A GIS-Based Multicriteria Analysis of Land Suitability for Groundnut Crop in Nghe An Province, Vietnam

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DOI: https://doi.org/10.52939/ijg.v17i6.2071

Abstract
This study focuses on identifying the potential lands for growing groundnut in Dien Chau district of Nghe An province (Vietnam), where groundnut is one of the major crops and brings high income for farmers. Based on the ecological requirements of groundnut, six criteria, including Soil Type, Soil Texture, Soil Depth, Slope, Average Temperature, and Average Total Rainfall in the planting season, were used. The Analytic Hierarchy Process method, commonly used in agricultural land use planning, was utilized to determine each criterion's weights via experts' opinions. A pairwise comparison matrix was established to support this assessment process. The results revealed that Soil Texture showed the highest weight (0.31727) for groundnut farming, which was followed by Average Temperature (0.21131), Soil Type (0.17426), and Soil Depth (0.13982). Slope and Average Total Rainfall were the lowest weight factors, with 0.08122 and 0.07612, respectively. The weighted sum overlay analysis was implemented by ArcGIS software to generate the spatial distribution of land suitability of groundnut. The land suitability map indicated that 6830.07 ha (22.26%) of the studied area was highly suitable (S1), 10413.85 ha (33.95%) was moderately suitable (S2), 4336.76 ha (14.14%) was marginally suitable (S3), and 424.99 ha (1.39%) was not suitable (N). The total area of constrained area, including Waterbody and Built-up Land, was 8671.39 ha, accounting for 28.27% of the total area. Finally, the proposed land for groundnut cultivation was 12928.69 ha. The outcomes of this study may be regarded as a good reference for local government in agricultural land use planning.

1. Introduction

The optimal growth of each plant species mainly depends on soil features and climatic conditions. Analyzing the relationship between soil features and crop requirements is significant as the first step in planning future agricultural land use (Taghizadeh-Mehrjardi et al., 2020, Yohannes and Soromessa, 2018). It enables extensive information about land performances to land users, land-use planners, and agricultural support services, making a critical decision for specific purposes to increase productivity (AbdelRahman et al., 2016). Numerous crop management programs carried out land suitability assessment (LSA) to locate potential areas for the cultivation of various crops, such as rice (Özkan et al., 2019), maize (Habibie et al., 2021), potato (Iliquín Trigoso et al., 2020), rubber (Ali et al., 2018), and coffee (Salas López et al., 2020). These studies conclude that LSA considered the importance of land suitability assessment a pivotal step in selecting potential cultivated plants and areas. Therefore, soil characterization and land evaluation for various land use play a crucial role in proposing strategies for achieving food security and environmental sustainability (Esu, 2004).

Groundnut is one of the significant industrial crops to produce edible oil and daily food (Pasupuleti et al., 2013). In recent years, groundnut is investigated as a crop to improve the income and livelihoods of local farmers in Dien Chau district, Vietnam. The policies in groundnut land expansion have been mentioned on strategies for future agricultural development of local government, but a detail of land suitability assessment is not involved. Hence, this study evaluated land performance for groundnut growth in Dien Chau district, Vietnam.

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FAO land suitability evaluation was commonly used worldwide to evaluate the soils (FAO, 1976). However, examining the contribution of ecological criteria on land performance was ignored in this approach. More recently, LSE methodologies have shifted from broad-based to a specific assessment. Elshiek et al., (2013) developed an automated system (as per FAO framework) that allows land evaluators to build expert systems for land evaluation (Elsheikh et al., 2013). However, a quantitative procedure by GIS-based multicriteria analysis (MCA), inclusive of all the factors influencing crop production, needs to be developed to evaluate soil series. In MCA, the relative importance of quantitative criteria is used to rank different alternatives. While weights often express the relative importance of criteria, the performance of sub-criteria is expressed by score. Subjective experts' opinions estimate weights through a pairwise comparison matrix (Ebrahimi et al., 2019) or objective calculation by the principal component analysis approach (Kosaki et al., 1989). In order to apply efficiently for spatial analysis, MCA is usually combined with Geographical Information System (GIS). A GIS-based multicriteria analysis includes stepwise procedures to analyze objectives influenced by spatially distributed factors according to chosen criteria.

In short, the purpose of this study was to (i) apply a GIS-based multicriteria to assess land suitability; (ii) explore some potential areas to cultivate groundnut crops. This study's outcomes might help local government release the right policy in using agricultural land.

