APPLICATION OF GEOGRAPHIC INFORMATION SYSTEM IN POTENTIAL ASSESSMENT OF *Hevea Brasiliensis* PLANTATION DEVELOPMENT IN BINH PHUOC PROVINCE

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SUMMARY

The suitable zones of conditions for rubbers - *Hevea brasiliensis* plantations was based on 5 ecological factors: elevation, slope, soil thickness, temperature, rainfall. Therefore, the zones of condition were classified by the authors into 3 levels: suitable, medium suitable and unsuitable. The results of this research identified the zoning threshold for rubbers plantation by each individual factor: most suitable elevation is less than 200 m, most suitable slope is less than 16°, most suitable soil thickness is less than 1.5 m, most suitable temperature is between 25°C and 28°C and most suitable rainfall is greater than 1,800 mm/year. From the area and zoned maps of site conditions, each factor indicated the area for corresponding level: 61.22% (468,501 ha) - medium suitable for rubbers plantations; suitable area occupied 31.06% (213,275 ha); unsuitable for rubbers plantations 0.82% (4,960 ha). The research has shown the comparison between the current planting status and suitable zones of site conditions for rubbers plantation in Binh Phuoc province. The most planted area was on two levels: suitable and medium, only a small area was unsuitable. The investigated growth of rubbers in the suitable area was much better than the growth of rubbers in the medium, similarly, the growth of rubbers in the medium suitable area was better than the growth of rubbers in the unsuitable area, even rubbers was unable to grow well. The results of this study could be used as reference for selecting suitable area for rubbers plantation development in Binh Phuoc province.

Keywords: Binh Phuoc, ecological factor, *Hevea brasiliensis* plantation, rubbers, site zoning.

1. INTRODUCTION

Vietnam has been the first exporting natural rubber latex in the world, rubber's plantation area covered 910,500 ha in our country (2012) (To Xuan Phuc et. al, 2014). In that year, the export value was 2 billion USD with 1 million tons (Ngo Kinh Luan, 2013). Rubber plantations has spreaded most in Central Highlands and Northest, the total area for rubber plantation was 234,602 ha in 2012 (MARD, 2013), this number is expected to increase in future. The rubbers were planted early with a large area in Binh Phuoc. The total area of rubbers in this province was 275,000 ha (2015), the area for harvesting was about 241,000 ha. The area for rubbers planting to 2020 has been 250,000 ha. However, in 2 recent years, the rubbers latex price has been reduced in a long time, impacts to the livelihood of local people. Parts of rubbers area has been cut down for other purposes, planned rubbers area of the province was eliminated. To deal with this problems, the rubbers should be planted on the appropriate area for sustainable development with conditions of Binh Phuoc province in specific and Vietnam in general. The research: "Application of geographic information system in the potential assessment of *Hevea brasiliensis* plantation development in Binh Phuoc province" will contribute the scientific bases for rubbers planning and development in Binh Phuoc. The study was implemented based on five objectives:

- Identifying the zoning thresholds of five ecological factors: elevation, slope, soil thickness, temperature, rainfall.
- Identifying the appropriate zoning methods of some ecological factors.
- Building the appropriate zoning site maps.
- Evaluating the suitable zones map of the site conditions.

2. RESEARCH METHODOLOGY

2.1. Selection of base maps

Inheriting the results from publications and some base maps: Binh Phuoc topology map with scale 1/50,000 of General Department of Land Administration - Ministry of Natural

Resources and Environment; temperature, rainfall, slope of Vietnam from database system - Eco-Climate in Forestry of Institute for Forest Ecology and Environment.

2.2. Identifying the zoning thresholds of ecological factors

Collecting the researches and sector standards, law documents was applying in the development of rubbers plantations in order to determine the suitable, medium suitable, unsuitable ecology thresholds base on elevation, slope, soil thickness, temperature, rainfall.

2.3. Determining the impacts of topology, soil, and weather on the growth, development of rubbers

Establishing the grids (90 x 90 m) for entire Binh Phuoc and update, interpolate all the data of ecological factors: elevation, slope, soil thickness, temperature, rainfall. The impacts were classified into 3 levels: suitable (site 1), medium suitable (site 2), unsuitable (site 3), analyzing the sites of ecological factors to identify suitable, medium suitable, unsuitable zones for each district in Binh Phuoc.

2.4. Making the suitable zoning site maps

The suitable zoning site maps for *Hevea brasiliensis* in Binh Phuoc were constructed by MapInfo version 12.5 software. Thematic zoning map by each factor was constructed by coloring method (color codes were attached in the legend).

2.5. Evaluating the suitability of zones maps of site conditions

The suitability evaluation was carried out in terms of: assessing the suitability of areas under cultivation and development of *Hevea brasiliensis* in Binh Phuoc province with the results of research, the growth status of rubbers forest currently planted in different appropriate areas according to research results to compare the similarity as the basis for assessing the relevance of research results. In order to compare the growth of rubbers at different suitability levels, three sample plots were established corresponding to each suitable factors. Trees in the sample plots have identical parameters: species, age, care measures.

