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Suitability of Mid Country Wet Zone Lands for Plantation Agriculture

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ABSTRACT. Lands in the mid country wet zone region of Sri Lanka hold high potential for plantation crops under rainfed conditions. This region receives an annual rainfall in the range 1250–3150 mm and is at an elevation ranging from 300 to 900 m. The objective of this study was to evaluate the suitability of mid country wet zone lands for plantation agriculture under rainfed conditions. Ten soil series were identified in this region and was evaluated using the FAO framework for land suitability evaluation. The land characteristics used were soil depth, texture, drainage, depth to ground water, gravel content, rockiness, slope, presence of wetherable minerals, cation exchange capacity (CEC), base saturation (BS%) and soil reaction (pH). These land characteristics were used to determine the land qualities. The results indicated that Maluboda, Homagama, Pallegoda and Weddagala series were most suitable for tea cultivation while all the lands in mid country were moderately suitable for coconut cultivation. Only Mawanella series was suitable for rubber cultivation. Kiribathkumbura series was found to be as non suitable for any of the plantation crops due to poor drainage condition.

INTRODUCTION

Land suitability evaluation is a process of estimating the potential of lands for alternative uses. This involves matching of the requirements of land uses and the qualities of the lands which could be obtained from the characteristics of the land (Dent and Young, 1984). The land and soil information collected in soil survey investigations are used to guide planners to identify the most beneficial use of resources while conserving them for the future use (Landon, 1984). The mid country wet zone of Sri Lanka is

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subdivided in to three agro-ecological regions (AER) namely, WM-1, WM-2, and WM-3. These three AERs are mainly differentiated on the basis of amount and distribution pattern of 75% probability of monthly rainfall. The wettest AER is WM-1 with a mean annual rainfall of 3150 mm while WM-2 is intermediate with a mean annual rainfall of 1400 mm, and the lowest mean annual rainfall of 1250 mm is found in WM-3 (Panabokke, 1996). The elevation ranges from 300 to 900 m amsl and the extent of the mid country wet zone is about 0.32 million ha. Plantation Agricultural crops such as tea, rubber and coconut are the dominant land uses within the mid country wet zone which earn valuable foreign exchange. In addition WM-2 and WM-3 regions are used to cultivate other export agricultural crops. As a result of the population increase, there is a growing demand to release the agricultural lands for non agricultural uses such as housing, industrial parks, forest reserve, *etc.* Therefore, it is important to evaluate the suitability of lands in mid country for major plantation crops under rainfed conditions.

The objective of this study was to evaluate the suitability of lands in the mid country wet zone for plantation crops under rainfed conditions.

MATERIALS AND METHODS

This study was conducted in the mid country wet zone of Sri Lanka. Ten extensively distributed upland soil series in this region (Senarath and Dassanayake, 1998) were used to obtain the soil information for this evaluation. The names of soil series, their great soil groups and Soil Taxonomic equivalents are given in Table 1.

Monthly rainfall (75% probability) for WM-1, WM-2, and WM-3 are shown in Figure 1. The suitability of lands in mid country were evaluated for the cultivation of tea, rubber and coconut under rainfed conditions according to the guidelines given in the framework for land evaluation proposed by the FAO (1976). According to this method, land qualities were derived using characteristics of the soils and matched with the requirements of crops to arrive at a suitability rating for each land unit. The mean monthly rainfall, mean monthly temperature and mean potential evapotranspiration rates were obtained from the Natural Resource Management Center (NRMC) of the Department of Agriculture, Sri Lanka. The distribution of three AERs in the mid country wet zone is shown in Figure 2 (Source: NRMC, Dept. of Agriculture). Soil properties such as, soil reaction (pH), cation exchange capacity (CEC), base saturation (BS%), major plant nutrients, soil texture, drainage, land characteristics such as surface rockiness and slope were used for this evaluation purpose. Certain land characters were observed and measured in the field while soil physical and chemical properties were determined in the laboratory. Soil samples for the determination of soil physical and chemical properties were obtained from the benchmark soil profiles for each soil series. Soil texture was determined using pipette method as described by Gee and Bauder (1986). Slope, landform, and stoniness of the study area were also recorded. The Sunto slope meter was used to measure the slopes, while the observations on drainage and soil depth were made in the field using the soil profiles. Soil depth was taken as the depth from the surface to parent material. Rockiness was estimated visually during site inspection. Soil acidity and CEC was measured by using a pH meter and ammonium acetate method, respectively (Rhoades, 1982).