2. Materials and Methods

2.1 Study Area

Dien Chau (18°51′31″N-19°11′05″N latitude and 105°30′13″E-105°39′26″ E longitude) is a coastal district of Nghe An province with an area of 306.77 km2 (Figure 1). The study area is located in a monsoon tropical climate region, but a combined consequence of the Truong Son mountainous in West and sea in East has created considerable differences from weather conditions between dry and rainy seasons. The average annual temperature fluctuates between 23°C - 24°C. The highest temperature can be over 40°C in June or July. The average annual rainfall is about 1200 mm - 2000 mm. The rainy season lasts from May to October. The topography of Dien Chau is divided into two forms, including hilly and coastal plains. The hilly terrains are mainly distributed in the northwestern and the south of the district. Their average elevation is from 100 m to 3000 m with a slope less than 15°. The remaining part is a flat sizeable coastal plain with an elevation from 0.5 m to 3.5 m and a slope less than 3°. The annual industrial crops in Dien Chau district include groundnut, soya-bean, tobacco, and sugar cane.

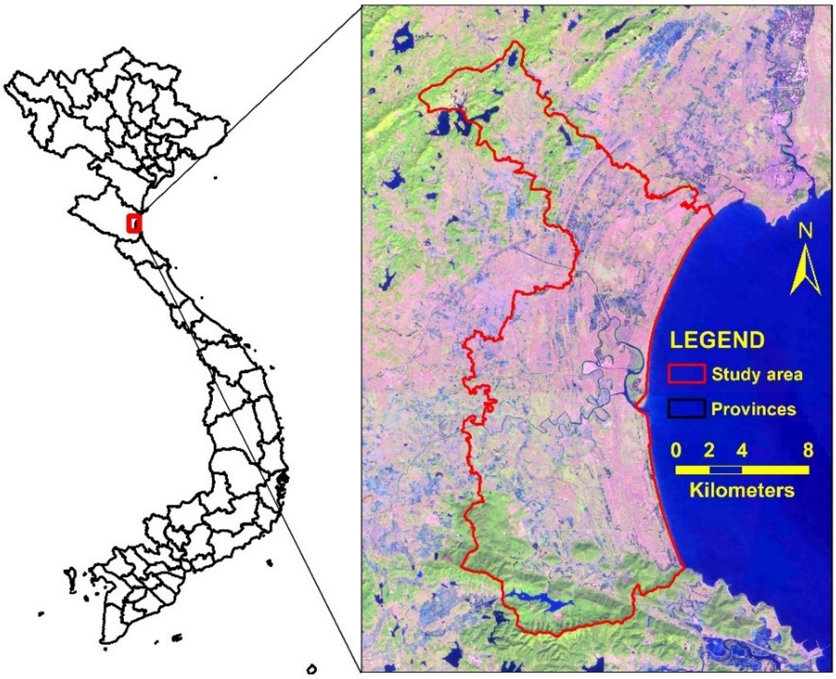

Figure 1: The location of study area

In 2019, the planted area of groundnut is the biggest, with 3278 ha, which was followed by the number of sugar-cane (32 ha) and tobacco (6 ha). According to the Nghe An statistical yearbooks 2019, there was a slight increase in the planted groundnut area from 3061 ha to 3278 ha (NASO, 2020). Meanwhile, tobacco and sugar cane planted areas decreased marginally, especially soya-bean was not planted in 2019. Therefore, land suitability assessment for planting groundnut is significant in the agricultural production of this district.

2.2 Criteria Used

Determining ecological criteria for crop cultivation is essential in land suitability analysis due to their dependence on each physical factor (e.g., climate, topography, or soil). In more detail, these factors typically include temperature, rainfall, humidity, elevation, slope, aspect, soil texture, soil type, soil depth, soil drainage, organic matter, and pH. Criteria were chosen based on crop type, a particular characteristic of the study area, technical regulation of each country, and data availability. For example, in order to determine the suitable site to grow rice in Turkey, Özkan et al., (2019) utilized nine characteristics of soil, including soil texture, soil drainage, pH, EC, CaCO3, TN, AvP, AvK, and AvZn (Özkan et al., 2019). While Kihoro et al., (2013) used six factors, including topography, humidity, temperature, pH, soil texture, and soil drainage, to assess suitable land levels to cultivate rice in Kenya (Kihoro et al., 2013). For groundnut cultivation, Gayathri (2018) utilized five criteria of the slope, soil texture, soil depth, drainage density, and mean annual rainfall to determine suitable lands in India (Gayathri, 2018). Suhairi et al., (2018) used rainfall, temperature, soil texture, soil depth, pH, and elevation to evaluate land suitability to plant groundnut for Malaysia (Suhairi et al., 2018). This study used six criteria based on the Vietnamese technical regulation on "Agricultural production land evaluation instruction for land use planning at district level" (MARD, 2010) and experts' opinions. These criteria were Soil Type, Soil Texture, Soil Depth, Slope, Average Temperature in the planting season, and Average Total Rainfall in the planting season. Their sub-criteria were classified into four levels of suitability: high (S1), moderate (S2), marginal (S3), and not suitable (N), with corresponding scores from 4 to 1.