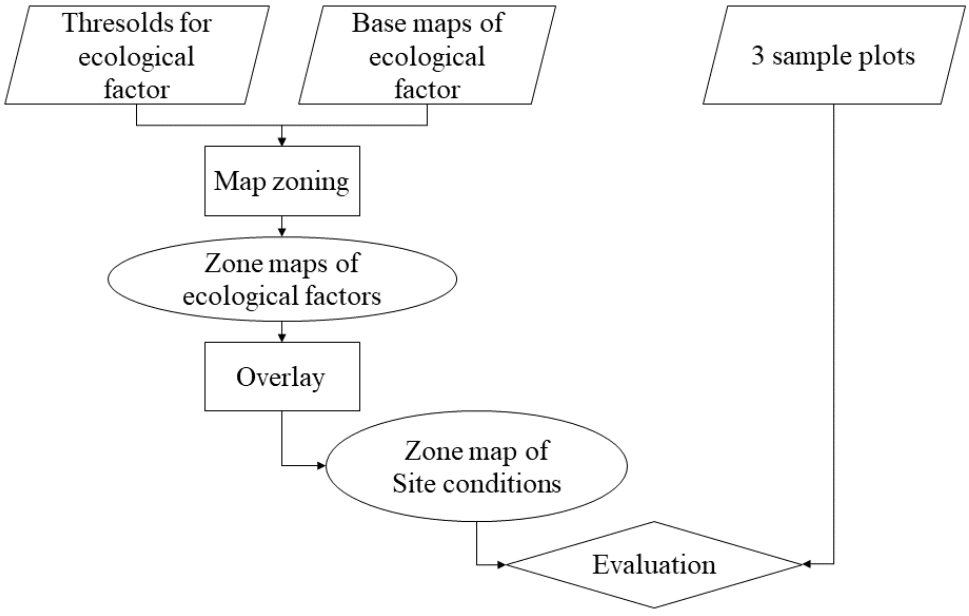

Figure 1. Workflow used for identifing zone map of site condition

3. RESULTS AND DISCUSSION

3.1. The zoning thresholds of some ecological factors

Determining the ecological thresholds based on 5-factors: elevation, slope, soil thickness, temperature, rainfall.

Table 1. Document used in identifying thresolds for ecological factors

Ecological factor	Reference documents
Elevation	- Circular No. 58/2009/TT-BNNPTNT dated 09/09/2009 of the MARD guiding the rubbers plantation on forest land.
Slope	- Rubber Technology Process of Vietnam Rubber Industry Group (2012).
Soil thickness	- Circular No. 58/2009/TT-BNNPTNT dated 09/09/2009 of the Ministry of Agriculture and Rural Development guiding the rubbers plantation on forestry land. - Process of rubbers cultivation of the Vietnam Rubber Industry Group.
Temperature	- Tong Viet Thinh et al., Institute of Vietnam rubbers, the classification system rubbers in Vietnam. - Agricultural knowledge. Techniques for growing and caring for rubbers in the South East, Central Highlands 2011.
Rainfall	- Tong Viet Thinh et al., Institute of Vietnam rubbers, suitable rainfall for planting and tending Hevea brasiliensis.

Five ecological factors were identified as table 2.

Table 2. Summary of thresolds for eacch ecological factor for rubber plantation

Ecological factor	Suitable	Medium suitable	Unsuitable
Elevation	< 200m	200m - 700m	> 700m
Slope	$< 16^0$	16^0 - 30^0	$> 30^0$
Soil thickness	> 1.5m	0.7 - 1.5m	< 0.7m
Temperature	$> 25^0$C	21^0C - 25^0C	$< 21^0$C
Rainfall	> 1,800mm	1,200mm - 1,800mm	< 1,200mm

3.2. Proper zoning of some ecological factors

3.2.1. Elevation

The research has identified the area of rubbers plantation of each district with the classification levels built for the elevation. The results are shown in figure 2.

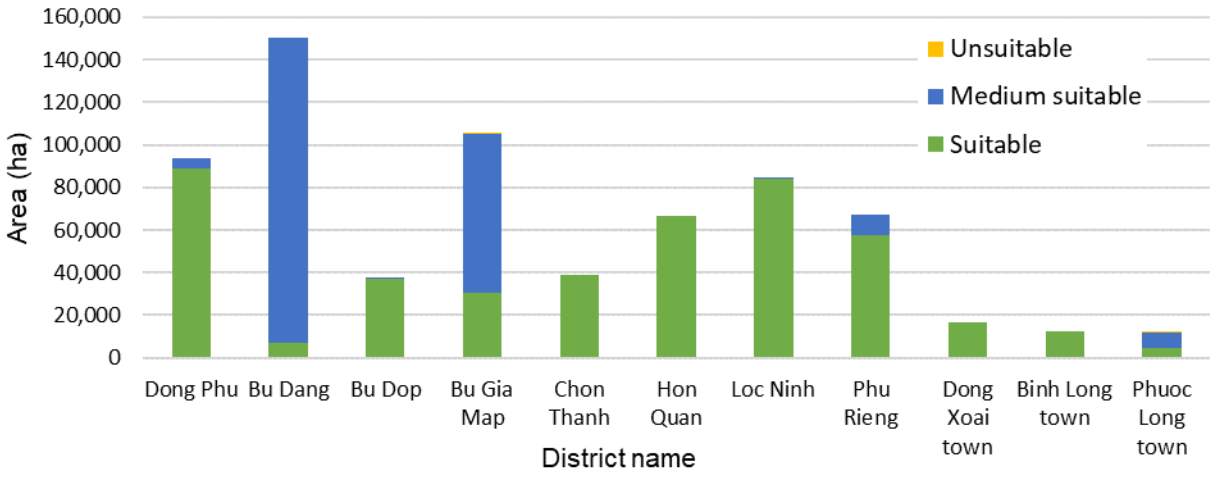

Figure 2. Area for planting rubbers according to absolute elevation

All districts in Binh Phuoc province are suitable for planting rubbers. The total area of the province: 444,026 ha, elevation ≤ 200 m area for rubbers plantation 64.66%. Area with elevation: 200 - 700 m medium suitable: 241,393 ha (35.14%). The small area of 1,317 ha occupied 0.2% with elevation > 700 m was unsuitable for rubbers plantations belong to Bu Gia Map district and Phuoc Long town.

