APPLICATION GIS IDENTIFY LAND AREA SUITABLE FOR RUBBER AND COFFEE TREES TO AGRICULTURE RESTRUCTURE GIA LAI PROVINCE

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ABSTRACT

Gia Lai has great potential for developing agricultural production, and it is home to a large crop industrial material area in Vietnam. It boasts nearly 100,000 hectares of coffee and nearly 90,000 hectares of rubber. The area has immense potential to develop its agricultural production due to its unique characteristics of soil and climate, which can support a rich diversity of plants and animal with high economic value. By creating areas for intensive agricultural production and concentrating on commodity products with a competitive advantage, Gia Lai can improve the efficiency of its agricultural restructuring. To achieve this goal, this research has utilized the Land Evaluation Method of the FAO method and GIS to identify suitable land areas for rubber and coffee trees to restructure agriculture in Gia Lai province. the results indicate that the land suitability for coffee trees is mainly moderately suitable (S2) with 86,163 hectares of land suitable for cultivation. Coffee trees are primarily grown in districts such as Chu Pah, Dak Doa, Chu Se and Ia Grai. On the other hand, the land suitability for rubber trees is mainly moderately suitable (S2) with 60,000 hectares of land suitable for cultivation. Rubber trees are primarily grown in districts such as Chu Pah, Dak Doa, Chu Se, Ia Grai and Chu Prong. These areas are characterized by the distribution of red basaltic soils, rainfall exceeding 2500 mm, and a favorable climate for the development of industrial plants.

Keywords: Coffee trees, Rubber trees, GIS, land suitability, Gia Lai province.

1. INTRODUCTION

Gia Lai is 15,000 km^2 in area of which over 1.4 million ha is agricultural land with favorable conditions for the development of industrial crops [1]. Rubber and coffee are one of the major crops of Gia Lai province [1]. It also helps to create jobs and contributes to poverty reduction for people in the area. Gia Lai province has over 100,000 hectares of rubber, with an output of 93,500 tons of dried latex per year; about 80,000 hectares of coffee, with an output of nearly 200,000 tons of green coffee per year.

Land suitability is the suitability of land type for a particular land use [2], as is the suitability of a particular crop for the production of a particular crop. Land suitability evaluation of FAO (LE) is used worldwide as the scientific basis for effective land use, supporting local and regional land use planning and country [3]. While agroecological zoning and land suitability assessment are extensively used in different countries and for different crop species [4] such as:

Methodological approaches to identify and map marginal land suitable for industrial crops in Europe [5], GIS-based assessment of land suitability for industrial crops (cotton, sesame and groundnut) in the Abyan Delta, Yemen [6]. in Vietnam, there are many studies to evaluate the suitability of land for industrial crops such as tea in Son La province [7]; perennial industrial plants in Kon Tum province [8]; Land suitability evaluation for sustainable development planning major perennial industrial crops in the Central Highlands [9]etc.

Coffee and rubber plantations have become fast growing, planted not according to planning, planted on small and unsuitable land areas. Specifically, from 2008 to 2011, Gia Lai province had the third largest area and output of coffee trees in the country, most of the perennial coffee was grown from 1995 to 1999 [1].

The province has approved 44 projects for 16

rubber growing enterprises with a total area of more than 32,000 ha but has more than 12,000 ha dead and underdeveloped [10]. Cultivating crops on land that is not suitable leads to less yield, high price, more old low productivity, high costs, rapid aging, many pests and diseases, low economic efficiency, especially in the current period when rubber prices and prices are low, so many areas have been cut down to replace with other more effective crops. In order to restructure the agriculture economy, including transforming areas of coffee and rubber trees with low efficiency, the agricultural economy, including converting the area of rubber and coffee plantations with low economic efficiency, keeping only a moderate size in appropriate places, research. This study was carried out to identify suitable planting areas for coffee and rubber trees and provide a scientific basis to help policy makers give planning and development orientations for these trees.