2.3 Data Used

Meteorological data (i.e., rainfall and temperature) from 2015 to 2019, provided by the Vietnam Institute of Meteorology Hydrology and Climate Change, was used to characterize climatic conditions. Soil Type, Soil Texture, and Soil Depth were extracted from the soil map at scale of 100,000 of Nghe An province. These data contained physical properties of soil in the study area and was obtained from the Soils and Fertilizers Research Institute. The slope information was generated from 10 m resolution of Dien Chau's DEM provided by the Center of Surveying and Mapping Data (Ministry of Natural Resources and Environment). Constrained areas, including Built-up land and Waterbody where groundnut can be not planted, were derived from the land use map of Dien Chau district. To validate the accuracy of the land suitability map, the location of 28 groundnut fields was collected using handheld GPS Garmin 72H in early October 2021.

2.4 GIS-Based Multiple Criteria Analysis for Land Suitability Assessment

Numerous methods were developed to assess the land potential for agricultural land. The FAO framework (FAO, 1976) for land suitability evaluation was considered standard and used for LSA projects (Fekadu and Negese, 2020 and Yohannes and Soromessa, 2018). This framework does not consider the different impact of ecological criteria on the land suitability assessment process, whereas each criterion has its contribution. For calculating the weight of criteria, the analytical hierarchy process (AHP) developed by Saaty (1980) was broadly used (Iliquín Trigoso et al., 2020 and Salas López et al., 2020). The importance of each criterion was estimated using an aggregation of experts' opinions. Besides, the LSA process becomes more straightforward with the support of spatial analysis tools of Geographic Information Systems (GIS). Many studies had effectively applied the integration of AHP and GIS to determine potential land for organic farming (Mishra et al., 2015), wheat and barley cultivation (Fekadu and Negese, 2020), or cassava (Purnamasari et al., 2019). Therefore, the application of GIS and AHP to determine land suitability for groundnut cultivation is feasible (Figure 2). The most important part of a land suitability evaluation model is to determine the weight of each criterion. Many ranking methods were used for this purpose, such as Analytical Hierarchy Process (Fekadu and Negese, 2020), Analytical Network Process (Seyedmohammadi et al., 2019), Weighted Linear Combination (Yin et al., 2020), and Ordered Weighted Average (Zabihi et al., 2019).

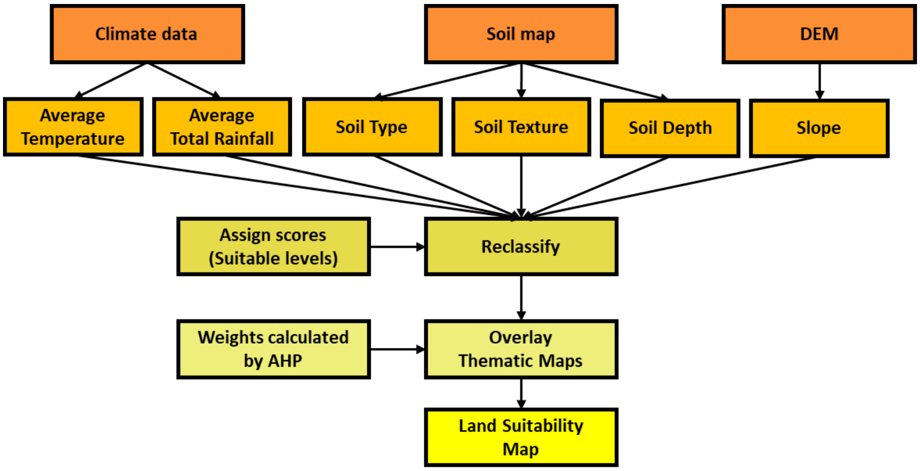

Figure 2: Flowchart of the methodology

Table 1: Saaty's nine points scale of pairwise comparison

1/9	**1/7**	**1/5**	**1/3**	**1**	**3**	**5**	**7**	**9**
Extreme	Very strong	Strong	Moderate	Equally important	Moderate	Strong	Very strong	Extreme
Less important					More important			

