

MAPPING MULTI-SCALED LANDSCAPE TYPOLOGY OF LANG SON PROVINCE

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Abstract. The landscape of a territory is generated by natural components, and it is also influenced by human activities. The complexity of factors making up landscape and the relationship between them with humans has created a diverse and complex differentiation of landscape in Lang Son province. Three factors reflecting typical characteristics of Lang Son landscape: Digital Elevation Model (DEM), soil, and land cover have been selected in this study. The concept of multi-scaled landscape classification based on the European Landscape Convention (ELC) is applied for combining the holistic with parametric approaches and combining typological with multi-scaled landscape classifications. A number of possible combinations between 9 land cover variables, 9 soil combination variables, and 5 topographic variables have yielded 40 landscape units for Lang Son province. The obtained results are basic documents for contributing to modern and practical landscape research on the one hand, and to territory planning for sustainable development of Lang Son on the other hand.

Keywords: multi-scale, typology, holistic, parametric, landscape.

1. Introduction

Historically, there are many different concepts of landscape and many different directions of landscape research in the world [1, 2], of which the most dominant are two traditional branches between Russian - Eastern European researchers, and Western European - North American ones [3]. The development of diverse international conventions on landscapes has led to the formation of more and more landscape classification systems in different countries. In Vietnam, some classification systems of Russia and Eastern Europe have been systematically deceived by geographers and widely applied in landscape study [4]. However, the author chooses a new approach of Western Europe to apply to Lang Son province, where there has not been any in-depth study on the landscape in this direction.

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Lang Son has a tropical monsoon climate with the longest and coldest winter in the country. The average temperature ranges from 17 to 22 °C, the average annual rainfall ranges from 1200 to 1600 mm. The average humidity in the year is 80 - 85%, lower than many different regions in the country. The average altitude is about 252 m, but low mountains are dominant, with few medium mountains and without high mountains. Due to the development of the karst, the network of rivers and streams is sparse. Ky Cung river is the largest river flowing through the province and it is unique in the country that flows upstream to the North for passing China's territory prior to discharge into the sea. Organisms are mainly arid subtropical species, while typical species of the tropics are only distributed in lowland areas, etc. The landscape of the study area is composed of natural components and is robustly influenced by humans. These factors have created the diversity and complexity of the landscape of Lang Son province. Up to now, there has been no in-depth study on the landscape and landscape differentiation of the entire Lang Son province according to the Western European approach.

In this study, the author has selected three main factors for analysis: digital elevation model (DEM), soil, and land cover because they reflect typical properties of the regional landscape. Lang Son is a mountainous province, with very clear differentiation in altitude. Soil and land cover represent local climate characteristics as well as the interrelationships between natural components [5, 6].

Specifically, the topographic elevation of the lowest location is 80m (Ky Cung river valley) to the highest location is 1541m (Mau Son mountain peak). Soil has 9 main types: red-yellow soil on acidic igneous rocks, red-brown soil on basic and intermediate igneous rocks, red-yellow soil from wet rice cultivation, yellow-brown soil on ancient alluvium, pale yellow soil on sandstone, red-yellow soil on clay and metamorphic rocks, red-brown soil on limestone, jagged soil. The land cover has 9 main types: evergreen forest, secondary forest, mixed forest, shrub and secondary grassland, rocky mountains and bare soil, plantation forest, perennial biome, annual tree biome, water surface.

The objective of this study is to map a multi-scaled landscape differentiation from the 3 factors that form the landscape of Lang Son province using the selected approaches as mentioned above. The study contributes to synthesizing a theoretical basis and enriching landscape study methods according to a new Western European approach for the provincial scope [7, 8]. Otherwise, the obtained results clearly show the characteristics as well as the landscape differentiation of Lang Son province, so they can be used for many different purposes, helping researchers and managers to have more reliable scientific foundations when conducting different aspects in Lang Son province.

