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Land evaluation for rubber cultivation

Adzemi Mat Arshad*

Laboratory of Soil Science, School of Science and Food Technology, Universiti Malaysia Terengganu, Kuala Nerus, Terengganu, Malaysia

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Key words: Land evaluation, Land characteristic, Rubber, Yield

Abstract

The FAO Framework for Land Evaluation was used for the development of a land evaluation for rubber cultivation in district of Temerloh and Kuantan, Pahang, Peninsular Malaysia. The combined limitation and parametric approach was used as it contributed to a more meaningful interpretation of the results. Eleven series soils were chosen to analyze the land evaluation system. The system of Sys *et al*. was used for the evaluation using land characteristics. The results showed that the evaluation using land characteristics for land evaluation was preferred due to its simplicity and the data required are obtainable from soil survey reports.

* **Corresponding Author:** Adzemi Mat Arshad ✉ adzemi@umt.edu.my

Introduction

Rubber is an important crop in Malaysian economy. Malaysia is currently the world's fifth largest producer of natural rubber after Thailand, Indonesia, Vietnam and China. Natural rubber production in Malaysia increased by 4.1% from 0.67 million tonnes in 2014 to 0.7 million tonnes in 2015. Exports of rubber products from Malaysia surpassed RM15 billion in 2014 and reached nearly RM18 billion in 2015. In 2015, exports of rubber products recorded a positive growth of 18.6% year-on-year, contributed mainly by a strong increase in exports of rubber gloves which accounted for 72.8% of the total exports of rubber products in the year.

For rubber cultivation, choice of land seems to have been limited by steep-sided hills in the interior by mangrove or established paddy on the coast and by inaccessibility in the remaining areas. The was little evidence that the planters preferred a particular land areas except that they avoided the more extensive peat deposits which were difficult to drain (Wycherley, 1963). Since rubber industry is important in agriculture sector suitable land has to be evaluated for rubber cultivation.

The different land evaluation systems in the country consider soil and landscape properties. As such the existing system of land evaluation for rubber in Peninsular Malaysia is confined solely to the evaluation of soil and landscape (Chan and Pushparajah, 1972).

Climate is often assumed to be the same or it is considered that differences due to climate are insignificant. Climate often defines ecological zones. As such the evaluation of climate forms a very important part in land evaluation. The relationship between climate and yield of rubber is not well studied in this country. This research is aimed to integrate all relevant climatic features, soil and landscape properties to evaluate the suitability of land for rubber cultivation in District of Temerloh and Kuantan, Pahang, Peninsular Malaysia.

Materials and methods

Climatic data of the study area

The evaluation criteria of climate suitability for rubber considered the climatic features that affect growth and yield of rubber. The criteria chosen are mean annual temperature, mean daily maximum temperature, mean daily minimum temperature, mean annual rainfall, length of dry season, sunshine and mean annual relative humidity.

Two meteorological stations in Pahang, Peninsular Malaysia were selected for the study. They are Temerloh (Table 1) and Kuantan (Table 2). The climatic data from Malaysian Meteorological Services Department between 2007 to 2016 of the above stations were used in this study. The principles of FAO (1976) were used together with the methodology of combined limitation-parametric evaluation methods. In the parametric approach the ratings for each climatic factor were multiplied in order to obtain a final score called climatic index. Climatic indices were expressed as percentages. The evaluation criteria of climatic requirements for rubber cultivation as proposed by Sys *et al.* (1991) was used in this study as shown in Table 3.

Table 1. Climatic data for Temerloh (Average over 10 years).

Criteria \ Months	J	F	M	A	M	J	J	A	S	O	N	D	Annual mean	Total
Mean temp.(°C)	25.8	26.4	27.2	27.6	27.7	27.2	27.0	26.7	26.7	26.7	26.2	25.8	26.7	
Mean daily max. temp (°C)	31.4	32.6	34.0	34.4	34.6	33.7	33.5	33.3	33.2	33.1	32.1	31.1	33.1	
Mean daily min. temp (°C)	22.5	22.5	23.1	23.6	23.8	23.4	23.0	23.1	23.1	23.2	23.2	23.0	23.1	
Mean rainfall (mm)	150.0	125.2	158.0	219.2	149.1	167.8	109.8	168.0	152.1	201.1	237.0	213.2		2050.5
Rain days	17.0	12.0	14.0	14.0	12.0	13.0	10.0	15.0	13.0	17.0	20.0	19.0		
Rainfall intensity	9.0	10.6	11.1	15.3	12.5	12.8	10.8	11.0	11.5	11.5	12.0	11.0		
Sunshine (hrs month^{-1})	173.0	184.0	201.5	209.0	211.0	186.5	185.0	171.0	145.5	162.0	137.0	121.0		2086.5
Mean relative humidity (%)	85.0	82.6	81.5	82.4	83.3	83.7	82.8	84.1	84.3	85.1	87.5	88.0	84.2	
Length of dry season (month year^{-1})														