Table 1. Soils of the mid country wet zone.

Soil Series	Great Soil Group**	Soil taxonomic name*
Galigamuwa	Red Yellow Podsolic soils (RYP)	Typic Haplustults
Matale	Reddish Brown Latosolic soils (RBL)	Typic Rhodustalfs
Kiribathkumbura	Low Humic Gley soils (LHG)	Aeric Fluvaquents
Kandy	RBL soils	Typic Troporthents
Mawanella	Immature Brown Loam soils (IBL)	Udic Ustorthents
Akurana	IBL soils	Typic Troporthents
Malaboda	RYP soils	Humic Hapludults
Pallegoda	RYP soils	Typic Paludults
Homagama	RYP soils	Typic Tropopsamments
Weddagala	RYP with semi-prominent A1 horizon	Typic Haplohumults

* Senarath and Dassanayake (1998) ** de Alwis and Panabokke (1972)

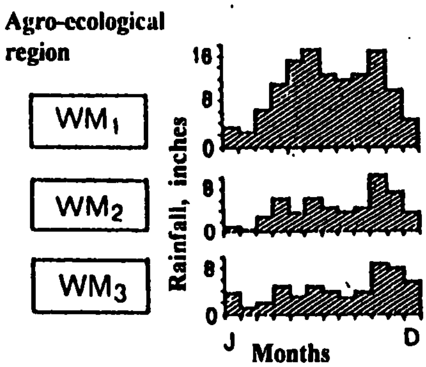

Figure 1. Monthly 75% rainfall probability for WM–1, WM–2, and WM–3 agro–ecological regions.

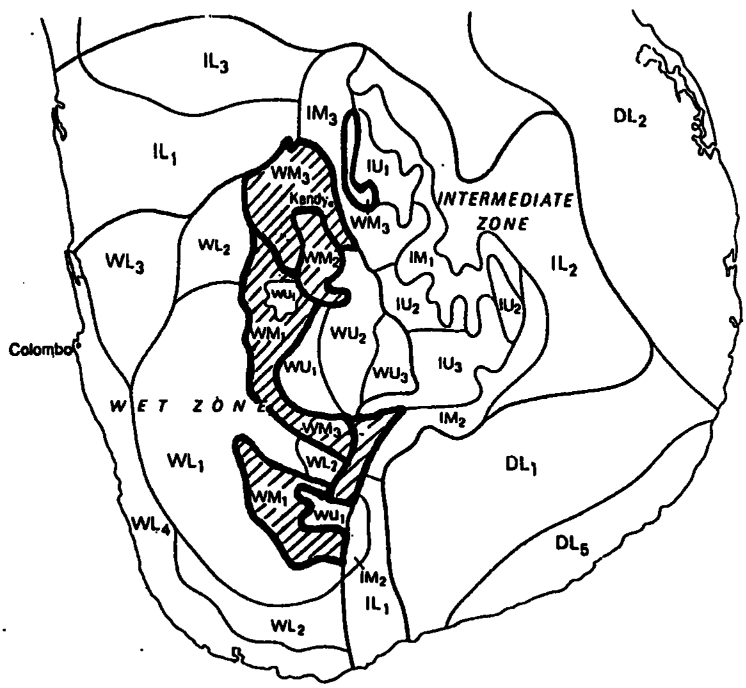

Figure 2. Agro–ecological map highlighting the mid country wet zone of Sri Lanka.