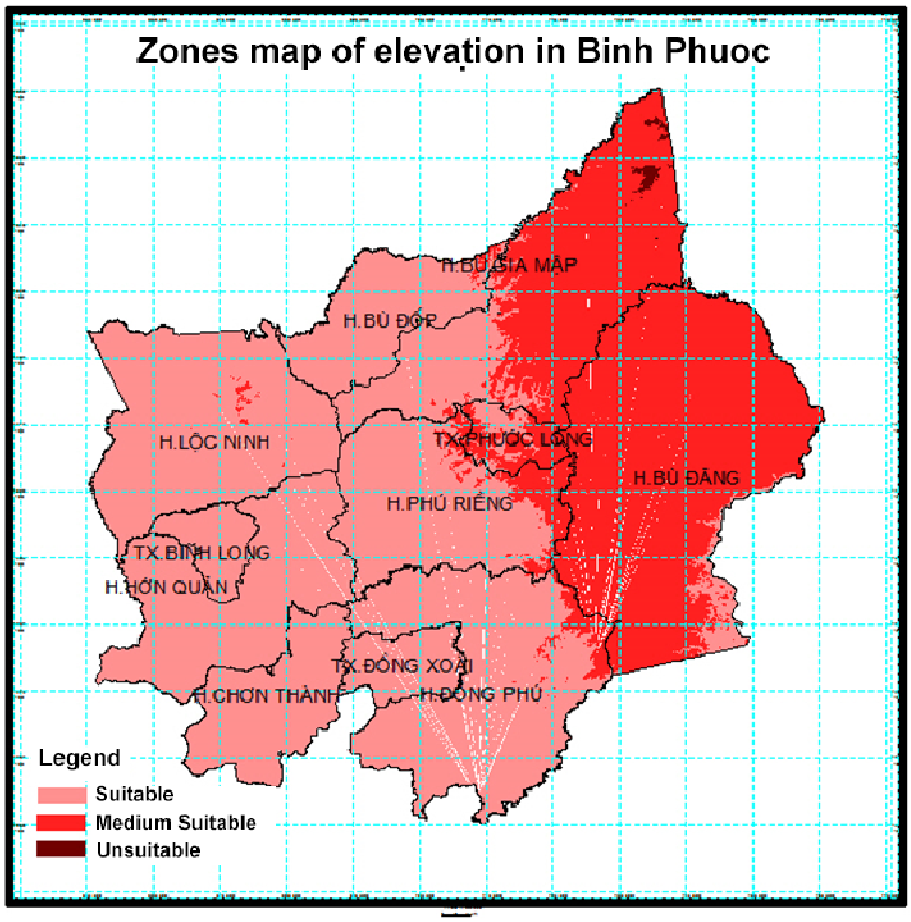

Figure 3. Zones map of elevation for rubbers plantation in Binh Phuoc

3.2.2. Slope

The study has appropriately zoned rubbers plantations at the slope level in Binh Phuoc province as figure 4.

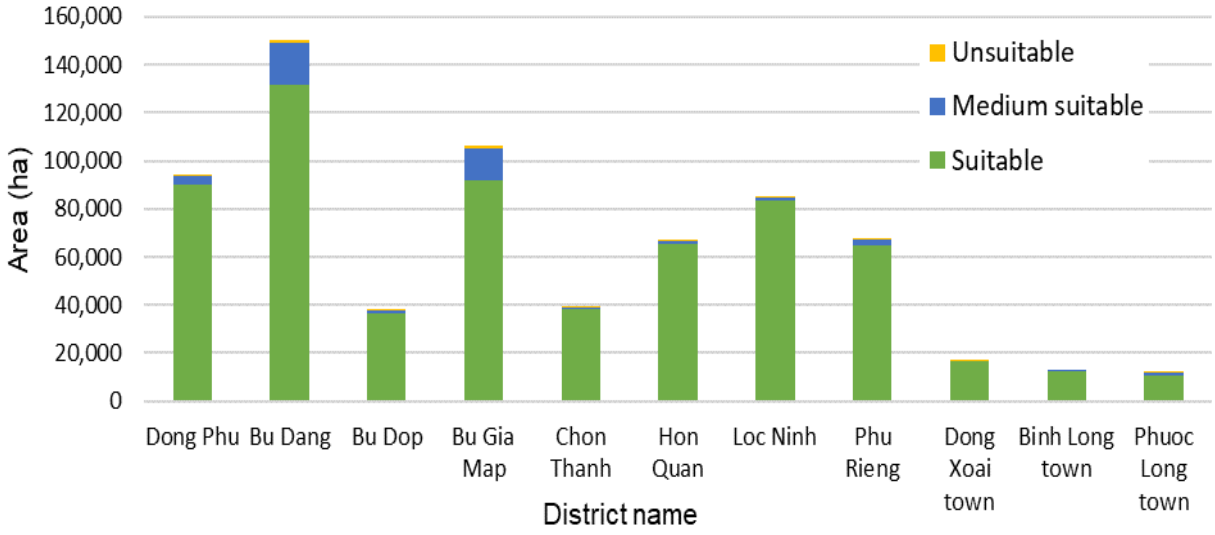

Figure 4. Area for planting rubbers according to the slope

The suitable area for growing rubbers in Binh Phuoc province is very large (642,812 ha) equal 93.60% total natural area of the province, the area with unsuitable slope was just a mere 0.3% (1,786 ha). The remaining 6.1% (42,138 ha) for medium suitable.