Table 2. Climatic data for Kuantan (Average over 10 years).

Criteria \ Months	J	F	M	A	M	J	J	A	S	O	N	D	Annual mean	Total
Mean temp.(°C)	25.0	25.4	26.1	27.0	27.3	27.1	27.0	27.0	26.6	26.3	25.5	25.0	26.3	
Mean daily max. temp (°C)	29.4	30.4	31.4	32.6	33.0	27.1	27.0	27.0	26.6	32.0	30.3	29.2	29.7	
Mean daily min. temp (°C)	22.0	22.1	22.6	23.3	23.6	23.4	23.2	23.1	23.1	23.0	23.0	22.5	23.0	
Mean rainfall (mm)	318.4	105.2	207.1	149.3	180.5	147.6	130.0	188.3	229.0	237.0	564.4	574.0		3034.0
Rain days	17.0	11.0	13.0	14.0	15.0	13.0	13.0	16.0	17.0	19.0	23.0	21.0		
Rainfall intensity	18.7	9.6	16.0	10.7	12.0	11.3	10.0	11.8	13.5	12.5	24.7	27.3		
Sunshine (hrs month^{-1})	155.0	196.0	201.5	213.0	211.0	201.0	192.2	186.0	159.0	149.0	102.0	111.6		2077.1
Mean relative humidity (%)	85.6	85.0	84.5	84.2	84.5	83.5	83.5	83.6	84.5	86.0	89.4	88.4	85.2	
Length of dry season (month year^{-1})														0.0

Table 3. Climatic requirements for rubber cultivation.

Climatic Characteristics	Climatic Class, Limitation and Rating Scale						
	S1	S2	S3	N1	N2		
	0	1	2	3	4		
	100	95	85	60	40	25	0
Mean annual temp. (°C)	28-25	24 – 22	21 – 20	19 – 18	<18	-	
Mean daily max. temp (°C)	34 – 29	28 – 27	26 – 24	23 – 22	<22	-	
Mean daily min. temp. (°C)	>20	20 – 19	18 – 17	16 – 15	<15	-	
Mean annual rainfall (mm yr $^{-1}$)	>2000	2000 - 1750	1749 -1500	1449 - 1250	<1250	-	
Expected total rain Interference (days/year)	0-30	31-60	61-90	>90			
Maximum wind Speed (m/s)	0-7	8-14	15-21	22-30	>30		
Length of dry season (mths yr $^{-1}$)	0 – 1	1 – 2	2 – 3	3 – 4	>4	-	
Sunshine (hrs yr $^{-1}$)	>2100	2100 - 1800	1799- 1400	1399- 1000			
Mean annual relative humidity (%)	<80	80 – 100					

Source: Yew, F.K. (1982).

Location of study area

The study area (Fig. 1) is located in the central part of the state of Pahang, Peninsular Malaysia. The geological formations are mainly sedimentary and metamorphic rocks in Temerloh, Maran and recent riverine and marine alluvium occurs on coastal plains and low hills inland in Kuantan. The natural vegetation is tropical rain forest. A total of 11 land units derived from a varied geology and providing a range of particle size class as well as different profile development stages were used in this study. Table 4 shows the soil series and their associated parent material. The evaluation of land (Table 5) for rubber cultivation by using land characteristics uses soil and landscape criteria given by Sys *et al.* (1991) is shown in Table 6.

