Tropical Agricultural Research Vol. 9 1997, 245-260

Land Suitability Evaluation for Cultivation of Oil Palm in the Wet Zone of Sri Lanka

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ABSTRACT. As a result of increasing consumption and decreasing production of edible oil, mainly coconut oil in Sri Lanka, other types of edible oil is presently being imported spending considerable foreign exchange. Therefore it becomes necessary to exploit new sources of edible oil in order to augment oil production in the country. The objective of this study was to evaluate the suitability of the wet zone lands for oil palm cultivation. The Low Country Wet Zone of Sri Lanka was identified as the most suitable area where the unproductive rubber and tea lands can be used to cultivate this crop. Lands of this area were characterized, evaluated and classified into suitability classes for cultivation of oil palm according to FAO classification system. Ten soil series were evaluated with their land characters. From these soil series Dodangoda, Pallama, Pannila, Malaboda and Agalawatta series were identified as the most suitable for growing oil palm. Boralu and Pallegoda series were classified as moderately suitable due to soil moisture limitations and erosion hazard, respectively. Nehinna series which showed erosion hazard and rockiness was also classified as moderately suitable. The Waguru and Madabokke series were unsuitable for oil palm cultivation due to many unfavourable factors including poor drainage.

INTRODUCTION

The consumption and export of coconut oil is increasing in Sri Lanka while the production is decreasing. In year 1996, 800 metric tons of copra was imported (Central Bank of Sri Lanka, 1996). Therefore it becomes necessary to exploit new sources of edible oil. One of the recognized potential sources of edible oil is oil palm (*Elaeis guineensis*) which can yield a tremendous quantity of oil per hectare. It has been reported that oil palm yields oil in the

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range of 2500–4000 kg/ha with an average of 2750 kg/ha from 15 years of age onward, against a yield of 600–1500 kg/ha of coconut oil, 340–440 kg/ha of ground nut oil and 230–400 kg/ha of soya been oil (Srivastara, 1975). Thus, no member of plant kingdom is capable of giving such a high yield of oil, as oil palm.

While the oil palm is the highest yielder of oil, it's cost of production is amongst the lowest. Oil palm produces fruits regularly from 5 years to 30 years of age and continuity of oil supply is ensured (Hartley, 1976). Additionally, oil obtained from palm fruits is of high quality. Palm oil is the only oil with vitamin A content comparable to cod-liver oil and also ten times richer than butter. Palm oil and palm kernel oil are used to manufacture edible fats as well as soap (Corley, 1982).

The oil palm is a typical tree crop of tropical rain forest and in equatorial areas it can be grown up to altitudes of about 600 m. The optimum mean daily temperature should be 24°C to 30°C with 1500 mm annual rainfall with dry periods of no longer than 3 months and at least 1300 annual sunshine hours for a high yield of fruits (Landon, 1984). These climatic conditions are found in the Low Country Wet Zone of Sri Lanka.

The total extent of oil palm stand in Sri Lanka was estimated at approximately 2000 ha in 1997 (Watawala Plantation Ltd., 1997) and was confined to Galle district. Oil palm can be expanded to many other areas in wet zone of Sri Lanka. The productivity of this crop will vary depending on the type of land and climatic conditions. No studies have been undertaken to evaluate the potential of growing oil palm in the wet zone of Sri Lanka.

The objective of this study was to characterize and evaluate the Low Country Wet Zone lands of Sri Lanka for suitability of oil palm cultivation. This was achieved by conducting a semi detail soil survey in this area and matching land characteristics with the crop requirement. Each soil series with its other land characters was defined as the land unit in this evaluation.

MATERIAL AND METHODS

Selection and description of study area

The semi detailed soil survey conducted to evaluate suitability for oil palm was limited to Low Country Wet Zone soils. The major soil great groups of this zone consist of various mapping units of Red Yellow Podzolic (RYP), Reddish Brown Latasolic (RBL), Immature Brown Loams (IBL) and Bog and Half Bog soils (De Alwis and Panabokke, 1972). Further subdivisions of wet lowland areas were considered according to rainfall and topography. The locations and agro-ecological zones of the study area are shown in Figures 1A and 1B. The monthly 75% probability of rainfall and mean monthly temperature of each agro-ecological area are shown in Figure 2. The study area covered Matara, Galle, Kalutara, Colombo, Gampaha, Ratnapura and Kegalle districts and was divided in to four major land form systems according to the physiography.