2. Content

2.1. Research methods and materials

2.1.1. Research methods

There exist two approaches to classifying landscapes, namely: the holistic approach and the parametric approach. The choice between the two approaches in classification system construction depends mainly on the nature of the datasets used. Veerle Van Eetvelde (2009) states as follows:

* *The holistic method*

Introduced by Troll to landscape studies in 1939, the holistic approach flourished with the use of aerial photography for providing a synoptic and detailed view of the landscape. The process is very similar to analog photo interpretation and relies on the Gestalt abilities of our perception in interpreting complex patterns. The holistic approach begins with building a spatial framework that becomes gradually filled when more detailed information is available. A holistic approach is indicated for landscapes with clear spatial linkages between components (such as land use, soil conditions, geomorphology) and complex patterns (such as field systems), that is revealed on the image or maps. This approach allows building an open framework to be consecutively completed [9, 10].

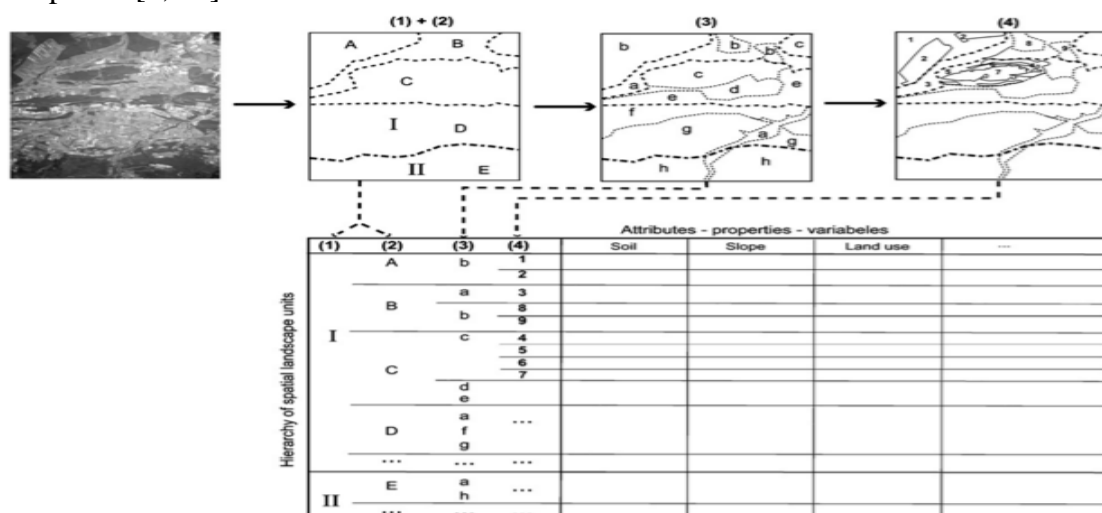


Figure 1. Spatial hierarchy of landscape units according to the holistic method [9]

* *Parametric method*

The parametric approach starts from superimposing a set of thematic maps, forming a composite map where the polygons define landscape units and the combined themes describe landscape types. This approach became popular when GIS and digital maps are available. This approach is efficient when high-quality digital maps are abundant. This is a semi-automatic technique in GIS, where the result notably depends on the map properties, such as legend, scale, quality, etc. Another specific problem is dealing with the sliver polygons that are obtained from overlaying data layers. In general, digital maps with adequate detail are available just for elevation and land cover. Therefore, other important properties can be omitted from the landscape classification. The use of a large number of themes makes statistical data analysis and clustering necessary [11].

The European Landscape Convention (ELC) represents revolutionary thinking regarding the development of landscape science, with particular emphasis on the meaning of the term "cultural landscape" [12]. The concept of multi-scaled classification based on the European Landscape Convention (ELC) is applied in the study. The landscape of Lang Son territory is a combination between typological classification and multi-scaled landscape [13]. With the provincial level and the

relatively small area, we chose a uniform research scale for all data layers according to the pyramid model [14].

- Multi-scaled landscape map scale: the study area is covered the entire Lang Son province, so with this scope I choose the map scale of 1:100,000.

- Multi-scaled landscape form: establishing the landscape map of Lang Son province consists of 2 levels and goes through the following steps:

- + Step 1: prepare data layers in vector structure such as DEM, soil, and land cover.

- + Step 2: landscape at first level: convert DEM, soil, land cover to raster structure for establishing landscape map with a cell size dimension of 1x1 (km).