2. RESEARCH METHODOLOGY

2.1. Data Collection Methods

Collect secondary data of information: annual reports, relevant research results, maps.

2.2. Statistical analysis

Collected data will be aggregated and processed on Excel software presented in tables, charts and graphs.

2.3. Professional Solution

The study used this method to consult experts on rubber, coffee and soil crops in the area. Experts may be supported to select soil properties that will be made in accordance with ecological requirements of rubber and coffee trees.

Table 1. Land use requirement of Rubber tree in Gia Lai

	S1	S2	S3	N
Soil type	Fe, Fk, Fs, Fa, Fq, Fp		Hk, Hs, Ha; Rk, Ru	E; A;Pbc, Pc;X, Xa,D
Slope	< 3°	3 - 8°	8 - 15°	-
Soil depth	> 100 cm	50 – 100 cm	< 50 cm	30 – 50
Irrigation	Active irrigation	Semi-active irrigation	Lack of irrigation	Without irrigation
Drainage capability	Good	Medium	Poor	Very poor
Annual rainfall	> 2,500 mm	1,500 – 2,500 mm	<1,500 mm	500 – 1,500 mm

Table 2. Land use requirement of Coffee tree in Gia Lai

	S1	S2	S3	N
Soil type	Fe, Fk, Fs, Fa, Fq, Fp		Hk, Hs, Ha; Rk, Ru; A; X, Xa	E
Slope	< 3°	3 - 8°	8 - 15°	>15°
Soil depth	> 100 cm	50 – 100 cm	< 50 cm	30 – 50
Irrigation	Active irrigation	Semi-active irrigation	Lack of irrigation	Without irrigation
Drainage capability	Good	Medium	Poor	Very poor
Annual rainfall	> 2,500 mm	1,500 – 2,500 mm	<1,500 mm	500 – 1,500 mm

2.4. The FAO guidelines for land evaluation

This study using processing land evaluation of FAO (1976), including: Description of land mapping units and land qualities; choice land utilization types (LUTs) on each suitable land mapping unit, Land suitability classification. This method uses a comparison and contrast between the land utilization types LUTs land

use requirements and land map units (LMUs), and then uses the method maximum limitation to evaluate the impact on the land use (LUT) to classify land suitability.

2.5. Land mapping unit

Based on collected data thematic maps were built including: soil map, slope map, rainfall map, depth soil map, irrigation capacity map with the guidance of the FAO soil classification system (FAO, 2006a). During the editing map process, the construction will handle geometry errors, convert the format... to shape files for use on ArcGIS 10.4 software. From single maps, this research use Intersect to create a land mapping unit of the study area.

2.6. Establishing and zoning suitable land maps

After developing land mapping units, combined with ecological requirements of each crop according to the appropriate assessment criteria of FAO (1976) will be developed a suitable map. On that basis, it will be combined with a map of the current status of rubber and coffee crops to provide appropriate planting zoning for these two crops.

