this landscape type is the evergreen closed forest landscape on Ferralic Acrisols soil (number 41), with a total area of 29,520.14 ha (Table 2), accounting for 70% of the total landscape area of landscape type.

The type of anthropogenic vegetation on low mountain has a high diversity, divided into 11 kinds with a total area of 20,018.25 ha. These kinds are scattered throughout the studied area. The landscape kind with the largest area in this landscape type is the evergreen closed forest landscape on Lithic Luvisols

soil (number 49), with a total area of 3,808.11 ha (Table 2), distributed and concentrated in Dak Smar, Kroong and Dak Roong communes.

In the subclass of low mountain, there is a type of aquatic landscape, consisting of only one kind (number 55).

(3) Diversity in Class of Valley and Hollow Between the Mountain

Subclass of valley erosion and accumulation: divided into 3 types with 19 kinds. This subclass has a high differentiation and diversity in the study area. The total area of 19 kinds is 44,299.64 ha. The type of evergreen tropical forests and shrubs, grasslands in this subclass own 7 kinds. Its total area is 14,199.79 ha, accounting for over 30% of the total area of this subclass. The kind of evergreen forests on Lithic Luvisols soil (number 65) has the frequency of 22 times with the largest area in this landscape type (8,241.25 ha) (Table 2), distributed but not concentrated in the vicinity of the Konkakinh mountain and the Konchurang Nature Reserve. The type of anthropogenic vegetation on the terrain of valley erosion and valley accumulation has a high diversity of kinds, including 11 kinds. Some kinds appear more frequently like the kind number 63 with 14 times. The aquatic landscape type has 1 kind, but with high appearance frequency (9 times). This type plays an important role in economic development of studied area, especially agricultural sector.

Subclass of terraces and plains accumulate-invasion with the aluvi-deluvi process: differentiated into 2 types with 13 kinds. This subclass has the lowest diversity of kinds in the researched area. The type of evergreen tropical forests and shrubs, grasslands in this subclass only consists of 2 kinds. The type of anthropogenic vegetation on accumulated-eroded terraces and plains is divided into 11 kinds, belonging to 3 groups: plantation forests, plants in residential areas and annual crops. Among them, the annual agricultural landscape kind on Haplic Lixisols soil (number 75) has the richest of contour number, the frequency of occurrence is 7 times with the largest area

of the type (2,188.12 ha). This landscape kind is mainly distributed in southern K'Bang district, in Dak Hlo and Dong communes.

The landscapes in the studied area have been influenced by human activities at different levels. Although there are still landscapes that keep the development under natural rule, other landscapes change dramatically, depending on direct impacts of human, (especially, the types and kinds of landscapes through the drastic transformation of the plant component-vegetation).

Class of mountain landscape has the highest diversity, with 5 types and 33 kinds (in which, subclass of medium mountain: 2 types, 14 kinds and subclass of low mountain: 3 types, 19 kinds). The diversity of landscapes in this studied area is lower than the diversity of mountains class in the area of Sathay – Ngochoi, Kontum province, where the latitude is similarities (6 types and 39 kinds) [7], and higher than mountains area in Dak Lak province (1 type and 27 kinds) [18], which located in the south of studied area. The diversity in studied area is due to two reasons: the first, is that the landscape kinds of evergreen tropical forest are well preserved in Konkakinh National Park and Konchurang Natural Reserve, the second is the diversity in agricultural landscapes, especially the landscape kinds of annual crops. This is a result of the Bana ethnic farming practices and the cultivation of the Kinh people in low areas along the large roads.

In the class of valley and hollow between the mountain, the diversity is low, especially the landscape evergreen tropical forest (only 6 kinds), but higher than the diversity of plain and valley class in the area of Sathay–Ngochoi [7]. However, the landscapes of annual crops have high diversity (15 kinds), while in this class in Sathay–Ngochoi is only 3 kinds. This shows strong human impacts on lowland landscapes, turning forest landscapes into agricultural landscapes and plantation landscapes.

3.3.2 Diversity of Landscape in Konkakinh National Park and Konchurang Nature Reserve

When comparing the two core areas of Konkakinh-Konchurang conservation area, it is noticeable that the diversity of the landscape in Konkakinh is much higher than Konchurang. Accordingly, in Konkakinh there are 35 landscape kinds distributed in 3 classes and 5 subclasses. Subclass of valley erosion and accumulation has the highest diversity, with 11 landscape kinds, the lowest is in the plain class with only 3 landscape kinds. Meanwhile, in Konchurang there are only 9 kinds of landscapes, distribute in 4 subclasses.

In terms of abundance according to the contours (frequency of occurrence), with a total of 67 contours, in which landscape number 65 has the highest frequency of occurrence (10 contours), Konkakinh National Park has much higher abundance compared to Konchurang Nature Reserve (with only 19 contours). This clearly reflects the differentiation according to the law of elevation belt of Konkakinh National Park.

Similarities have been noted between the two core areas of Konkakinh-Konchurang conservation area. Landscape No. 5 and No. 2 do not repeat in other areas. There are 8 landscapes appearing both in Konkakinh National Park and Konchurang Nature Reserve. The similarities are also expressed in the frequency of occurrence of landscape kinds. Accordingly, landscapes numbers 1, 37, 46 and 57 appear only once in each area, while landscapes No.10 and No.41 have quite a high level of abundance, ranging from 4 to 7 contours per each region (Konkakinh or Konchurang).

4. Conclusion

Konkakinh-Konchurang conservation area has a special geographical position in Vietnam and a deep differentiation of natural and anthropogenic components. In particular, the humid tropical climate is affected simultaneously by climate circulation in the Central Highlands and Central Coast on the terrain intertwined by mountains, plateaus, valleys and plains.

The differentiation of natural and anthropogenic conditions has formed the landscape of

Konkakinh-Konchurang conservation area with 1 system, 1 subsystem, 3 classes, 5 subclasses, 13 types and 87 kinds. Types of evergreen tropical forests and annual crops have a large area and a wide distribution, containing primitive or affected forest ecosystems typical for the Central Highlands of Vietnam.

The natural-anthropogenic landscapes in the studied area is quite diverse in types and kinds. Plateau subclass has the highest level of diversity with 3 types and 22 kinds; Subclass of terraces and plains accumulate-invasion with the aluvi-deluvi process has the lowest level of diversity with only 2 types and 13 kinds. The diversity of landscape in Konkakinh National Park is much higher than Konchurang Nature Reserve: There are 35 types of landscapes distribute in 3 layers and 5 subclasses in Konkakinh while in Konchurang there are only 9 landscape kinds distribute in 4 subclasses.

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