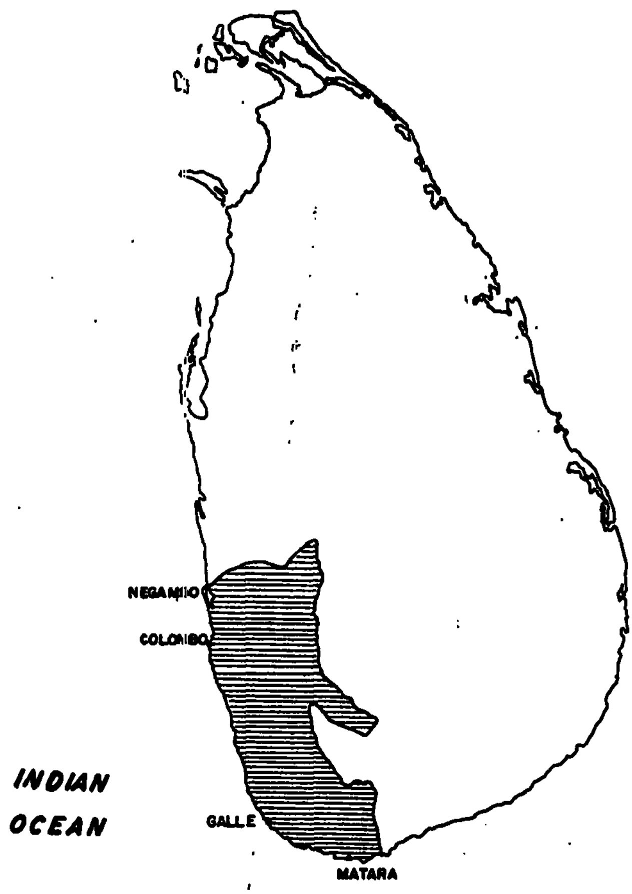

Figure 1A. Location of the study area.

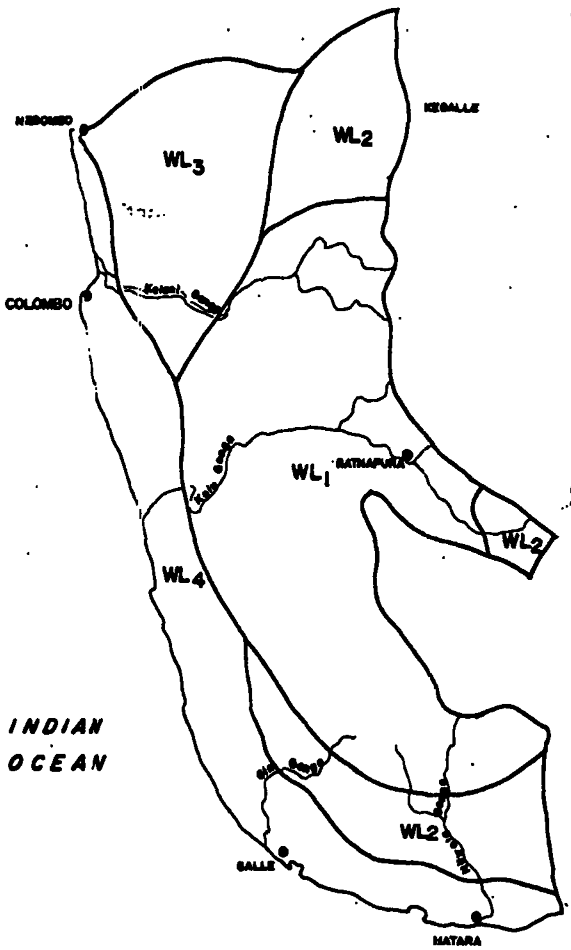

Figure 1B. **The agro-ecological map of Low Country Wet Zone of Sri Lanka.**

Geology of study area

The parent rock in the survey area are from the pre-cambrian and is part of the Highland series. In the survey area, garnet-sillimanite schist and gneiss, quartz-feldspar granulite, charnockite gneiss, pyroxene, amphibolite, garnet biotite gneisses, biotite gneisses and biotite hornblende gneisses are the most common rock types (Cooray, 1984).