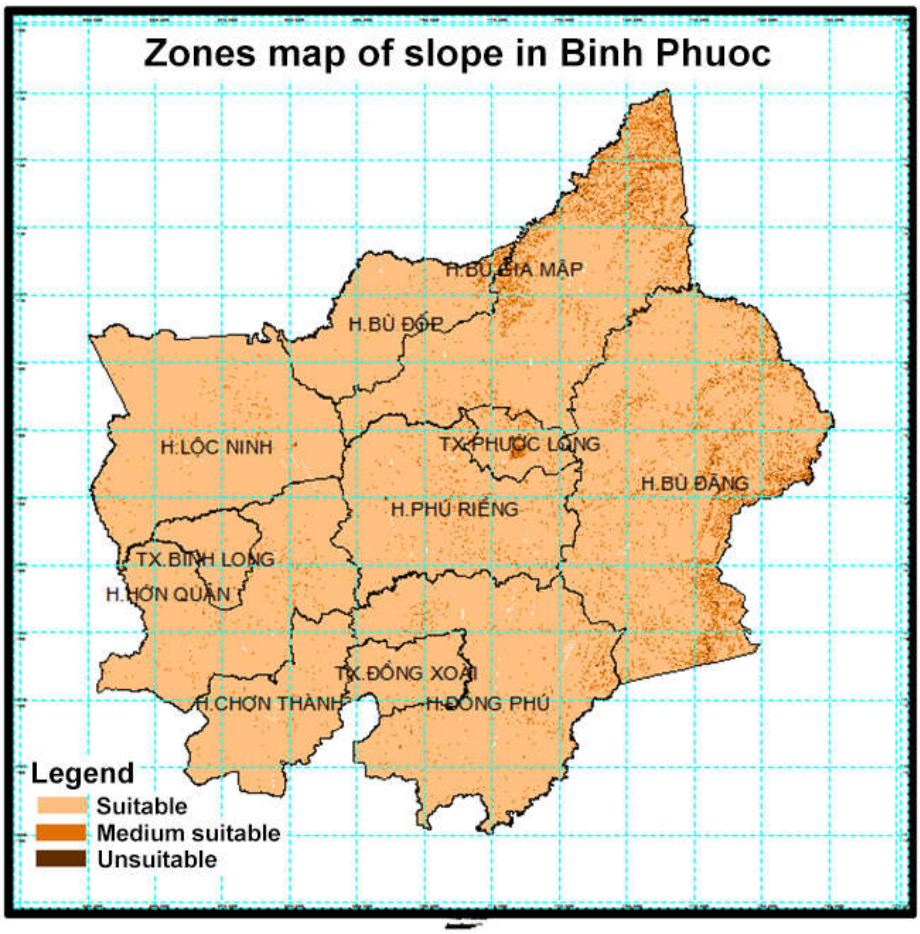

Figure 5. Zones map of slope for rubbers plantation in Binh Phuoc

3.2.3. Soil thickness

The study has appropriately zoned rubbers plantations with soil thickness factor in Binh Phuoc province as figure 6.

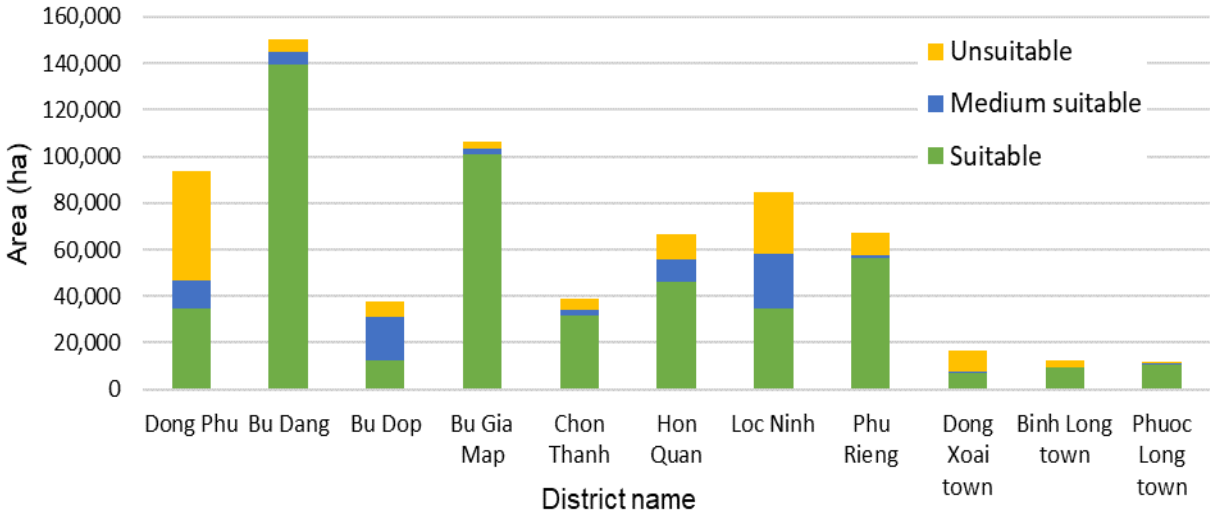

Figure 6. Area for planting rubbers according to soil thickness

It can be seen that most of the area in Binh Phuoc province has a thick soil layer suitable for rubbers. Bu Dang district has the largest suitable area for planting rubbers (139,594 ha), Dong Phu district has the largest area with soil thickness is not suitable for rubbers is with 46,954 ha.