- + Step 3: landscape at second level: analyzing and processing the first level landscape to form the map at the second level landscape with characteristic and independent landscape units unduplicated.

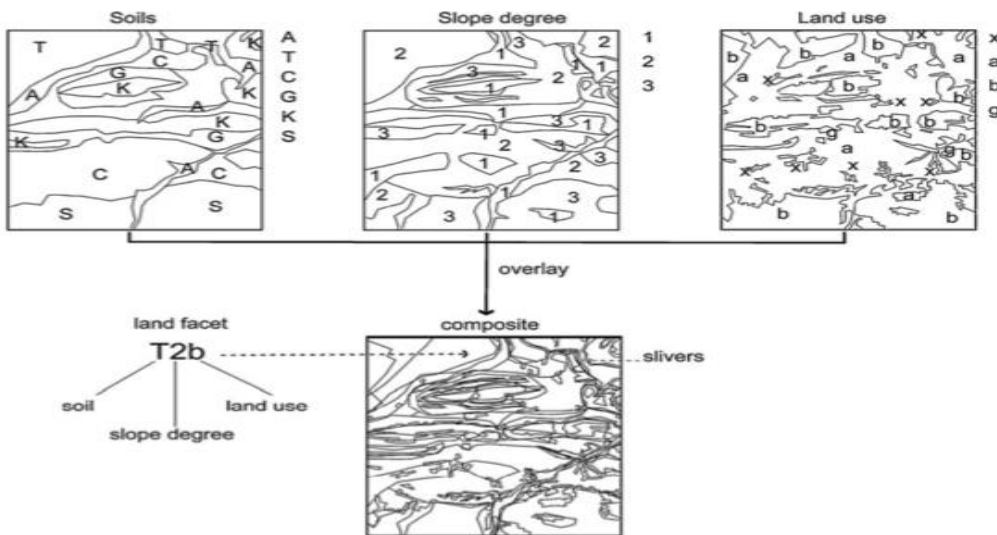


Figure 2. Parametric method of overlaying component data [9]

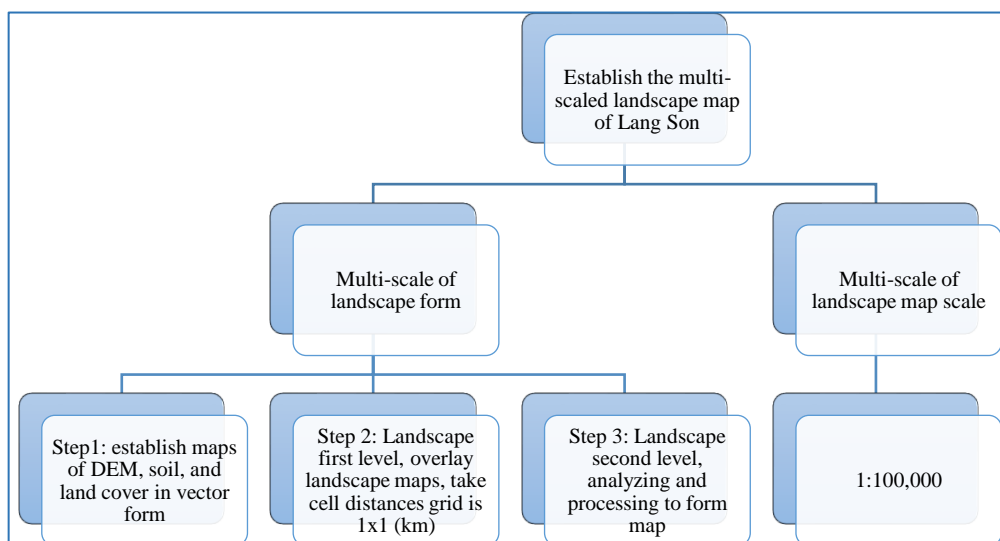


Figure 3. The process of making a landscape map of Lang Son province

2.1.2. Time and research materials

- Time range: a set of data layers was collected from 2010 to 2020.
- Research materials: for mapping landscape, the number of input factors can be changed depending on the research purpose. Three factors are used to distinguish landscape units by the bottom-up approach and the boundaries of landscape units are determined according to the principle of analysis in GIS. Several specialized software in the field of mapping, remote sensing, and GIS are exploited for handling with thematic maps, digital databases, landscape analysis such as ArcGIS, Mapinfo, Microstation, SPSS, etc. The observations from the fieldwork investigation are used to validate the characteristics and the differentiation of elements that make up the landscape of Lang Son province.