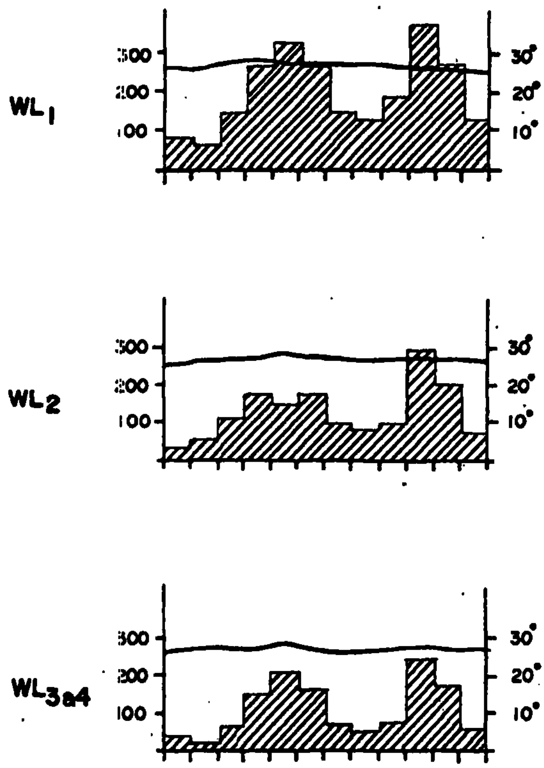

Figure 2. Monthly 75% rainfall probability and mean temperature of Low Country Wet Zone.

Interpretation of aerial photographs

The general approach used was to study the soils on 1:20,000 and 1:25,000 black and white aerial photographs. The aerial photographs were interpreted using a mirror stereoscope equipped with binoculars and used to identify each physiographic unit, soil units and drainage class.

Characterization of soils

Each of the identified units were confirmed by extensive field checking and corrected wherever needed. Land units of each physiographic unit were studied with respect to its general land form, climate (characterized by agro– ecological regions), soil characters, rockiness and degree of erosion. Climatic data was obtained from the Department of Meteorology and Watawala Plantation Ltd.. Soils were characterized by field descriptions according to the methods outlined in the Soil Survey Manual (USDA, 1972). Horizon depths, soil colour, soil texture consistency, structure, gravel content, root penetration, activity of soil organisms and horizon boundaries were described. Field classifications were confirmed using laboratory analysis. The soils were classified in to soil units, having a high degree of homogeneity in their characteristics.

Land characteristics classes

Measured or estimated land characteristics were used for land resource mapping, which include slope, rainfall, soil texture, salinity *etc.*. The land characteristic classes from which relevant land qualities were derived are shown in Table 1. This includes a code for easy reference. It should be noted that these codes are reference numbers to the classes and not grading of the classes in any order.

In characterizing the lands, slope was measured using the Suunto slope meter while the soil drainage and depth observations were made in the field using soil profile pits. The texture was characterized by sieving and pipette method (Gee and Bauder, 1986). Gravel content was obtained as a percentage while describing soil profiles. Soil pH was determined using a pH meter and cation exchange capacity using the ammonium acetate method (Rhoades, 1982). Rockiness was estimated visually during site inspection.

Land suitability evaluation

The general procedure outlined in the FAO soils bulletin No. 32 titled "A Frame Work of Land Evaluation" (FAO, 1976) was used for land suitability classification. This gives a standard set of principles and concepts on which national or regional evaluation methods can be constructed. As shown in Table 2 the framework structure includes the order, class and subclass. The details of the four suitability classes are given below.