According to Somasiri *et al.* (1994) soil series is considered as the appropriate mapping unit that could provide the necessary information on soils for the purpose of land suitability mapping for coconut. The basic unit of suitability evaluation was the soil series stated in Table 1.

Land characteristic classes

Land characteristics are primary physical attributes of the land, which can be measured or described directly. Thus, rainfall regime, temperature, slope, rockiness, *etc.* are land characteristics. The performance of crop plants however, is not dependent directly on land characteristics but on their effects on certain secondary attributes as moisture availability, nutrient availability, *etc.* which the plants are sensitive. Such secondary or inferred attributes are referred to as land qualities. The land characteristic classes from which relevant land qualities are derived are shown in Table 2 with codes for easy reference. These codes are reference numbers and not grading of the classes.

The structure of the FAO framework which was used to evaluate the lands is given in Table 3. The framework structure includes the order, class and sub class. Two orders were defined as suitable (S) and non suitable (N). The purpose of classification at the order level is to minimize the risk of misunderstanding by establishing the basic meaning of more detailed interpretations (Sys *et al.*, 1991).

The framework at its origin permits complete freedom in determining the number of classes within each order. However, it has been recommended to use only three classes within the order suitable (S) and two classes within the order non suitable (N).

The class is indicated by an Arabic number in sequence of decreasing suitability within the order; and therefore reflects degree of suitability within the orders. The sub–classes are reflecting the limitations or improvement measures required within classes. Class S–1 lands have no significant limitations and therefore, no sub–classes are included. Class S–2 and class S–3 lands have sub–classes, which are indicated by the symbol of the land qualities that is limiting. Lands in sub-class N are not usually defined, as in many cases, the limitations are numerous. The major symbols for sub–class include m–for moisture limitations, e–for erosion, r–for limitation due to rockiness, c–for climatic limitations, t–for topographic limitations, and n–for limitations of salinity (and/or alkalinity). They are indicated in the symbol using lower case letters with mnemonic significance (Sys *et al.,* 1991).

Table 2. The land characteristic classes used to evaluate land suitability.

1. Agro-ecological region	Code	7. Rockiness %	Code
WM-1	1	0–10	1
WM-2	2	10–20	2
WM-3	3	20–30	3
		>30	4
2. Soil depth	**Code**	**8. Gravel content %**	**Code**
Deep (>1.2 m)	1	0–10	1
Moderately shallow (50-120 cm)	2	10–50	2
Shallow (<50 cm)	3	>50	3
3. Soil texture	**Code**	**9. Slope range**	**Code**
Sandy to coarse loamy	1	0–2	1
Fine loamy to clayey	1	2–8	2
		8–16	3
		16–30	4
		>30	5
4. Soil drainage	**Code**	**10. Presence of wetherable minerals**	**Code**
Well–drained	1	Moderate	1
Imperfectly–drained	2	Low	2
Poorly–drained	3	No	3
5. Soil pH	**Code**	**11. CEC, cmole$_c$ kg^{-1} soil**	**Code**
4.0–5.0	1	>10	1
5.1–6.0	2	5–10	2
		<5	3
6. Depth to ground water	**Code**	**12. Base saturation**	**Code**
>1.5 m	1	>50	1
<1.5 m	2	35–50	2
		<50	3

Table 3. Structure of the land suitability evaluation.

Order	Class	Sub–class
S	S–1 Highly Suitable	
	S-2 Moderately Suitable	S2–m (moisture)
		S2–e (erosion)
		S2–r (rockiness)
	S–3 Marginally Suitable	
N	Non Suitable	

Land suitability classes

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

Class S–2 Moderately Suitable–Lands with limitations which together constitute a moderately severe limitation for sustained production. These limitations will either reduce productivity appreciably below the levels in class S1 lands or require considerably increased inputs to maintain similar production levels.