Table 2: Consistency Ratio according to the number of criteria

Number of criteria	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

However, the AHP method has been the most widely applied agricultural land suitability analysis (Iliquín Trigoso et al., 2020). To calculate the weights of criteria, using Pairwise Comparison Matrix (Table 1), where the relative importance of criteria is evaluated from 1 to 9 (Saaty, 1980). Experts decide these values, academic researchers, or decision-makers in the study field. The geometric mean method implemented the group aggregation of experts' judgments using Equation 1:

$$M = \sqrt[n]{\prod_{i=1}^{n} a_i}$$

Equation 1

Because of the subjective evaluation of experts, their judgments might be inconsistent (Francisco et al., 2019). For identifying the level of the inconsistency of the judgments, the consistency ratio index (CR) will be estimated by the Equation 2:

$$CR = \frac{CI}{RI}$$

Equation 2

With: RI is a random index provided by Saaty (Table 2). And CI is the Consistency Index, which is computed as Equation 3:

$$CI = \frac{\lambda_{max} - n}{n - 1}$$

Equation 3

In which, λ_{max} is the prime eigenvalue in the comparison matrix. Then n is the number of alternatives. It is suggested that $CR < 0.1$. In case that $CR > 0.1$, the level of consistency is not reasonable.

2.5 Thematic Maps Generation

2.5.1 Rainfall and temperature

The growth, flowering, and fruiting of groundnut are significantly affected by climatic conditions, including temperature and rainfall (Kumar et al., 2012 and Reddy et al., 2003). In Dien Chau district, groundnut is planted from July and harvested at the end of October. Average Temperature and Average Total Rainfall data in these months in Dien Chau district were interpolated based on nine meteorology stations' data in adjacent districts (Nghe An province) in the period 2015-2019.