Table 1. The land characteristic classes used to evaluate the land suitability for oil palm.

1. Agro ecological region	Code	6. Gravel	Code
WL-1	1	0 - 10	1
WL-2	2	10 - 50	2
WL-3	3	> 50	3
WL-4	4		
2. Slope range		**7. Soil pH**	
0 - 2	1	5.1 - 6.0	1
2 - 16	2	4.0 - 5.0	2
16 - 30	3		
30 - 60	4		
60 - 90	5		
> 90	6		
3. Soil Drainage		**8. CEC**	
Well drained	1	> 10 cmol(+)/kg	1
Imperfectly drained	2	5 - 10 cmol(+)/kg	2
Poorly drained	3	< 5 cmol(+)/kg	3
4. Soil depth		**9. Rockiness**	
Deep	1	0 - 10	1
Moderately shallow	2	10 - 30	2
Shallow	3	> 30	3
5. Soil texture			
Sandy and coarse loamy	1		
Fine loamy to clayey	2		
Mucky clays	3		

Table 2. Structure of the land suitability evaluation method.

Order (Kind of suitability)	Class (Degree of suitability)	Sub Class (Kind of limitations)
S Suitable	S1 Highly Suitable	
	S2 Moderately Suitable	S2–m (moisture) S2–e (erosion) S2–r (rockiness)
	S3 Marginally Suitable	
N Not Suitable	N1 Currently Not suitable	N1–m N1–e N1–r
	N2 Permanently Not suitable	

Class S–1: Highly suitable – Lands having no significant limitations to sustained production or only minor limitations that will not significantly reduce productivity.

Class S–2: Moderately suitable – Lands having limitations which together constitute a moderately severe limitation for sustained production. These limitation will either reduce productivity appreciably below the levels in class S–1 lands or require considerably increased inputs to maintain similar production levels.

Class S–3: Marginally suitable – Lands which has limitations that, in aggregate are severe enough to reduce productivity or require increased inputs to such an extent, that benefits are only marginally greater than the cost.

Class N: Non-Suitable – Lands that are not suitable for a given use, even with improvements that are within the means of the average user.

Sub classes

Land suitability sub classes are defined in terms of dominant limitation that reduce the productivity of the land for a given use. Class S–1 lands have no significant limitations and therefore no sub classes. Class S–2 and class S–3 lands have sub classes which are indicated by the symbol of the land qualities that is limiting. Sub class for class N lands are not usually defined as in many cases the number of limitation are too numerous. The major symbols for sub classes include m – for moisture limitation, e – for erosion and r – for limitation due to rockiness.

RESULTS AND DISCUSSION

Physiography of the study area, the great soil groups and major soil series identified for the agro ecological region of the Low Country Wet Zone are given in Table 3. Ten major soil series were included and the manner these occur in the landscape is shown in Figure 3. Brief description of soil characters of the ten major soil series are given in Table 4. According to the identified land characters, land characteristics classes are summarized in Table 5.

Table 3. Physiography, agro-ecological zones and great soil groups.

Physiography of survey data	Agro ecological region	Great soil group	Major soil series
1. Alluvial plan	WL–4	Bog and half bog soils	1. Wagura series 2. Madabokka series
2. Undulating and rolling	WL–3 and WL–3	RYP with soft and hard laterite	1. Boralu series 2. Dodangoda series 3. Pallama series
3. Hill and valley	WL–1 and WL–2	RYP with strongly mottled sub soil	1. Pallegoda series 2. Pannila series
4. Ridge and valley	WL–1 and WL–2	RYP modal	1. Malaboda series 2. Agalawatta series 3. Nehinna series