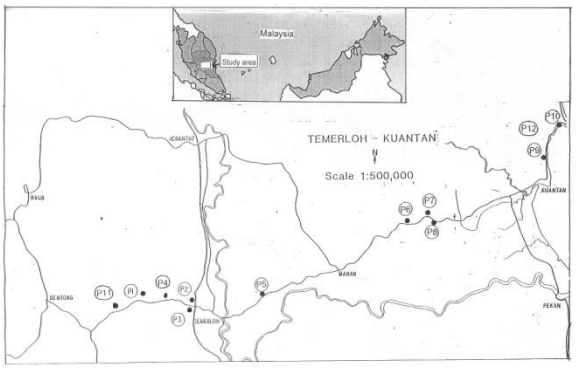

Fig. 1. Location of the Pedons.
Source: S. Paramananthan (1977).

Table 4. The classification of the soils.

Profile No.	Soil Series	Soil Taxonomy Sub-group Level	FAO
1	Lancang	Typic Kandiudult	Haplic Acrisol
2	Musang	Plinthic Paleudult	Plinthic Acrisol
3	Batu Anam	Plinthaquic Hapludult	Plinthic Acrisol
4	Durian	Typic Plinthudult	Plinthic Acrisol
5	Segamat	Rhodic Hapludox	Plinthic Acrisol
6	Bungor	Typic Kandidult	Haplic Nitisol
7	Pohoi	Typic Kandidult	Haplic Nitisol
8	Kemuning	Typic Kandidult	Haplic Nitisol
9	Beserah	Typic Hapludox	Xanthic Ferralsol
10	Kawang	Plinthic Kanhapludux	Plinthic Acrisol
11	Rengam	Typic Kandidult	Haplic Nitisol

Table 5. Land characteristics of representative land units in Temerloh-Kuantan.

Land Unit	Topography/ Slope (t) (%)	Wetness(w)		Physical Soil Characteristics (s)		Soil Fertility Characteristics at 50cm depth (f)			
		Flooding	Drainage	Texture/ Structure	Depth (cm)	CEC (cmol(+)/ kg soil	BS (%)	pH (H_2O)	Organic carbon (%)
Lancang	14	No	Well drained	Cs	210	6.58	5.5	3.8	0.8
Musang	4	No	Well drained	SiC	100	8.7	10.0	3.8	2.6
Batu Anam	16	No	Somewhat imperfect	Cs	98	7.2	8.0	4.5	0.85
Durian	9	No	Mod. well. drained	Cs	104	7.7	3.8	4.2	0.4
Segamat	8	No	Well drained	Cs	137	9.2	2.4	4.4	1.1
Bungor	22	No	Well drained	SCL	190	3.2	12.2.	4.8	0.6
Pohoi	18	No	Mod. Well drained	Cs	97	5.8	3.6	4.5	1.4
Kemuning	13	No	Well drained	Cs	56	6.6	5.2	4.4	0.5
Beserah	10	No	Well drained	SCL	141	5.1	12.0.	4.7	0.6
Kawang	14	No	Mod. well drained	SC	66	6.0	34.0	5.2	0.6
Rengam	7	No	Well drained	SCL	150	3.5	6.2	4.8	1.6

Table 6. Land Suitability Requirements for Rubber Based on Land Characteristics.

Climatic Characteristics	Class, Degree of Limitation and Rating Scale						
	S1	S2	S3	N1	N2		
	0	1	2	3	4		
	100	95	85	60	40	25	0
Topography (t)							
Slope (%)	0 – 10	11-209	20- 30	31-45	>45		
Wetness (w)							
Flooding	F_0	F_0	F_1	F_2	-	F_3	
Drainage	Well drained	Mod. well drained	Imperf. drained	Poor (aeric) (easily drained)	Poor (typic) difficult	Very poor	
Physical Soil Characteristics (s)							
Texture/Structure	CL, Co, SC, Cs	SiC, SCL, L	SL, LSf	LSm, LSc Cm, SiCm, Sf	Sm, Sc	LcS, S	
Soil Depth (m)	150	149 – 100	99 – 50	49 – 25	< 25		
Soil Fertility Characteristics (f)							
CEC (cmol(+)kg^{-1} soil	> 16	< 16(-)	< 16(+)				
Base Saturation (%)	> 35	34 - 20	< 20				
Organic Carbon (%)	> 1.5	1.5- 0.6	< 0.6				

For texture/structure, the suffixes: o = weak structure and consistence of the oxic horizon, s = angular or subangular structure, m = massive, f = fine, m = medium, c = coarse

Source: Sys *et al* (1991).