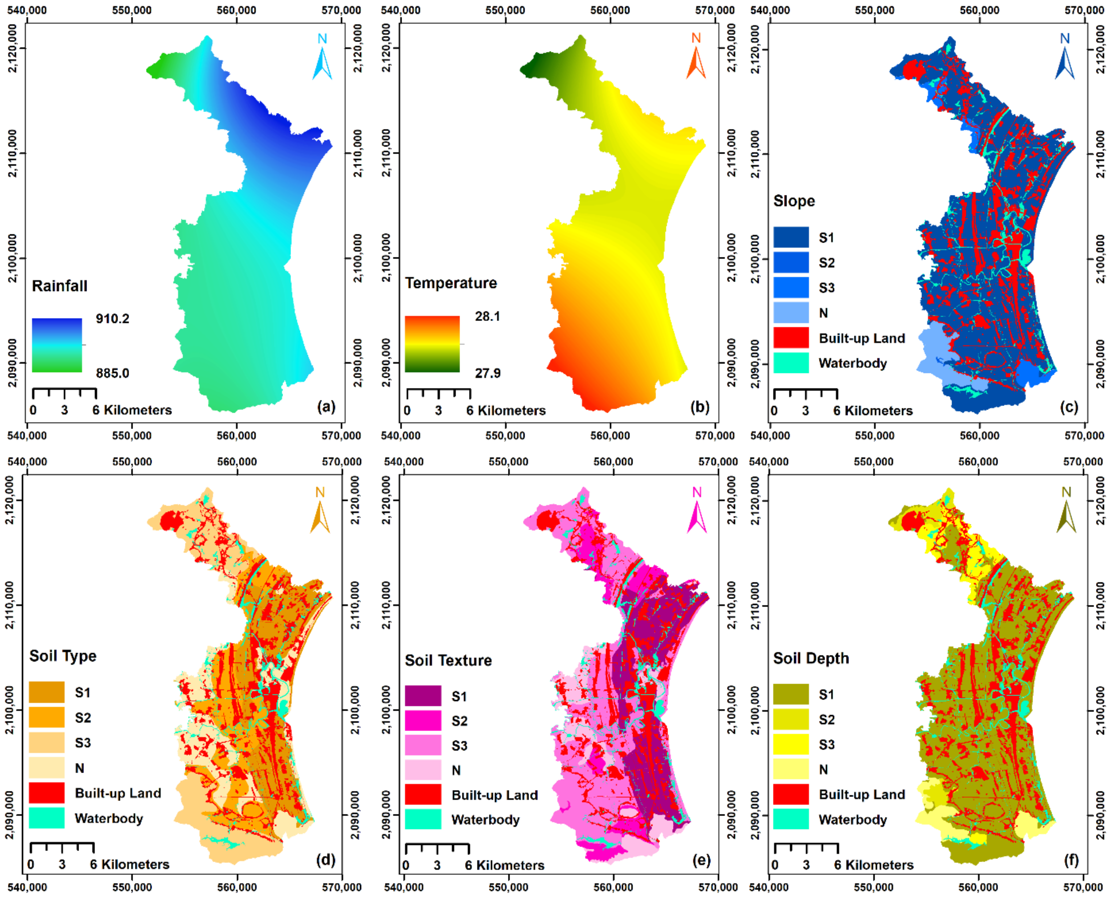

Figure 3: Thematic maps

The interpolation was implemented by the Ordinary Kriging method proved better than Universal Kriging, IDW or Spline (Earls and Dixon, 2007, Firdaus and Talib, 2016 and Nusret and Dug, 2012). The interpolation results showed no significant difference between the Average Total Rainfall and the Average Temperature between parts of this district (Figure 3a, 3b). The Average Total Rainfall of the four months ranged from 885 mm to 910 mm, which was highly suitable (S1) for planting groundnut. Furthermore, the Average Temperature varied in the range of 27.9°C-28.1°C, which was moderately suitable (S2) to grow groundnut. In conclusion, the climate conditions of Dien Chau were favorable for growing groundnut.

2.5.2 Soil type, soil texture and soil depth

Soil is a critical part of the thriving agriculture of each country. It is the storage place for water, nitrogen, nutrients, and minerals dissolved in water, vitally needed by the crop to live and grow. So that, the evaluation of soil properties is crucial for land suitability analysis of groundnut. Soil type, soil texture, and soil depth were chosen in this research. These map layers were generated from the soil map of Nghe An province. Soil Type is a criterion that needs to be considered in agricultural land suitability assessment (Bozdağ et al., 2016). Different types of soil are appropriate to plant different crops and bring different productivities. For growing groundnut purposes, 5912.55 ha (19.27%) of Haplic Arenosols (C) distributed along the eastern side of the district is highly suitable (S1). Dystric Fluvisols (Pc), moderately suitable land (S2) for groundnut, covered an area of 5063.95 ha (16.51%) and scattered over the middle of the study area. The area of Feralic Acrisols (Fs) and other kinds of Soil Type, which were marginally suitable (S3) and not suitable (N), constituted 5946.64 ha (19.38%) and 5082.53 ha (16.57%), respectively. The map of Soil Type is shown in Figure 3d.

Table 3: Criteria, sub-criteria and their importance

Criteria	Weights	Sub-criteria	Suitable levels	Score	Area (ha)	Percentage (%)
Soil Type	0.17426	Haplic Arenosols (C)	S1	4	5912.55	19.27
		Dystric Fluvisols (Pc)	S2	3	5063.95	16.51
		Feralic Acrisols (Fs)	S3	2	5946.64	19.38
		Others	N	1	5082.53	16.57
Soil Texture	0.31727	Sandy (b)	S1	4	5846.24	19.06
		Sandy Loam (c)	S2	3	2721.05	8.87
		Sand (a), Silty loam(d)	S3	2	10172.70	33.16
		Clay loam (e), Clay (g)	N	1	3265.68	10.65
Soil Depth	0.13982	> 70 cm	S1	4	17579.52	57.31
		50 cm – 70 cm	S2	3	1034.26	3.37
		30 cm – 50 cm	S3	2	1755.16	5.72
		< 30 cm	N	1	1636.73	5.34
Slope	0.08122	0° - 3°	S1	4	19036.36	62.05
		3° - 8°	S2	3	31.95	0.10
		8° - 15°	S3	2	1179.23	3.84
		>15°	N	1	1758.13	5.73
Average Temperature	0.21131	27.9°C-28.1°C	S2	3	30677.06	100
Average Total Rainfall	0.07612	885 mm – 910 mm	S1	4	30677.06	100

Soil Texture is defined as the ratio of sand, silt, and clay in soil content. It decides the aeration, water-releasing capacity of the soil, and root penetrability. Thus, it has significant impacts on the growth of stems, leaves, flowers, and the number of pegs of groundnut (Zhao et al., 2015). In Dien Chau, Sand and Silty Loam (marginally suitable - S3) were dominant with 10172.70 ha (33.16%), which was followed by the corresponding figures of Sandy (highly suitable - S1) with 5846.24 ha (19.06%). Next were Clay loam and Clay (not suitable – N) with 3265.68 ha (10.65%). Sandy Loam (moderately suitable – S2) had the lowest area, with only 2721 ha (8.87%) (Table 3). The map of Soil Texture is shown in Figure 3e.