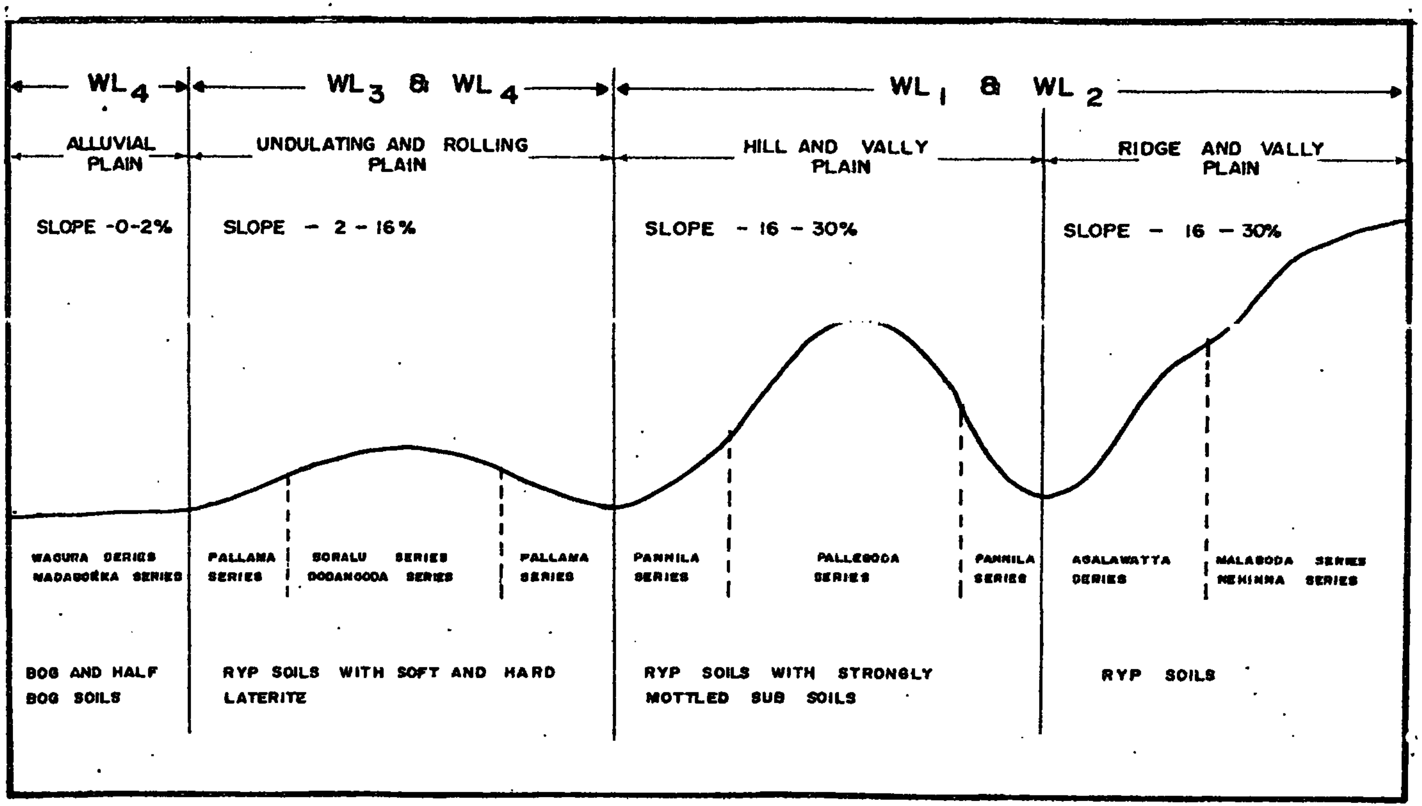

Figure 3. Physiography of the study area.