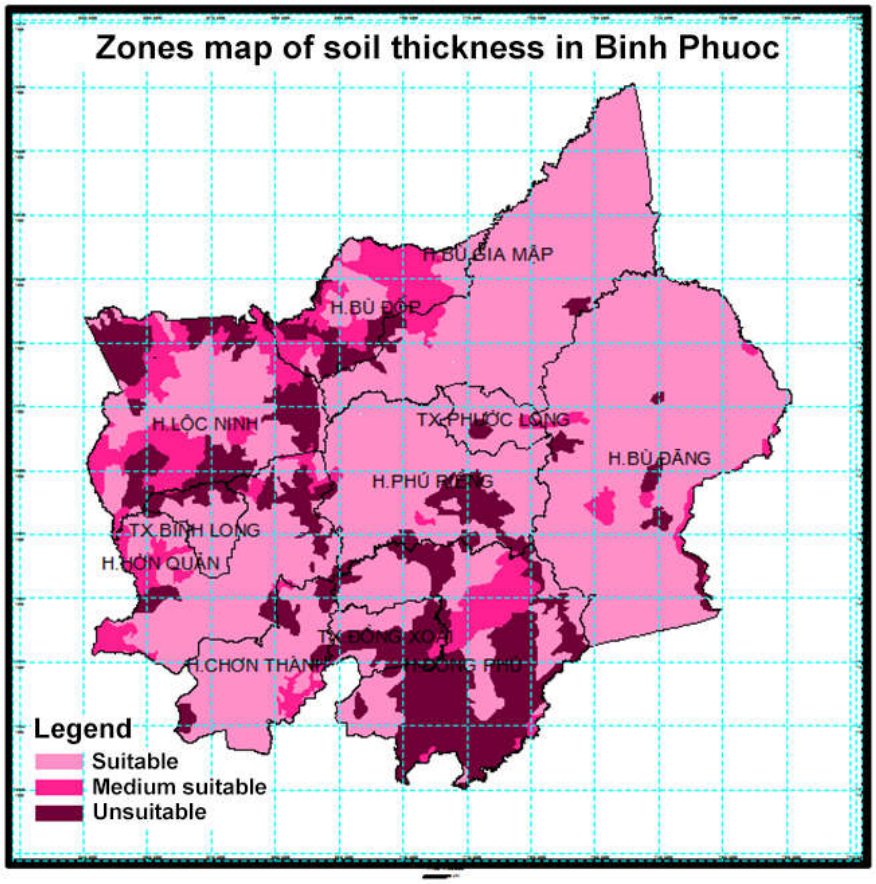

Figure 7. Zones map of soil thickness for rubbers plantation in Binh Phuoc

3.2.4. Temperature

The temperature factor is one of the important factors in assessing the suitability as well as the growth and development of rubbers plantations throughout the harvesting process. The annual average temperature is decentralized to rubbers through the following figure 8.

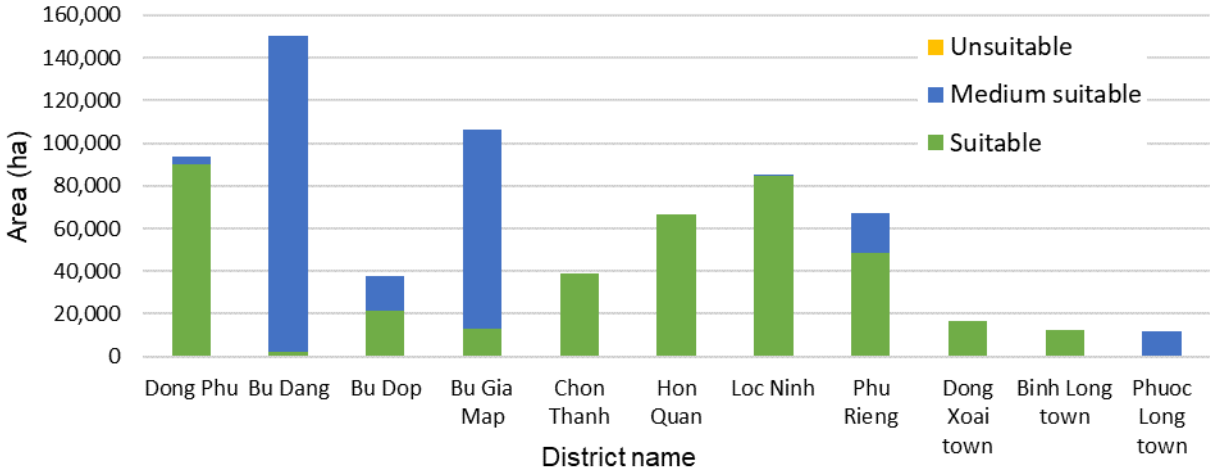

Figure 8. Area for planting rubbers according to temperature

Figure 8 shows that the area with an average annual temperature in Binh Phuoc is not suitable for planting rubbers was 0%. The suitable area for rubbers was 57.51% and 42.49% Phuoc Long town was the only district in the province that did not have the land area suitable for planting rubbers, the whole area of the town was located in the medium suitable area.