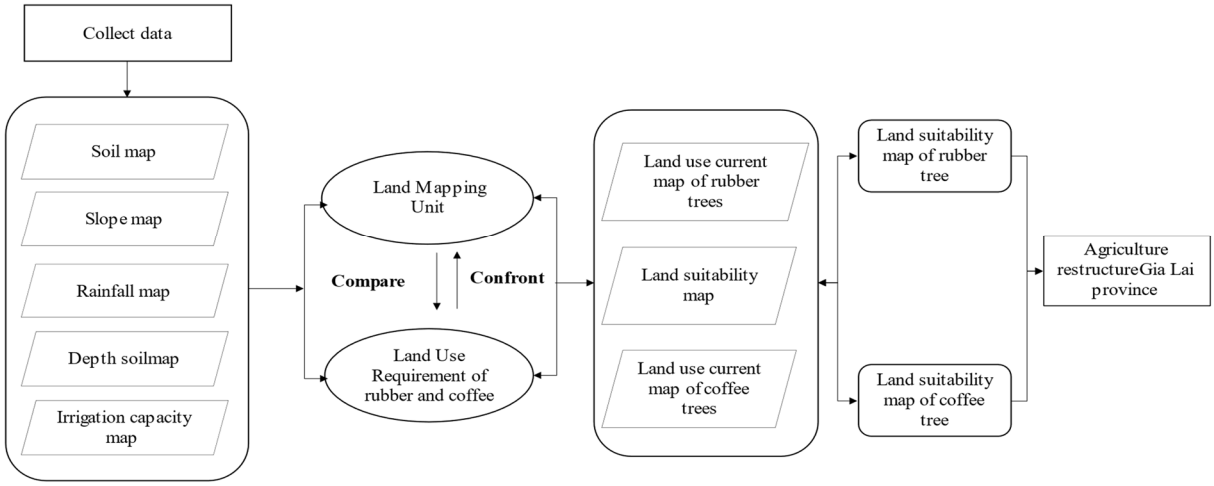

Figure 1. Concept of method

3. RESULTS AND DISCUSSION

3.1. Build a land mapping unit

The land unit map of Gia Lai province is the result of overlaying the single maps, including: Soil map, irrigation capacity map, rainfall map, depth soil map, slope map. The total number of land mapping units (LMUs) is 356 with a natural area of 15,057,245 hectares. This shows that the land characteristics of the area are less homogeneous and complex in which: the smallest LMU has an area of 0.15 ha, the largest LMU has an area of 257,233 ha.

3.2. Building a suitability map for plant

3.2.1. Rubber tree

Rubber tree planting area is suitable to the natural conditions of the area which occupies a small area. According to the results of the research, rubber trees also show that the moderately suitable area (S2) accounts for 28.20%, the marginally suitable area (S3) accounts for 7.20%, the rest is unsuitable (N) 64.59%. The unsuitable area accounts for a large proportion, because rubber trees are only suitable for planting on 3 types of soil: red basalt soil, Gray Podzolic soil on ancient alluvium, average temperature 22 - 30^{o}C when low temperature affects the latex extraction process.