Table 4. **Some of the important soils identified in the Low Country Wet Zone.**

Soil series	Brief description of the soil
1. Boralu series (unit 1)	Shallow to moderately deep well drained sandy to loamy soils overlying sandy clay loam, ironstone gravel more than 25% up to 75%
2. Dodangoda series (unit 2)	Moderately deep to deep, moderately well drained, sandy loam to light sandy clay loam over loam to clay with hard ironstone gravel more than 25% up to 75%, plinthite within 100 cm
3. Pallama series (unit 3)	Deep, imperfectly drained, coarse loamy over fine loamy soil, with occasional soft and hard ironstone
4. Pallegoda series (unit 4)	Moderately deep, well drained, loamy surface horizons with fine rock fragments and some lateritic gravel over clayey horizons
5. Pannila series (unit 5)	Deep to very deep, well drained sandy clay loam over mottled clayey soils with ironstone gravel less than 25%
6. Malaboda series (unit 6)	Deep to very deep, well drained, sandy clay loam over clay loam with less than 25% ironstone gravel and few decomposing rock fragments in B horizon
7. Agalawatte series (unit 7)	Deep to very deep, well drained sandy clay loam to clay loam, ironstone gravel less than 25% and few rock fragments
8. Nehinna series (unit 8)	Deep to very deep, well drained sandy clay loam to clay loam, common decomposing rock fragments, surface is some time eroded
9. Waguru series (unit 9)	Deep to very deep, poorly to very poorly drained black mucky soils, having more than 30% organic matter, to a depth of 50 cm
10. Madabokka series (unit 10)	Deep to very deep, poorly to very poorly drained, black mucky soils having 15–30% organic matter to a depth of 50 cm

Land qualities

Soil moisture availability

Soil moisture availability for oil palm was estimated by integrating soil characteristics, drainage and the climate characteristics of the different agro-ecological regions. The oil palm root system lies fairly close to the surface. Active root system is between 5–35 cm and maximum depth is about 1.5 m.

In general it seems likely that the greatest part of the root system is closer to the surface, but on a deep soil, some roots may descend to a considerable depth (Hartley, 1976).

The WL-1 and WL-2 regions are expected to feature a 75% expectancy of a minimum of 1 ½ (January and February) month dry period. The RYP modal and RYP strongly mottled sub soil in these regions show high moisture availability. The WL-3 and WL-4 regions are expected to feature a 75% expectancy of a maximum of 2 ½ (January, February, March and August) months dry period.

The Malaboda, Aglawatta, Pallegoda, Pannila and Dodangoda are well drained series showing high moisture availability. The imperfectly drained Pallama series, and the poorly drained Wagura and Madabokka series also show high available moisture. The shallower RYP with soft and hard laterite of these areas have lower moisture availability due to low moisture storage resulting from high laterite content.

Table 5. Land characteristic classes of the Low Country Wet Zone.

Soil series	Zone	Slope	Drainage	Depth	Texture	Gravel	pH	CEC	Rockiness
1. Boralu	3,4	2	1	2,3	1	2,3	2	2	1
2. Dodangoda	3,4	2	1	1	1,2	1,2	1,2	1,2	1
3. Pallama	3,4	1,2	2	1	1	1	1,2	1,2	1
4. Pallegoda	1,2	3	1	2	1	1	2	1	1
5. Pannila	1,2	2,3	1	1	1,2	1,2	2	1	1
6. Malaboda	1,2	3	1	1	1	1	2	1	1
7. Agalawatta	1,2	3	1	1	1	1	2	1	1
8. Nehinna	1,2	3	1	1	2	1	2	1	2
9. Waguru	3,4	1	3	1	3	1	1,2	1	1
10. Madabokka	3,4	1	3	1	3	1	1,2	1	1

Nutrient availability

The nutrient availability for crop growth depends on the natural fertility of the soil (release of nutrients from weathering of minerals), cation exchange capacity and soil acidity.

Nutrient demand by oil palm

Three types of nutrient demand by oil palm may be distinguished. They are:

(a) Nutrient removed from the area entirely as in fruit bunches
(b) Nutrient taken up and not returned by the palm, since they are immobilized in the palm itself
© All nutrients recycled to the soil in leaf litter, dead leaves and male inflorescence

Of these (a) + (b) is a measure of the long–term depletion of the soil, while (a) + (b) + © is a measure of the immediate rate of supply to the roots which the soil must be able to provide. According to Tinker (1976) soil must be able to supply 1.3 kg N, 0.2 kg P, 1.8 kg K to each palm per year of which about 60% is permanently removed from the soil.