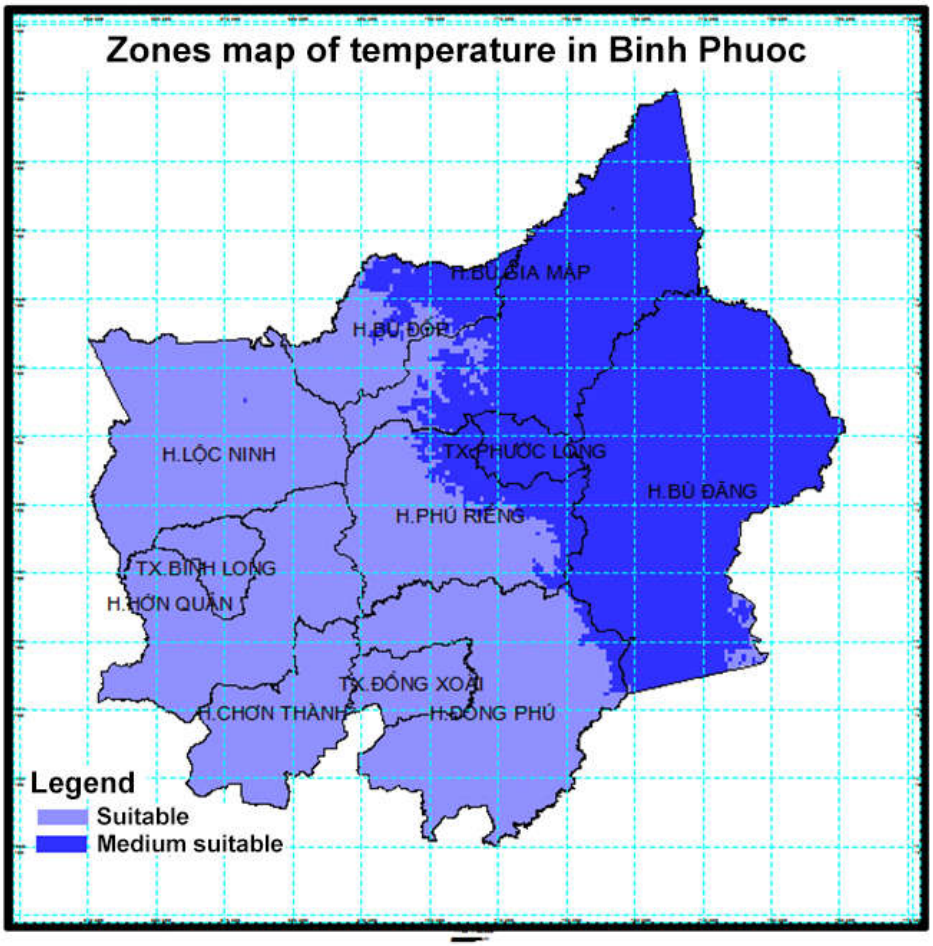

Figure 9. Zones map of temperature for rubbers plantation in Binh Phuoc

3.2.5. Rainfall

The data of suitable, medium suitable, unsuitable for the area of Binh Phuoc province based on rainfall is shown in the following figure 10.

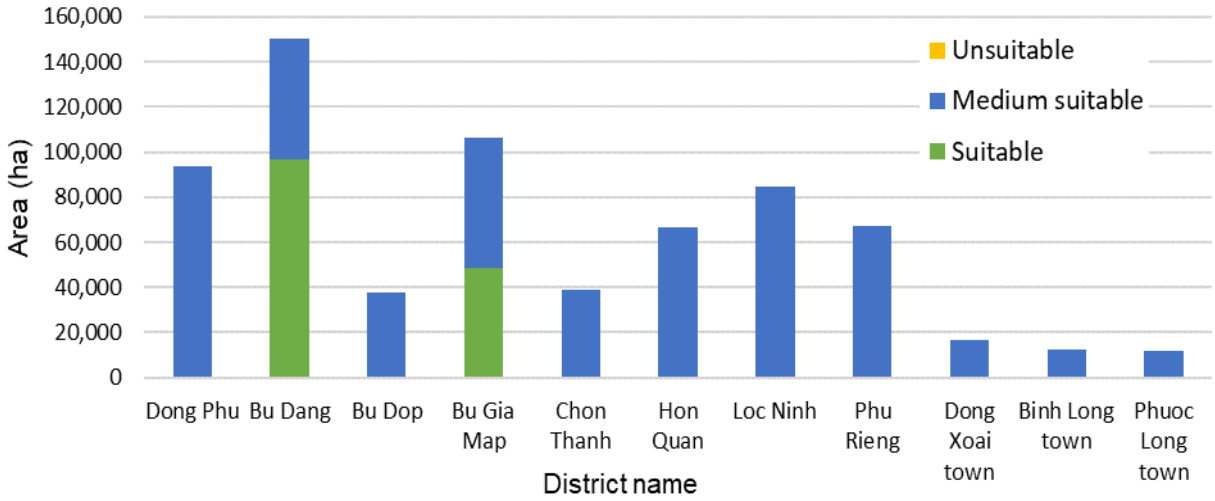

Figure 10. Area for planting rubbers based on rainfall

The result shows that the entire province did not have any districts with unsuitable rainfall for planting rubbers. The most area has suitable rainfall average rubbers.