2.2. Results and discussion

2.2.1. Multi-scaled landscape map of Lang Son province

For generalization, a grid was applied with the cell size of 1km x 1km. A total of 8719 cells has been formed for Lang Son province. The combining between 9 variables of land cover, 9 variables of soil, and 5 variables of elevation yields 40 possible landscape units. Landscape typologies are assigned to each cell and the map represents landscape units based on the most essential and characteristic features. This is the first level of landscape map for Lang Son province.

Based on the first level landscape map, some landscape units are grouped to generate a second level landscape map to reflect the differentiation of the local landscape more accurately. The grouping of landscape units is based mainly on the properties of the landscape types, except the area and spatial location of adjacent landscape units.

Table 1. Area of landscape units in Lang Son province (ha)

Landscape units	Area	Landscape units	Area
1) Landscape of high hill on red and yellow soil planted forest	43030.1	21) Landscape of low hill on light yellow land of planted forest	28477.6
2) Landscape of high hill on sloping land with planted forests	5801.8	22) Landscape of Thuong river valley with alluvial soil and annual trees	45902.3
3) Landscape of low hill on red and yellow soil planted forest	4520.8	23) Landscape of high hill on red and yellow soil with perennial trees	12389.6
4) Landscape of high hill on red and yellow soil with perennial trees	11087.4	24) Landscape of low hill on ancient alluvial soil	10840
5) Landscape of high hill on red and yellow bare land	23916.4	25) Landscape of low hill on red-brown soil and evergreen forest	19213.1
6) Landscape of high hill on red and yellow soil with shrubs	11174.3	26) Landscape of high hill on pale yellow land with perennial plants	4415.6

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7) Landscape of low mountain on red soil and evergreen forest	73021.8	27) Landscape of low mountain and hill on red-brown soil fruit trees	22542.9
8) Landscape of high hill on red and yellow soil, evergreen forest	11950.7	28) Landscape of low mountain interspersed with Bac Son limestone basin	67429.6
9) Landscape of high hill on red and yellow soil, evergreen forest	18271.5	29) Landscape of low mountain on red yellow land and evergreen forest	35013.5
10) Landscape of high hill on red and yellow soil annual trees	5157.1	30) Landscape of high hill on red and yellow soil with perennial trees	4145.1
11) Landscape of low mountain on red yellow land with perennial plants	39438.3	31) Landscape of low hill on the yellow-brown land of planted forest	5861.1
12) Landscape of low mountain on red and yellow soil planted forest	10084.7	32) Landscape of low mountain on scrubland limestone	6642.8
13) Landscape of low mountain on red soil and evergreen forest	22186.5	33) Landscape of high hill on red and yellow soil with perennial trees	20496.2
14) Landscape of low hill on red yellow land with perennial trees	16074.2	34) Landscape of low mountains and hills on red and yellow soil with perennials	23520.2
15) Landscape of low mountain on pale yellow land of planted forest	19931.7	35) Landscape of low mountain on red soil and evergreen forest	43261
16) Landscape of low mountain on pale yellow land and evergreen forest	19278.8	36) Landscape of low mountain on red soil and evergreen forest	4685.1
17) Landscape of low hill on red and yellow soil planted forest	36322.9	37) Landscape of low mountain bare land on red and yellow soil	23464.3
18) Landscape of hills and low mountains on the red and yellow soil of planted forests	19713.6	38) Landscape of high hills and bare land on pale yellow land	6903.7
19) Landscape of low hill and urban settlement basin	5343.1	39) Landscape of Mau Son mountain on red humus soil and evergreen forest	11938.7
20) Landscape of Ky Cung river valley with alluvial soil and annual trees	19603.1	40) Landscape of high hill on red-yellow soil mixed forest	19024.4
Total	832.075,82 (ha)		