CEC values of the Malaboda, Agalawatta, Pallegoda, Pannila, Pallama and Nehinna series were approximately 10–15 cmol(+)/kg while Boralu and Dodangoda series showed values less than 10 cmol(+)/kg. Wagura and Madabokka series had CEC values higher than 15 cmol(+)/kg. Acidity of the top soil of all well drained and moderately well drained soils of the study area was between pH of 5.5–6.0 and that of the sub soil was between 5.0–5.5. Due to high rainfall and high temperature of this region weathering and leaching are higher. Therefore, the nutrient availability of the study area is medium to low and application of fertilizer is necessary for higher yields.

Resistance to erosion

The resistance to erosion depend on the erosivity of rainfall (rainfall amount and intensity), erodibility of soil and topography. The lands in agro–ecological regions WL–1 and WL–2 having high rainfall exhibit higher susceptibility to erosion than the lands in WL–3 and WL–4. Due to higher rainfall intensity some areas of WL–4 region are also faced with erosion hazard.

Availability of solar radiation

Sunshine hours of each agro–ecological region for the 10 years from 1986 to 1995 as the mean annual and mean daily sunshine hours are shown in Table 6. It is apparent that solar radiation availability is low in WL–1 and WL–2 than WL–3 and WL–4 due to low sunshine duration during rainy days, but there is no considerable differences among them. All these regions show more than 1300 sunshine hours per annum which is very favourable for fruit set. The rainfall records are shown as the mean annual rainfall exceeding 1500 mm in this area. Therefore, solar radiation availability and the rainfall of entire Low Country Wet Zone is sufficient to meet the demand by oil palm.

Land suitability evaluation

The ten soil series were classified into four suitability classes by using these evaluations as shown in Table 7. Accordingly, Dodangoda, Pallama, Pannila, Malaboda and Agalawatta series are the most suitable with the highest potential for oil palm cultivation. Unproductive rubber and tea lands in these series could be used to cultivate oil palm effectively. The Boralu series showed limitations of soil moisture while Pallegoda series showed erosion hazard and were classified as moderately suitable for oil palm cultivation. The

Table 6. Mean annual and mean daily sunshine hours in the agro-ecological zones of Low Country Wet Zone.

Agro–ecological zone	Mean annual sunshine hours	Mean daily sunshine hours
WL–1	2417	6.62
WL–2	2392	6.65
WL–3	2473	6.77
WL–4	2526	6.92

Table 7. Suitability of the ten soil series for oil palm cultivation.

Soil series	Suitability class
1. Boralu series	S–2m
2. Dodangoda series	S–1
3. Pallama series	S–1
4. Pallegoda series	S–2e
5. Parnila series	S–1
6. Malaboda series	S–1
7. Agalawatta series	S–1
8. Nehinna series	S–2er
9. Waguru series	N
10. Madabokka series	N

Nehinna series which showed two limitations, erosion hazard and rockiness was also classified as moderately suitable. The Waguru and Madabokke soil series were classified as non suitable due to poor drainage and many other unfavourable factors.

CONCLUSIONS

Oil palm has been suggested as a potential source of edible oil as an alternative to coconut oil. This study was an attempt to evaluate the suitability of wet zone soils of Sri Lanka for oil palm cultivation. The lands were classified using the FAO guidelines for land suitability classification to highly suitable, moderately suitable, marginally suitable and non–suitable for oil palm cultivation. Land qualities such as moisture and nutrient availability, resistance to erosion, drainage were used in this evaluation. The Dodangoda, Pallama, Pannila, Malaboda and Agalawatta series were classified as the most suitable having the highest potential for oil palm cultivation. Unproductive rubber and tea lands in these series can be used to cultivate oil palm effectively. The Boralu and Palleboda series were classified as moderately suitable due to soil moisture limitations and erosion hazard, respectively. The Nehinnna series showed erosion hazard and rockiness to be classified as moderately suitable. Due to poor drainage and many other limiting factors Waguru and Madabokke soil series were classified as non suitable for oil palm cultivation.

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