Soil Depth is thick which crops' roots can penetrate, develop, and absorb the nutrient. Each crop requires a different depth of topsoil layers to grow well and produce a high yield (Sadras and Calviño, 2001). Deeper topsoil will supply more water and nutrients to crops than shallow topsoil. There was 57.31% of the study area, accounting for 17579.52 ha, deep over 70 cm. It means over half of the study area had a highly suitable depth (S1) for planting groundnut. By contrast, suitable land, marginally suitable land, and unsuitable land with a depth ranging from 0 to 70 cm, constituted about 15% of this district. Therefore, this district has favorable Soil Depth conditions for planting groundnut. The map of Soil Depth is shown in Figure 3f.

2.5.3 Slope

Another criterion that must be considered in the land evaluation process of agricultural land is Slope. It affects the depth of topsoil, irrigation, drainage, and especially the use of machines in the agricultural manufacturing process (AbdelRahman et al., 2016 and Özkan et al., 2020). The slope map showed that the terrain of Dien Chau district is relatively flat. The slope less than 3°, highly suitable (S1), dominated with 62.05% total area, accounting for 19036.36 ha. The slope greater than 3° constitutes only about 10% total area. Hence, the topography condition of this district is very favorable to cultivate groundnut. The map of Slope is shown in Figure 3c.

2.5.4 Constrained areas

Built-up land and Waterbody cannot be cultivated. This land uses also will not be transformed to agricultural land by the current land policy. So they are considered restricted areas and excluded from the mapping of the suitable land assessment process. According to the map data, the area of Built-up land and Waterbody is 6719.51 ha and 1851.88 ha, accounting for 22.23% and 6.04 % of the total area of Dien Chau district, sequentially.

2.6 Land Suitability Mapping

Land suitability index (LSI) will be computed based on the weight of criteria and the score of suitable levels, as the Equation 4:

$$LSI = \sum_{i=1}^{n} w_i \times s_i$$

Equation 4

In which n is the number of criteria. The criteria weight is defined as w_i. Moreover, the score of sub-criteria is represented as s_i. The weighted overlay technique can implement this work in ArcGIS software. The areas with a high land suitability index are more suitable for growing groundnut than those with a low land suitability index. The final land suitability map will be generated after the LSI is reclassified as the above proposal with four suitable levels: highly suitable, moderately suitable, marginally suitable, and unsuitable. The Equation calculates the difference between suitable levels 5:

$$D = \frac{S_{max} - S_{min}}{N} \quad (5)$$

Equation 5

Where S_{max} is the highest score of suitable levels (4), S_{min} is the lowest score of suitable levels (1), and N is the number of ranking levels (4). In this study, S_{max} = 4, S_{min} =1 and N = 4. Hence, the difference between suitable levels D = (4-1)/4 = 0.75 and the scores of 4 suitable levels are 3.25-4, 2.5-3.25, 1.75-2.5, and 1-1.75, respectively.

3. Results

3.1 Weight of Criteria

Nine questionnaires were sent to experts of academic lecturers/researchers and local agricultural managers to evaluate the relative importance of six selected criteria. Their judgments were synthesized by the geometric mean method. Because it satisfies consistency requirements when aggregates the relative importance of pairwise comparisons (Barzilai, 1997). For estimating the weight of six selected criteria, the AHP method was implemented, and weights were calculated by normalizing the Pairwise Comparison Matrix (Table 4). Groundnut flowers above the ground and fruit under the ground require strict conditions of Soil Texture (Smartt, 1994). Furthermore, the growth and yield of groundnut also depend heavily on Soil Texture characteristics (Kanber et al., 1989). Therefore, it is easy to understand why Soil Texture was evaluated by the highest weight (0.31727). The second important criterion was Average Temperature with 0.21131 of weight. It can be explained by the strong dependence of the growing and fruiting of groundnut on temperature (Bolhuis and Groot, 1959). The weight of Soil Type was 0.17426, which was followed by the corresponding figure of Soil Depth, with 0.13982. Slope and Average Total Rainfall were the two selected criteria having the lowest weight, with only 0.08122 and 0.07612, respectively. Local agricultural managers explained this. They underestimated the influence of terrain and rainfall in the groundnut cultivation process in their district because most agricultural land is flat, and an irrigation canal system ensures irrigation. The consistency ratio of Pairwise Comparison judgments was 0.076995 (<0.1), which indicated that these comparisons were consistent (Saaty, 1980). Furthermore, it showed that the relative weights were adequately selected.