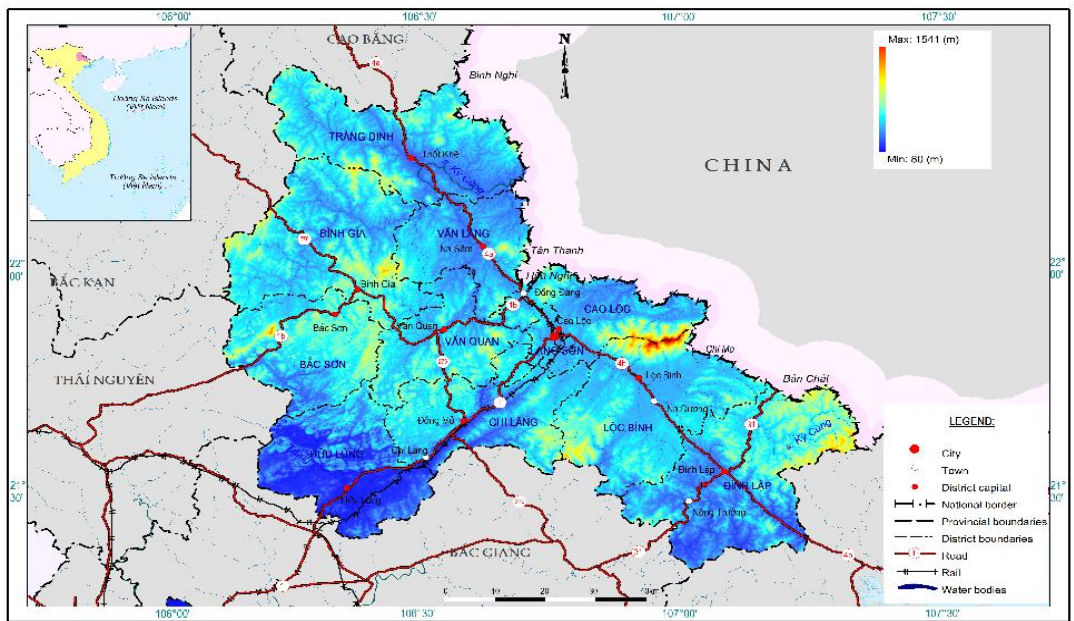


Figure 4. DEM map of Lang Son province
Data source: Aster GDEM (JAXA)

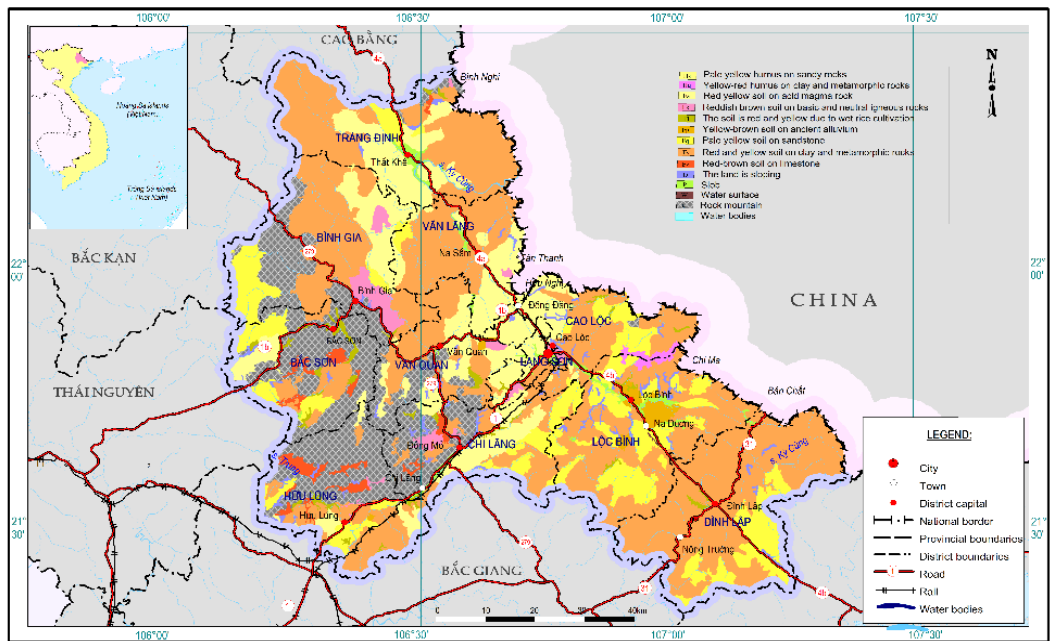


Figure 5. Soil map of Lang Son province
Data source: Institute of Agricultural Planning and Design