The evaluation for rubber cultivation by using land characteristics uses soil and landscape criteria given by Sys *et al.* (1991) is shown in Table 3. The suitability classification is a qualitative classification. Classes are defined with regard to the number and the intensity of the limitations and are generally related to a specific value of land indices calculated for individual ratings of characteristics according to the general formula:

$$C = A \cdot \frac{B}{100} \cdot \frac{C}{100} \cdots$$

Land suitability classification is an agreement with the FAO framework of land evaluation (FAO, 1976) defining orders, classes and subclasses. The class is indicated by an arabic number in sequence of decreasing suitability within each order. Therefore it reflects degree of suitability within each order. Based on these consideration orders and classes are defined as follows:

Order S : Suitable
Land units with no, slight or moderate limitations and no more than two severe limitations that however do not exclude the use of the land. The land index is > 25 to 100

Class S1 : Highly suitable
Land units with no or only slight limitations which in combination give land index values ranging from 75 to 100

Class S2 : Moderately suitable
Land units with slight or moderate limitations which in combination give land index values ranging from 50 to 74

Class S3: Marginally suitable
Land units with moderate limitations or normally not more than two severe limitations which in combination give land index values ranging from 25 to 49.

Order N: Not suitable
Land units with more than two severe limitations or with at least one very severe limitations that exclude the use of the land. The land index is normally 24 or less.

Class N1: Currently not suitable
Land units with severe or very severe limitations which may be overcome in time but which cannot be corrected with existing knowledge at current acceptable cost.

Class N2: Permanently not suitable
The following subclasses are considered
t: topography limitations
w: wetness limitations
s: limitations of physical soil conditions
f: soil fertility limitations

Results and discussion

Evaluation of Climate for Rubber Cultivation in Temerloh and Kuantan District

Table 7 shows the evaluation of climate for rubber cultivation in the regions. All the regions have no limitations to good rubber cultivation.

Table 7. Evaluation of climate for rubber cultivation in Temerloh and Kuantan district.

Characteristics	Temerloh	Kuantan
Mean temp.	0(100)	0(100)
Mean daily max. temp.	1(99)	1(99)
Mean daily min. temp.	0(100)	0(100)
Mean annual rainfall	0(100)	0(100)
Sunshine	1(90)	1(90)
Mean annual relative humidity	0(100)	0(100)
Length of dry season	0(100)	0(100)
Actual suitability	S1(89)	S1(89)
Potential suitability	S1(95)	S1(95)

Land Evaluation by Land Characteristics and Climate of the Region

The actual suitability of the land units consider the land in its original condition without any improvement measures at the time of land clearing from primary forest conditions prior to subsequent cultivation. Even if rubber can be grown, the control of plant diseases are not done.

The results showed that the actual suitability classification of the land unit are ranked as follows: Lancang, Durian, Segamat and Rengam soil series are marginally suitable: Musang, Batu Anam, Bungor, Pohoi, Kemuning, Beserah and Kawang soil series are currently not suitable (Table 8).

The potential suitability of the land refers to its suitability after improvements have been made on the land. The improvement that may be required include the control of flooding, the drainage of water-logged land, the control of soil erosion hazards or the construction of roads and paths to increase accessibility and traffic ability. Minor improvements of the land include the use of fertilizers to improve soil fertility status for the low nutrient of the soils. The standard agronomic practices include the establishment of legume covers, the control of weeds and diseases.

The ranking of the potential suitability classification of the land units are as follows: Lancang and Durian soil series are highly suitable: Batu Anam, Segamat, Bungor, Pohoi, Kemuning, Beserah and Rengam soil series are moderately suitable: Musang and Kawang soil series are marginally suitable (Table 9).

Table 8. Actual Suitability Classification of the Land Units for Rubber Cultivation by Using Land Characteristics for Temerloh-Kuantan, Pahang.