The six chosen criteria can be gathered into three main groups: Soil (Soil Type, Soil Texture, Soil Depth), Climate (Average Temperature, Average Total Rainfall), and Topography (Slope). Furthermore, their total weights were 0.63135, 0.28743 and 0.0812, respectively. This result is a similar trend with previous results of agricultural land suitability in Turkey (Bozdağ et al., 2016), cropland suitability in Kenya (Kamau et al., 2015), significantly growing groundnut in Malaysia (Suhairi et al., 2018).

3.2 Land Suitability Map

The groundnut land suitability map showed the highly suitable areas, moderately suitable, marginally suitable, or not suitable to plant groundnut in Dien Chau district (Figure 4a). It was generated by the combination of thematic maps, criteria weights, and sub-criteria scores. The Weighted Overlay tool (in ArcGIS software) was effectively utilized for this purpose.

Table 4: Pairwise comparison matrix

Criteria	(1)	(2)	(3)	(4)	(5)	(6)	Weight
Soil Type (1)	**1**	1/2	2	3	1/2	2	0.17426
Soil Texture (2)	2	**1**	2	3	4	3	0.31727
Soil Depth (3)	1/2	1/2	**1**	3	1/2	2	0.13982
Average Total Rainfall (4)	1/3	1/2	1/3	**1**	1/4	1	0.07612
Average Temperature (5)	2	1/4	2	4	**1**	2	0.21131
Slope (6)	1/2	1/3	1/2	1	1/2	**1**	0.08122
λmax = 6.469	**RI = 1.24**		**CI = 0.094**		**CR = 0.076**		**Σ = 1**

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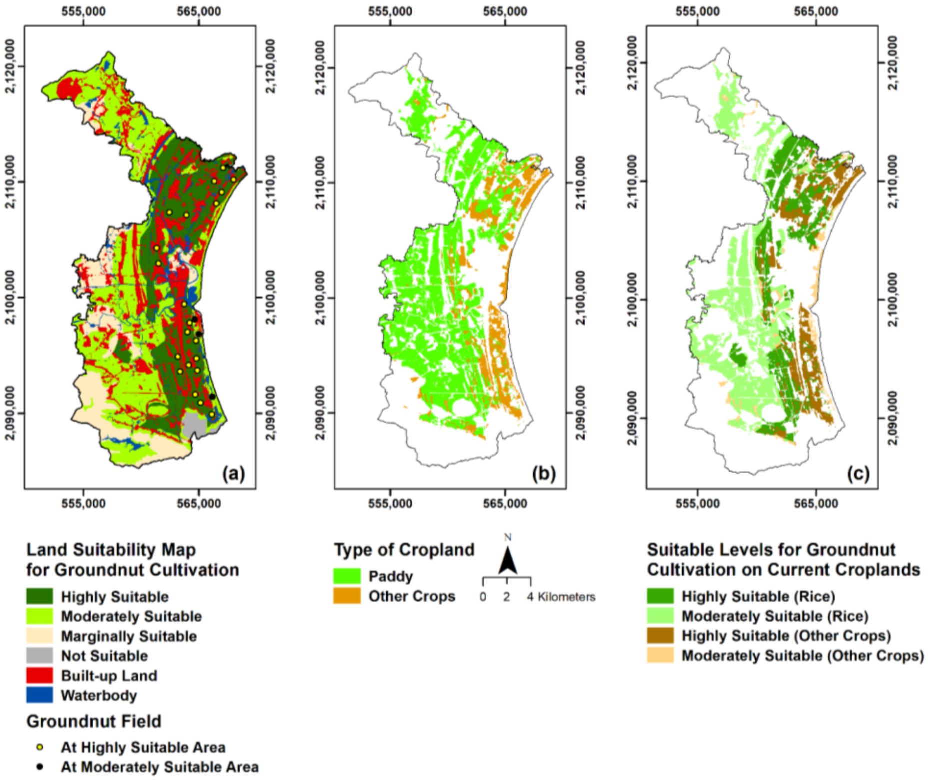