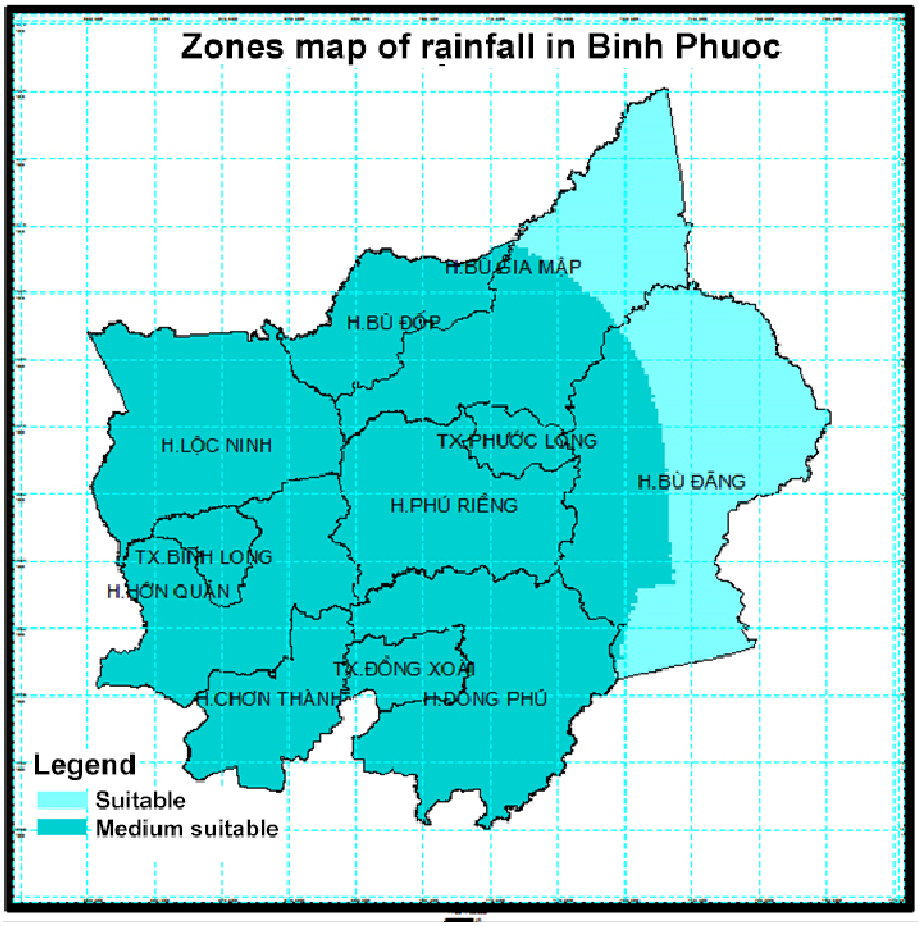

Figure 11. Zones map of rainfall for rubbers plantation in Binh Phuoc

3.3. Zones site map for rubbers

Unsuitable area for planting rubbers was an area where at least one of the five research factors is within an ineligible range when compared with the classification thresholds for rubbers plantations. The suitable average area was all 5 factors are in the average level according to the hierarchy. The suitable areas were the rest (no factor are in the unsuitable level, at least one of the 5 factors researched was considered suitable), the data for zoning in Binh Phuoc province by each district was samurai as the following table 3 and figure 12 and 13.

Table 3. The area by each level of suitability planting rubbers in Binh Phuoc province (ha)

No.	District name	Suitability classes		
		Suitable	Medium suitable	Unsuitable
1	Dong Phu	31,012	61,377	1,264
2	Bu Dang	3,588	144,696	1,792
3	Bu Dop	5,883	31,840	13
4	Bu Gia Map	9,787	95,626	754
5	Chon Thanh	31,189	7,785	1
6	Hon Quan	45,128	21,319	1
7	Loc Ninh	33,001	51,917	8
8	Phu Rieng	37,474	29,426	562
9	Dong Xoai town	6,877	9,842	0
10	Binh Long town	9,336	3,290	0
11	Phuoc Long town	0	11,383	565
	Total (ha)	**213,275**	**468,501**	**4,960**