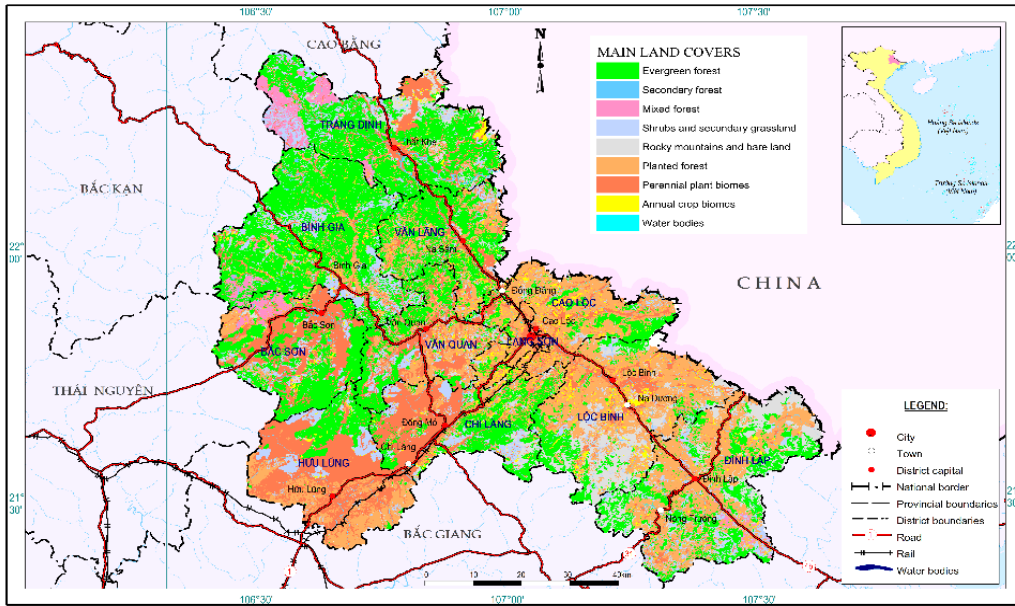


Figure 6. Land cover map of Lang Son province

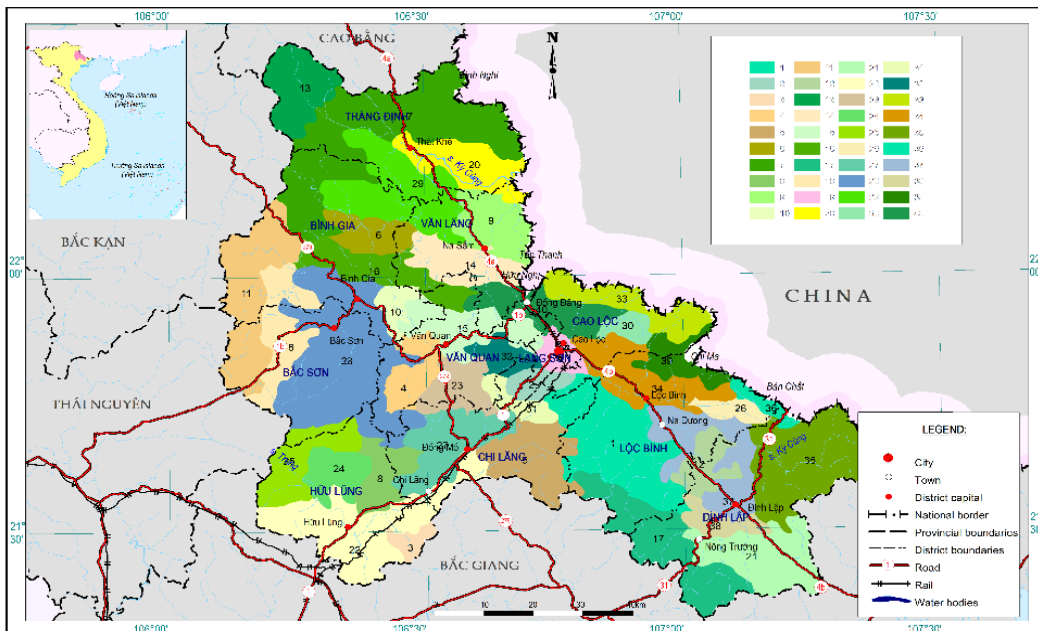


Figure 7. Landscape map of Lang Son province
(Scale 1:550.000 - Establisher: Bui Thi Thanh Dung)



The landscape of low mountain on red soil and evergreen forest (7)



The landscape of low mountain on red yellow land with perennial plants (11)



The landscape of low hill on red-brown soil and evergreen forest (Huu Lien protected area) (25)



The landscape of low mountain and hill on red-brown soil fruit trees (27)



The landscape of low mountain interspersed with Bac Son limestone basin (28)



The landscape of Mau Son mountain on red humus soil and evergreen forest (39)






Figure 8. Field investigation of some landscape units in Lang Son province






Validation: After establishing the landscape map of Lang Son province according to the European Landscape Convention approach, the satellite images together with field investigation are associated with landscape units for validation purposes (Figure 8). Through analysis and comparison, it shows a high concordance between the landscape units with reality. The results of the study prove its practical value [15].






2.2.2. Discussion

The combination of three factors: DEM, soil, and land cover determined 40 landscape units, but only 15 main representative landscape units are introduced in this section because they are the largest landscape units and they represent the most distinctive features for the mountainous landscape of Lang Son province.

Table 2. Description of some typical landscape units in Lang Son province

No.	Location of landscape units	Description