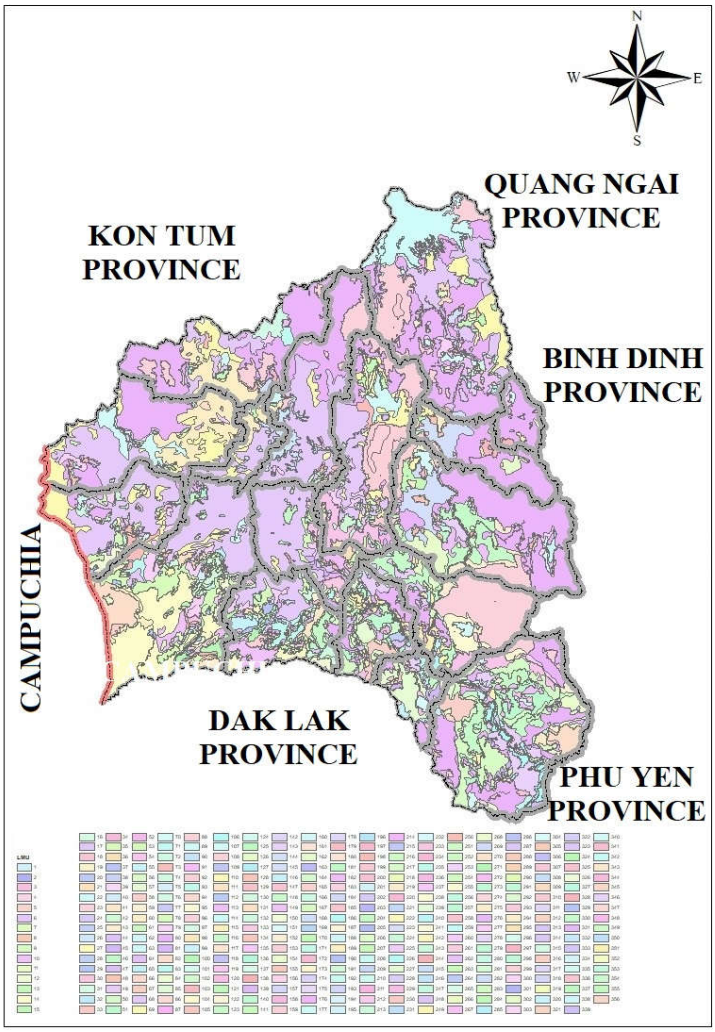

Figure 2. The land unit map of Gia Lai province

Table 3. Land suitability classification natural of rubber tree in Gia Lai province

Land suitability classification	Area (ha)	Percentage	The main distribution area
Unsuitable (N)	9,726,000	64.59	An Khe, Ayun Pa, Krong Cho, Krong Pa, Ia Pa, Phu Thien
Marginally suitable (S3)	1,084,807	7.20	Krong Pa, Chu Se, Phu Thien, Ayuan Pa, Ia Grai, K'Bang
Moderately suitable (S2)	4,246,438	28.20	Duc Co, Chu Se, Chu Prong, Mang Yang
Total	**15,057,245**	**100**	

3.2.2. Coffee tree

The results of this research showed that this tree was planted mainly in districts such as: Ia Grai, Chu Prong, Chu Pah, Dak Doa, Chu Se, Mang Yang with the moderately suitable area (S2) accounted for 28.2%; the marginally suitable area (S3) accounts accounts for 14.01%, unsuitable area (N) accounts for 57.78% due to limitations in soil types such as sloped black soil, soil Inert in extinct erosion area; limitations on irrigation capacity, slope, adverse weather effects of each area.

Table 4. Land suitability classification natural of coffee tree in Gia Lai province

Land suitability classification	Area (ha)	Percentage	The main distribution area
Unsuitable (N)	8.700.599	57.78	Duc Co, Dak Doa, An Khe, Ayun Pa, Chu Prong, Chu Se, Ia Pa, Krong Pa.
Marginally suitable (S3)	2.110.208	14.01	Duc Co, Dak Doa, Chu Se, Phu Thien, Ia Grai, Dak Po, Ia Grai, K'Bang.
Moderately suitable (S2)	4.246.438	28.20	Ia Grai, Chu Prong, Chu Se, Mang Yang, Dak Doa.
Total	**15.057.245**	**100**	