Figure 4: Land suitability maps

The calculation results revealed that the area of highly suitable land for growing groundnut was 6830.07 ha, making up 22.26%. This area was about two times larger than the planted area of groundnut in 2019 (3,278 ha) and mainly concentrated in the eastern parts of the district with favorable conditions of physical properties of soil (Haplic Arenosols, Sandy, topsoil thickness >70 cm) and topography (Slope < 3°). These areas were ideal for groundnut cultivation and promised high yield and quality. The moderately suitable land covered the most prominent area, with 10,413.85 ha, accounting for 33.95% of. It was over three times larger than the current actual planted area of groundnut and distributed in the western parts of the district. It was an integrated of Dystric Fluvisols, Sand, and Silty Loam, topsoil thickness >70 cm, and slope < 3°. The marginally suitable land was scattered in the western parts with 4336.76 ha, comprising 14.14%. There was a small part with only 424.99 ha that was unsuitable for growing groundnut. It was located in the south of the district with unfavorable conditions of physical properties of soil and difficulty in using machinery because of a steep slope. According to the overlay analysis results between groundnut fields location and land suitability map, 25/28 (89.3%) groundnut field was located in a highly suitable area, and 3/28 (10.3%) groundnut field were located in a moderately suitable area (Figure 4a). It means that farmers were right when selected location for groundnut cultivation and indicate a satisfactory fit between the land suitability map and currently agricultural practices.

3.3 Proposed Land for Growing Groundnut

The purpose of agricultural land planning is to indicate the best location for growing a specified crop. For achieving the highest production, the land for growing groundnut should be classified at a moderately suitable level or highly suitable level. Furthermore, planting groundnut on agricultural production land will be the most convenient because of the availability of irrigation and road systems. It will help farmers to be easy to implement intensive cultivation and transport their products (Mishra et al., 2015). In 2020, the total area of cropland was 14592.60 ha, including paddy (11158.14 ha) and other annual crops land (3434.46 ha). The other annual crops were predominantly groundnut and partly maize, sweet potato, mung bean, sesame, watermelon, vegetables.

Table 5: Area of proposed land for groundnut cultivation

	Rice		Other Crops		Total Area (ha)	Percent (%)
	Area (ha)	Percent (%)	Area (ha)	Percent (%)		
Highly Suitable	3760.92	39.40	2645.34	78.20	6406.26	49.55
Moderately Suitable	5784.93	60.60	737.50	21.80	6522.43	50.45
Total	9545.85	100	3382.84	100	12928.69	100

The crop's land map is shown in Figure 4b. The proposed land for growing groundnut is the intersection result of the two highest suitable classes of land suitability index map (highly suitable - S1 and moderately suitable - S2) and crops land map. The result revealed that there was 12928.69 ha, including 3382.84 ha of other annual crops land and 9545.85 ha of paddy land, to be proposed for groundnut cultivation (Figure 4c). The highly suitable land and moderately suitable land area were approximate, with 6406.26 ha (49.55%) and 6522.43 ha (50.45%), respectively. In order to reserve protective forest, some parts in the north and west of this district were not proposed to cultivate groundnut, although they were moderately suitable (Table 5).

The economic efficiency of groundnut production is 2-3 times higher than that of rice production (Sao and Dong, 2017). However, conversion of rice to groundnut on a large scale is infeasible and loses the balance of agricultural goods. For an effective transformation, the authority firstly should determine the low-efficiency rice land located on high lands and highly/moderately suitable for groundnut cultivation. Secondly, policies should be released to encourage farmers to transform from rice cultivation to groundnut cultivation, such as supporting the initial outlay of seed and fertilizer. Thirdly, supervising and technically consulting during the cultivation process to maximize productivity. Last but not least, finding the market for groundnut products both at home and abroad.

4. Conclusion

This research proposed GIS and AHP to evaluate land suitability in Dien Chau district for groundnut cultivation. Six criteria, namely Soil Texture, Soil Type, Soil Depth, Slope, Average Temperature, and Average Total Rainfall, were considered. AHP was used to estimate the weight of criteria based on experts' opinions of the importance of each criterion. Sub-criteria were classified into four classes, including highly suitable, moderately suitable, marginally suitable, and unsuitable, with corresponding scores of 4,3,2,1. The result showed that this district had great potential for planting groundnut, with 17243.92 ha of highly suitable land and moderately suitable land, accounting for 56.21% district's area. However, only 12928.69 ha of these lands where currently cultivate crops, were proposed to cultivate groundnut. The integration of GIS and AHP estimates the degree of influence of ecological factors and shows the location, area, and levels of land suitability for growing groundnut. This study is a good illustration of the usefulness of this method for multiple criteria decision-making. The study result can be utilized as a good reference for efficient use of land resources of local authorities.

Acknowledgments
We are grateful to Mr. Tran Hoai Nam (Land Registration Office, Department of Natural Resources and Environment) who was enthusiastically helped us to collect field data of groundnut fields in the days affected by the Covid pandemic.

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