Land Unit	Topography Slope (t)	Wetness(w)		Physical Soil Characteristics (s)		Soil Fertility Characteristics at 50cm depth (f)			Climate (c)	Land Index	Suitability Class
		Flood	Drainage	Texture/ Stucture	Depth	CEC	BS	OC			
Lanchang	2 (85)	0(100)	0(100)	0(100)	0(100)	2(85)	2(85)	1 (95)	1(89)	52	$S3t_f$
Musang	3 (60)	0(100)	0(100)	2(85)	0(100)	2(85)	2(85)	2(85)	1(89)	28	Nts_f
Batu Anam	2 (85)	2(85)	2(85)	0(100)	0(100)	2(85)	2(85)	1 (95)	1(89)	37	N_{tsf}
Durian	1 (95)	1(95)	0(100)	0(100)	0(100)	2(85)	2(85)	1 (95)	1(89)	55	$S3_f$
Segamat	2 (85)	2(85)	1(95)	0(100)	0(100)	2(85)	1(95)	1(95)	1(89)	47	$S3t_f$
Bungor	3 (60)	0(100)	0(100)	1(95)	0(100)	2(85)	2(85)	1(95)	1(89)	35	Nt_f
Pohoi	3 (60)	0(100)	0(100)	0(100)	0(100)	2(85)	2(85)	2(85)	1(89)	33	Nt_f
Kemuning	3 (60)	1(95)	0(100)	0(100)	0(100)	2(85)	2(85)	2(85)	1(89)	31	Nt_f
Beserah	3(60)	1(95)	0(100)	1(95)	0(100)	2(85)	2(85)	1(95)	1(89)	35	Nt_f
Kawang	2(85)	1(95)	0(100)	3(60)	0(100)	2(85)	1(95)	1(95)	1(89)	33	Ntsf
Rengam	2(85)	1(95)	0(100)	1(95)	0(100)	2(85)	2(85)	1(95)	1(89)	47	$S3t_f$

Table 9. Potential Sutability Classification of the Land Units for Rubber Cultivation by Using Land Characteristics for Temerloh-Kuantan, Pahang.

Land Unit	Topography Slope (t)	Wetness(w)		Physical Soil Characteristics (s)		Soil Fertility Characteristics at 50cm depth (f)			Climate (C)	Land Index	Suitability Class
		Flooding	Drainage	Texture/ Stucture	Depth	CEC	BS	OC			
Lanchang	1(95)	0(100)	0(100)	0(100)	0(100)	0(100)	0(100)	0(100)	1(95)	90	S1
Musang	2(70)	0(100)	0(100)	1(95)	1(92)	0(100)	0(100)	0(100)	1(95)	58	S3t
Batu Anam	1(90)	0(100)	1(90)	0 (100)	0(100)	0(100)	0(100)	0(100)	1(95)	77	S2t
Durian	1(99)	0(100)	0(100)	0(100)	0(100)	0(100)	0(100)	0(100)	1(95)	94	S1
Segamat	1(90)	1(90)	1(95)	0(100)	0(100)	0 (100)	0(100)	0(100)	1(95)	73	S2tw
Bungor	2(70)	0(100)	0(100)	1(95)	0(100)	0(100)	0(100)	0(100)	1(95)	63	S2t
Pohoi	2(70)	0(100)	0(100)	0(100)	0(100)	0(100)	0(100)	0(100)	1(95)	66	S2t
Kemuning	2(70)	0(100)	0(100)	0(100)	0(100)	0(100)	0(100)	0(100)	1(95)	66	S2t
Beserah	2(70)	0(100)	0(100)	1(95)	0(100)	0(100)	0(100)	0(100)	1(95)	66	S2t
Kawang	1(90)	0(100)	0(100)	3(60)	0(100)	0(100)	0(100)	0(100)	1(95)	51	S3ts
Rengam	1(90)	0(100)	0(100)	1(95)	0(100)	0(100)	0(100)	0(100)	1(95)	81	S2t

Soil Properties and Management Implication for Rubber Cultivation

Lancang series soil has low base saturation and low CEC values indicate that these soils have a low inherent fertility status and therefore a good dosage of fertilizers is necessary if high yields of crops are to be obtained and maintained. With fertilization the soils should be suitable for a wide range crops depending on the slopes on which these soils occur. The yield potential of these soil for rubber is 2,500-2,700 kg/ha Panel B. Musang series soil has moderate to low fertility status and thus a good dosage of

fertilizers need to be applied if good yields are to be obtained. Physically these soils have coarse structures and firm consistence with low permeability which can result in temporary ponding at the surface. Moderate hindrance to root growth can be expected in this soil. K reserves are slightly higher but release may be slow. The yield potential on this soil for rubber is 2,000-2,500 kg/ha Panel B.