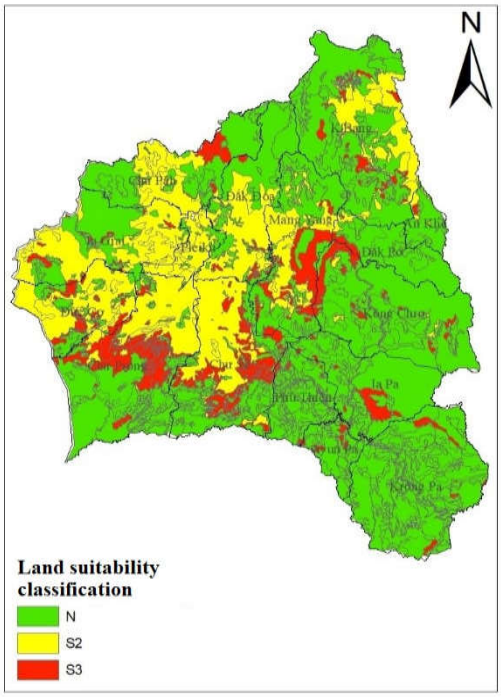

Figure 3. Land suitability natural map of rubber tree in Gia Lai province

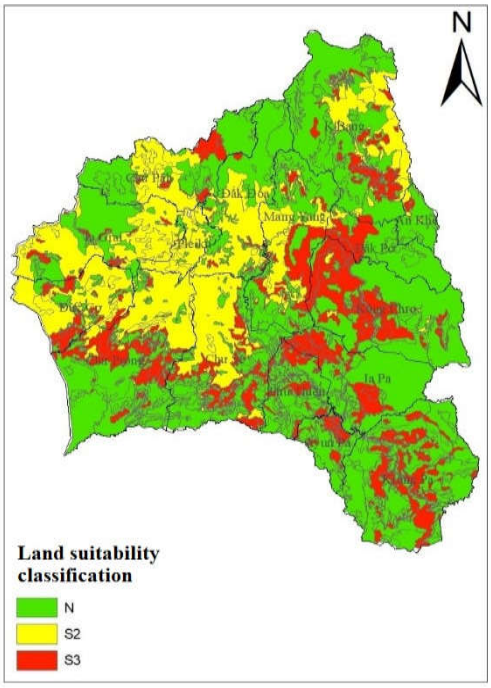

Figure 4. Land suitability natural map of coffee tree in Gia Lai province

3.4. Proposing suitable planting areas for rubber and coffee trees to serve agricultural economic restructuring in Gia Lai province

Gia Lai province have been facing challenge of the strong development of coffee and rubber trees, including the rapidly increasing area of aging rubber and coffee trees, reclamation of the planted land, use of chemical fertilizers has caused soil degradation, scarcity of irrigation water in the context of climate change, many areas have developed unsuitable areas for these two crops, so the efficiency is not high. On that basis, this study uses a map of the current status of rubber and coffee trees overlaying with a map of the natural suitability of these two crops and combined with the provincial agricultural restructuring orientation to bring suitable planting areas for coffee and rubber trees.

3.4.1. Rubber tree

Rubber tree planting in Gia Lai are identified as multi-purpose trees and have high economic value, sedentary cultivation for ethnic minorities, greening bare land and bare hills and associated with national security protection (Nguyen Hu Can, 2010). According to the report of Gia Lai Department of Agriculture and Rural Development as of 2019, rubber has over 96,000 hectares of which nearly 75% of the area

is business rubber, 15.4% of the smallholder rubber area. Rubber is planted in 11/17 districts, towns and cities, of which mainly Duc Co, Chu Prong, Ia Grai.

After overlaying the current map of rubber trees in Gia Lai province in 2020 with the map of natural suitability of rubber trees, the result of research shows that the suitable planting area for rubber trees is 60,000 ha, mainly moderately suitable (S2). This result is completely consistent with the province's orientation to restructuring the agricultural sector until 2040 (Table 5).

3.4.2. Coffee tree

Coffee is one of the main crops in Gia Lai province. In 2020, the province has over 97,000 hectares of coffee; the area in the business stage is about 83,148 ha, the rest is in the stage of basic construction and re-cultivation (Gia Lai, 2020). The results overlap with the current status of coffee trees, showing that the suitable area for coffee trees is 86,163 ha, mainly moderately suitable (S2), this area is consistent with the orientation of restructuring the agricultural sector of the province to 2040 (Table 4).

Table 5. Compare and propose rubber and coffee plantations in Gia Lai province

(Unit: hectares)

	Year 2020	Year 2030	Year 2040
Rubber plantation area (orientation to restructure the agricultural sector) (Area)	87,000	60,000	57,000
Recommendations for rubber plantation area		60,000	60,000
Coffee plantation area (orientation to restructure the agricultural sector) (Area)	97,000	94,000	91,000
Recommendations for Coffee plantation area		**86,164**	**86,164**