1		<p><i>The landscape of low hills on red and yellow soil and planted forests (unit 3)</i></p> <p>It has an area of 4520.8 ha. Located in the low hills in the south of Lang Son province in the territory of Huu Lung district, the climate is hotter than other areas, mainly red-yellow soil on clay and metamorphic rocks. This area has developed plantations and perennial industrial plants, now many macadamia trees are planted.</p>
2		<p><i>Low mountain landscape on red and yellow soil, evergreen forest (unit 7)</i></p> <p>Has an area of 73021.8 ha. Located in the low mountains in the north of Lang Son province in the territory of 2 districts of Trang Dinh and Binh Gia, the climate is not hot, mainly red-yellow soil on clay and metamorphic rocks, acid magma. This area has the largest area of evergreen forest in the province.</p>
3		<p><i>Low mountain landscape on red-yellow soil with perennial plants (unit 11)</i></p> <p>Has an area of 39438.3 ha. Located in the western low mountains of Lang Son province in the territory of 2 districts of Binh Gia and Bac Son, the climate is not hot, mainly red-yellow soil on acidic magma. This area plants perennials (anise).</p>
4		<p><i>Low hill landscape on red and yellow soil planted forest (unit 17)</i></p> <p>It has an area of 36322.9 ha. Located in the low hills in the south of Lang Son province in Dinh Lap district, the climate is not hot, mainly red and yellow soil on clay and metamorphic rocks. This area develops plantation forests.</p>
5		<p><i>The landscape of low hills and urban settlement basins (unit 19)</i></p> <p>It has an area of 5343.1 ha. Located in the low hills and basins in the territory of Ho Chi Minh City. Lang Son is the center of politics - economy - society of Lang Son province, the climate is not hot, mainly soil. This area is mainly urban landscape and residential area.</p>