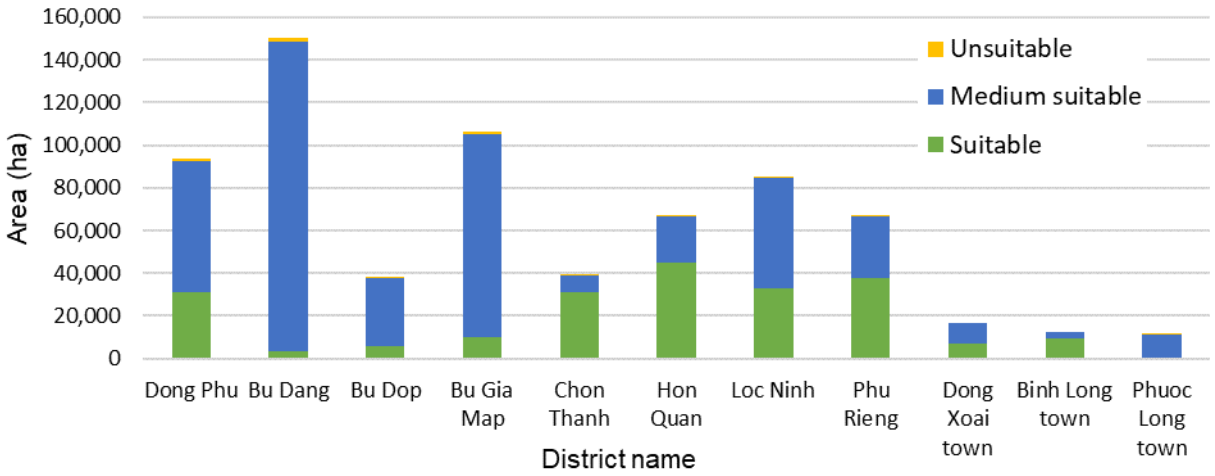

Figure 12. The area showing the suitability level for planting rubbers

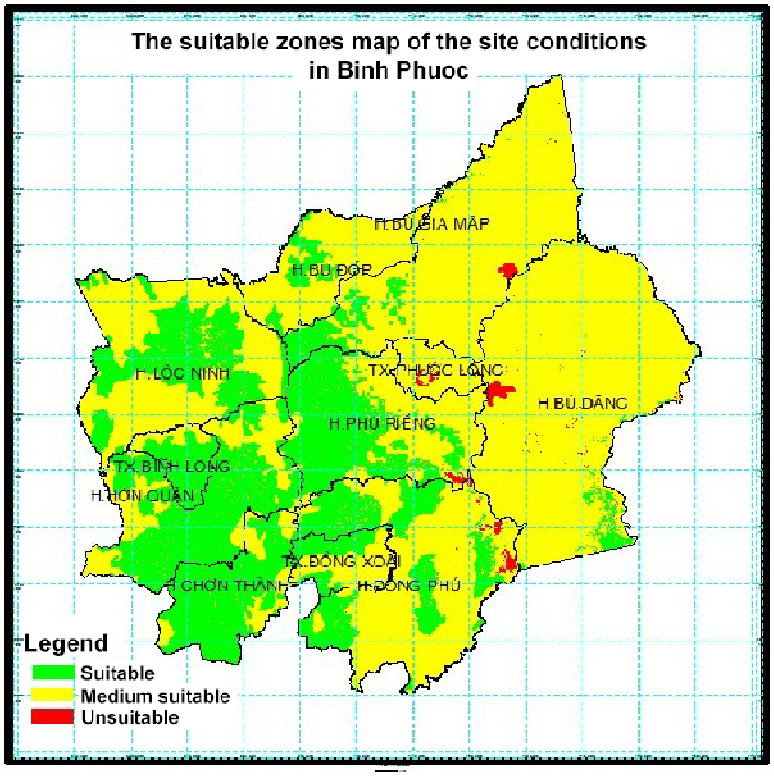

Figure 13. The suitable zones map of the site conditions for rubbers plantations

The results showed that 68.22% of the province's area was suitable for planting rubbers in Bu Dang, Phuoc Long, Bu Gia Map districts. Some regions of Dong Phu, Bu Dop and Loc Ninh districts were unsuitable for planting rubbers (0.82%) scattered distribution in districts, the suitable area occupied 31.6% concentrated mainly in the districts Chon Thanh, Phu Rieng, Hon Quan, Loc Ninh and Binh Long Town.

The suitable for rubbers planting were mainly in Dong Phu, Phu Rieng, Loc Ninh, Hon Quan and Chon Thanh (30,000 ha for each district), specific as follows:

Site 1: Dong Phu district along with DT 741;

Site 2: Phu Rieng, Loc Ninh district;

Site 3: Along with national 14 of Chon Thanh district, a part of Phuoc Long town;

Site 4: A part of Chon Thanh.

3.4. Evaluating the suitable zones map of site conditions

The diameter ($D_{1,3}$) and top height (H_{vn}) of *Hevea brasiliensis* in sample plots for each level of suitability were summarised as table 4.

Table 4. $D_{1,3}$ and top height H_{vn} of *Hevea brasiliensis* in sample plots

Plot no.	Location	$D_{1,3}$ (cm)	H_{vn} (m)	Suitability level
01	Tan Lap commune, Dong Phu district	9.3	8.5	Suitable
02	Binh Long commune, Phu Rieng district	7.4	8.0	Medium suitable
03	Loc Tan commune, Loc Ninh district	6.2	6.5	Unsuitable

Based on the surveyed data, the average growth criteria of each standard plot represented different areas of suitability level, showing the diameters and the height of *Hevea brasiliensis* in Tan Lap commune, Dong Phu district was the largest (suitable area), diameter and height of *Hevea brasiliensis* in Loc Tan commune, Loc Ninh district was the smallest (unsuitable). The results were relatively suitable to the development situation of the *Hevea brasiliensis* plantations in fact in Binh Phuoc.

4. CONCLUSION

The study has been well suited for rubbers plantation in Binh Phuoc province by 5 factors: elevation, slope, soil layer, temperature, rainfall. Based on that, the suitable zones map of the site conditions for rubbers in Binh Phuoc province was constructed. The research shows that the suitable level for planting rubbers in the province is 468,501 ha concentrated mainly in Bu Dang district, Phuoc Long town and Bu Gia Map district. The suitable natural area of the province for planting rubbers is 213,275 ha; belong to Chon Thanh, Phu Rieng, Hon Quan, Loc Ninh and Binh Long districts. The unsuitable area is 4,960 ha accounting for a small proportion scattered across districts.

The results showed the comparison between actual rubbers plantations and results from the suitable zones map of the site conditions, almost actual area was suitable and medium suitable, the unsuitable area is quite small. The results of the study can be used as reference material for the selection of suitable areas for rubbers in Binh Phuoc province.

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ỨNG DỤNG HỆ THỐNG THÔNG TIN ĐỊA LÝ TRONG ĐÁNH GIÁ TIỀM NĂNG PHÁT TRIỂN CÂY CAO SU TRÊN ĐỊA BÀN TỈNH BÌNH PHƯỚC

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TÓM TẮT

Các tác giả đã nghiên cứu và xác định được các ngưỡng phân vùng thích hợp cho trồng rừng Cao su dựa trên cơ sở phân tích 5 nhân tố sinh thái: độ cao, độ dốc, độ dầy tầng đất, nhiệt độ, lượng mưa. Nghiên cứu đã phân vùng thích hợp cho phát triển cây Cao su tại Bình Phước thành 3 cấp: thích hợp, thích hợp trung bình, không thích hợp. Kết quả nghiên cứu đã xác định ngưỡng phân vùng thích hợp cho trồng rừng Cao su tại Bình Phước như sau: độ cao phù hợp nhất là dưới 200 m; độ dốc thích hợp nhất là < 160; bề dầy tầng đất thích hợp nhất là >1,5 m; Nhiệt độ thích hợp nhất là 25 - 28^{0}C; lượng mưa thích hợp nhất là >1.800 mm/năm. Từ diện tích và bản đồ phân vùng thích hợp cho trồng cây Cao su ứng với từng nhân tố ảnh hưởng đã chỉ ra rằng 61,22% (468.501 ha) diện tích thích hợp trung bình cho việc trồng cây cao su; diện tích thích hợp chiếm 31,06% (213.275 ha); 0,82% (4.960 ha) diện tích không thích hợp. Nghiên cứu đã so sánh được vùng trồng Cao su tại tỉnh Bình Phước với kết quả phân vùng lập địa thích hợp cho trồng cây Cao su. Kết quả cho thấy hầu hết diện tích đã trồng Cao su đều thuộc hai cấp thích hợp và thích hợp trung bình, một phần diện tích nhỏ là không thích hợp; sinh trưởng của cây Cao su tại các vùng thích hợp là tốt hơn hẳn so với các vùng thích hợp trung bình và không thích hợp. Kết quả nghiên cứu này có thể được sử dụng làm tư liệu tham chiếu cho việc lựa chọn vùng thích hợp cho việc phát triển cây Cao su tại tỉnh Bình Phước.

Từ khóa: Bình Phước, nhân tố sinh thái, phân vùng lập địa, rừng trồng Cao su.

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