Batu Anam series soil is mainly governed by their coarse structures and firm consistence coupled with their low permeability. Temporary water-logging is common after rain. Root growth is severely hindered in this soil. To prevent this some shallow surface drains are necessary. This soil has a low fertility status with some reserve of potassium. Their yield potential for rubber is 1,700-2000 kg/ha Panel B.

Durian series soil has strong structures and firm consistence. Root proliferations are moderately to severely hindered in this soil. This soil has a low fertility status but a good reserve of potassium though it may be released slowly. The rubber potential yield is 1,800-2,100 kg/ha Panel B.

Segamat series soil has low fertility status, very low cation retention capacity and low moisture retention due to the soil's high permeability. Establishment of crops sensitive to moisture stress on this soil is difficult. The use of an organic mulch not only helps to improve moisture but also makes phosphorus more readily available should be practiced. Higher levels and band placement of phosphorus also helps to improve phosphorus uptake. The use of empty fruit bunches should also be beneficial on such soils. The potential rubber yield is 2,500-3,000 kg/ha Panel B.

Bungor series soil is deep, well to moderately well drained soils with a low inherent fertility status. Terrain will be a limiting factor on these soils as they occur on slopes up to 38%. Thus a good dosage of fertilizer needs to be applied if good yields are to be obtained. The rubber yield potential is 2,500-3,000 kg/ha Panel B.

Pohoi series soil has similar to that of Bungor series except for its colour. Most of Pohoi series is moderately deep. Root growth is moderately to severely hindered in this soil due to its firm consistence and coarse structures. This soil has a low inherent fertility fertility status and commonly occur on rolling to hilly terrain. Thus the management of this soil often involves soil conservation practices and fertilizer applications. The potential rubber yield is 1,800-2,000 kg/ha Panel B.

Kemuning series soil commonly occurs on hilly to rolling terrain and hence soil conservation measures are important. Root growth is moderately to severely hindered in this soil. The fertility status is moderate to low. The potential rubber yield is 1,800-2,100 kg/ha Panel B.

Beserah series soil commonly occurs on rolling to hilly and steep terrain and due to their gravelly nature they are highly erodible soils. Moreover due to the presence of these gravels their effective clay content is much less and hence they are prone to moisture stress and hence yield fluctuations depending on rainfall. This soil is also of low fertility status. Thus mulching and the use of fertilizers are essential if high yield are to be obtained. Soil and water conservation measures will be helpful. The rubber yield potential is 2,200-2,700 kg/ha Panel B.

Kawang series has low base saturation and low cation exchange capacity values indicate a soil that is infertile. The moderate depth can cause rooting problems in the later stages of growth. Moisture stress can be a problem if the rainfall distribution is not good. The rubber yield potential is 2,000-2,300 kg/ha Panel B.

Rengam series soil is deep, well drained soils with a low inherent fertility status. This is very common soils on granite. Terrain can be a limiting factor in this soil and hence soil erosion can be serious. A goof fertilizer program is essential to obtain and maintain good yield. The rubber yield potential is 2,700-3,000 kg/ha Panel B (Paramananthan, 1977).

It is important to preserve the organic matter in the top soil. The data showed that for impoverished soils the upper horizons with higher organic matter contents contribute significantly to higher cation retention capacities and larger nutrient reserve. Soong and Lau (1977) reported that the organic matter also contributes substantially in maintaining a good soil structure. Similarly, the soils which are low in nutrients and rubber grown on these soils require an ample supply of fertilizers. The results showed that the evaluation using land characteristics for land evaluation was preferred due to its simplicity and the data required are obtainable from soil survey reports.

Conclusion

Considering the planting of rubber on the basis of land suitability evaluation showed that Lancang and Durian soil series are highly suitable: Batu Anam, Segamat, Bungor, Pohoi, Kemuning, Beserah and Rengam soil series are moderately suitable: Musang and Kawang soil series are marginally suitable. For rainfed agriculture, rubber planting on the respective suitable soil series will deal mainly with maintenance of soil fertility. The evaluation work is based on survey of natural resources of land units, the final decision for planting of rubber should be made after integrating with investigations such as socio-economic conditions, agricultural services and human resources.

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