6		<p><i>The landscape of Ky river valley with alluvial soil and annual plants (unit 20)</i></p> <p>Covering an area of 19603.1 ha. Located in the Ky Cung river valley in the north of Lang Son province in Trang Dinh district, the climate is not hot, mainly alluvial soil. This area grows annual crops and grows wet rice, which is the largest field in Lang Son province.</p>
7		<p><i>The landscape of the Thuong river valley, alluvial soil, annual plants (unit 22)</i></p> <p>It has an area of 45902.3 ha. Located in the valley of the Thuong River valley with the lowest terrain in the south of Lang Son province in the territory of Huu Lung district, the climate is hotter than other areas, similar to the climate regime with some other provinces. by the Red River (Bac Giang, Bac Ninh), mainly alluvial soil and yellow-brown soil on ancient alluvium. This area grows mainly annually.</p>
8		<p><i>The landscape of low hills on red-brown soil and evergreen forest (with Huu Lien conservation area) (unit 25)</i></p> <p>Covering an area of 19213.1 ha. Located in the low hills southwest of Lang Son province in Huu Lung district, the climate is hotter than other areas, mainly red-brown soil on limestone. This area develops evergreen forest and is the province's only national nature reserve.</p>
9		<p><i>The landscape of low mountains and hills on red-brown soil with fruit trees (unit 27)</i></p> <p>It has an area of 22542.9 ha. Located in the low mountains and hills south of Lang Son province in Chi Lang district, the climate is hotter than other areas, mainly rocky mountains and red-brown soil on limestone. This area is the largest growing area in the province and the largest in the North of Vietnam.</p>
10		<p><i>Low mountain landscape interspersed with Bac Son limestone basin (unit 28)</i></p> <p>Covering an area of 67429.6 ha. Located in the western low mountains of Lang Son province in Bac Son district, the climate is not hot, mainly rocky mountains and red-brown soil on limestone, red-yellow soil due to wet rice cultivation in the basin. This area develops plantations in the mountains and annual crops (rice) in the basin. There is a very special and outstanding tropical karst landscape here.</p>

11		<p><i>Low mountain landscape on red yellow land evergreen forest (unit 29)</i></p> <p>Covering an area of 35013.5 ha. Located in the low mountains in the north of Lang Son province, bordering 3 districts of Trang Dinh - Binh Gia - Van Lang, the climate is not hot, mainly red-yellow soil on acidic magma. This area develops evergreen forest.</p>
12		<p><i>The landscape of low mountains and hills on red and yellow soil perennial plants (unit 34)</i></p> <p>It has an area of 23520.2 ha. Located in the low mountains and hills east of Lang Son province in the territory of 2 districts of Cao Loc and Loc Binh, the climate has a relatively low temperature, mainly red-yellow soil on acid magma, pale yellow soil on the sandy rock. This area grows perennials (anise, cinnamon, peach).</p>
13		<p><i>Low mountain landscape on red soil and evergreen forest (unit 35)</i></p> <p>It has an area of 43261 ha. Located in the low mountains in the southeast of Lang Son province in the territory of Dinh Lap district, the climate is not hot, mainly red-yellow soil on clay and metamorphic rocks. This area develops evergreen forest. There is Bat Xa border commune where the headwater of Ky Cung river is located and is famous for being the land of thousands of laurels.</p>
14		<p><i>The landscape of Mau Son mountain on red-yellow humus soil and evergreen forest (unit 39)</i></p> <p>Covering an area of 11938.7 ha. Located in the highest mountainous area of Lang Son province in the east in the territory of 2 districts of Loc Binh and Cao Loc, Mau Son peak is the "roof of Lang land" with an altitude of 1541 m, has the coldest climate in the province, mainly red-yellow humus on clay and metamorphic rocks of subcontinental origin. This area develops evergreen forests with subtropical and temperate species predominating.</p>
15		<p><i>High hill landscape on red-yellow soil mixed forest (unit 40)</i></p> <p>Covering an area of 19024.4 ha. Located in the eastern high hills of Lang Son province in the territory of 2 districts of Van Lang and Cao Loc, the climate is not hot, mainly red-yellow soil on acid magma. This area develops mixed forests with tropical and subtropical species composition.</p>

3. Conclusions

According to this research method that allows multi-scale analysis of landscape types in many aspects, the main input components for creating flexible and non-rigid maps, 3 main component maps are selected as DEM, soil, and land cover to create landscape maps in detail, accurately and in line with landscape research trends. As a result, Lang Son territory has 40 unique landscape units that do not overlap. This creates the basis for modern and highly practical landscape research, contributing to the current trend of landscape research in the world. At the same time, this study also allows the application of many different purposes, helping the locality in the orientation and planning of territorial development.

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