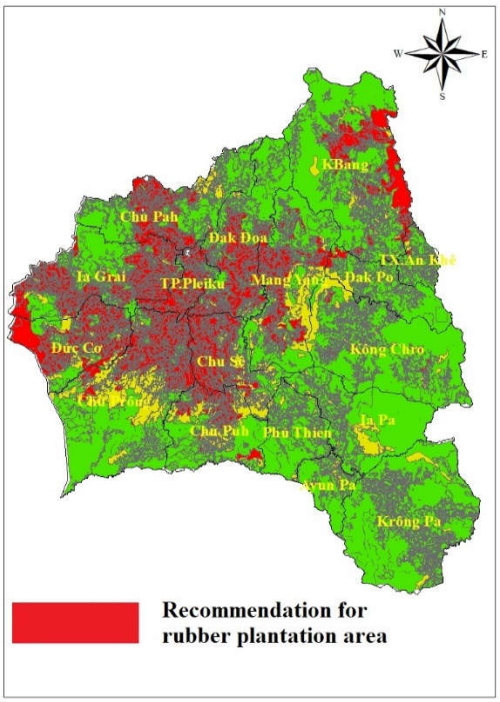

Figure 5. Recommendations for rubber plantation area in Gia Lai province

Figure 6. Recommendations for coffee plantation area in Gia Lai province

4. CONCLUSION

The study has built a suitable map for coffee and rubber trees in Gia Lai province based on building a map of land units and comparing and comparing with the land use requirements of each of these trees. On that basis, combined with the current map of rubber and coffee crops to give appropriate zoning results for restructuring the agricultural sector in Gia Lai province.

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ỨNG DỤNG GIS XÁC ĐỊNH VÙNG ĐẤT THÍCH HỢP TRỒNG CÂY CAO SU, CÂY CÀ PHÊ PHỤC VỤ CƠ CẤU LẠI KINH TẾ NÔNG NGHIỆP TỈNH GIA LAI

Nguyễn Thị Bích, Hoàng Xuân Phương

Trường Đại học Lâm nghiệp

TÓM TẮT

Gia Lai có nhiều tiềm năng phát triển sản xuất nông nghiệp, là nơi có vùng nguyên liệu cây công nghiệp lớn của Việt Nam. Nơi đây có gần 100.000 ha cà phê và gần 90.000 ha cao su. Khu vực này có tiềm năng to lớn để phát triển sản xuất nông nghiệp do có đặc điểm độc đáo về thổ nhưỡng và khí hậu, điều kiện thuận lợi nhiều loại cây trồng và vật nuôi có giá trị kinh tế cao. Tạo vùng sản xuất nông nghiệp chuyên canh, tập trung sản phẩm hàng hóa có lợi thế cạnh tranh sẽ nâng cao hiệu quả tái cơ cấu ngành nông nghiệp của Gia Lai. Để đạt được mục tiêu trên, nghiên cứu này đã sử dụng phương pháp Đánh giá đất đai theo phương pháp của FAO và ứng dụng GIS để xác định diện tích đất thích hợp cho cây cao su và cà phê nhằm chuyển dịch cơ cấu nông nghiệp tỉnh Gia Lai. Kết quả cho thấy mức độ thích hợp đất đai đối với cây cà phê chủ yếu là thích hợp trung bình (S2) với diện tích là 86.163 ha. Cây cà phê được trồng chủ yếu ở các huyện Chư Păh, Đak Đoa, Chư Sê và Ia Grai. Mặt khác, mức độ thích hợp đất đai cho cây cao su chủ yếu là thích hợp trung bình (S2) với 60.000 ha. Cây cao su được trồng chủ yếu ở các huyện Chư Păh, Đak Đoa, Chư Sê, Ia Grai, Chư Prông. Những khu vực này có đặc trưng do sự phân bố của đất đỏ bazan, lượng mưa trung bình năm khoảng 2500 mm và khí hậu thuận lợi cho sự phát triển của các cây công nghiệp.

Từ khóa: cây cà phê, cây cao su, GIS, thích hợp đất đai, tỉnh Gia Lai.

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