Class S–3 Marginally Suitable– Lands which has limitations, which in aggregate are severe enough to reduce productivity or require increased inputs to such an extent, and that the benefits are 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.

RESULTS AND DISCUSSION

The brief description of each soil series found in the mid country wet zone is given in Table 4. The codes given for land characters for each soil are given in Table 5.

Land suitability evaluation

The general procedure outlined by the FAO (1976) was used to classify lands to three suitability classes and the results are given in Table 6.

Land qualities

Moisture availability (m) for perennial crops are assessed by integrating soil characteristics, water table depths, drainage and climatic characteristics of the different agro-ecological regions (Dimantha and de Alwis, 1981). For the tea crop, the rainfall is not a limiting factor in WM–1 region. Inadequate amount of rainfall in WM–2 and WM–3 regions may reduce the tea yields with respect to the WM–1 region. Coconut cultivation does not suffer from the water deficit in WM–1 region, but the soil moisture conservation practices must be adopted in coconut cultivating lands. All the soil series are well drained except Kiribathkumbura and are deep except Mawanella series. Heavier textures in Kiribathkumbura soils make them unsuitable for coconut.

The nutrient availability (n) for crop growth depends on the release of nutrients from wetherable minerals, cation exchange capacity (CEC), Base Saturation (BS), soil reaction, (pH) *etc.* and their relation to inputs of fertilizers. Soils with the reaction of pH 4.5 to 5.5 are ideal for tea (Watson, 1986). When consider the top soil, CEC values of the Matale, Mawanella, Akurana and Weddagala series were approximately 10–20 $cmol_c\ kg^{-1}$ soil while Galigamuwa, Kiribathkumbura, Kandy, Malaboda and Homagama series showed values less than 10 $cmol_c\ kg^{-1}$ soil. Acidity of top soils of the study area was between 4.0 to 6.0. Kandy, Mawanella, Akurana and Kiribathkumbura soils contained high amount of Potassium in the profile and this must be considered in fertilizer application for the plantation crops. Matale, Kiribathkumbura, Mawanella and Akurana soil series showed higher base saturation than the other soils.

Table 4. Characteristics of the important soils identified in the mid country wet zone.

Soil series	Brief description of characteristics
Galigamuwa	Deep well–drained, gravelly SL to gravelly SCL in texture, fine to medium granular and weak SAB structure, pH–5 to 5.5, CEC–7 to 10 dominant cation, ASS– Homagama. Pallegoda
Matale	Very deep, well–drained, CL in texture, moderate SAB structure, pH–5.0 to 5.5, CEC–10 to 15, dominant cation–Ca, Mg. ASS–Ukuwela
Kiribathkumbura	Deep, poor to very poor drained, CL to clay in texture, strong SAB structure, pH–4.5 to 5.5, CEC- 8 to 10, dominant cation–Ca, Mg, K, mica present. ASS–Gampola
Kandy	Deep, well–drained, SCL in texture, weak to moderate SAB structure, pH–5 to 5.5, CEC–4 to 5, dominant cation–Ca, K. ASS- Mawanella, Akurana, Galigamuwa, Kiribathkumbura
Mawanella	Shallow, well–drained, gravelly SCL to gravelly SL in texture, moderate medium SAB structure, mica in B horizon, pH–4.5 to 5, CEC–10 to 20, dominant cation–Ca, Mg, K. ASS–Kandy, Akurana, Galigamuwa, Kiribathkumbura
Akurana	Moderately deep, well–drained, SC to CL in texture, moderate to strong SAB, mica in the profile, pH- 5.5 to 6, CEC- 15 to 20, dominant cation- Ca, Mg. ASS- Mawanella, Kandy, Kiribathkumbura
Malaboda	Deep, well–drained, SCL in texture, weak to moderate SAB, pH–5.0 to 5.5, CEC– 6 to 10. ASS- Pallegoda.
Pallegoda	Deep, well–drained, SCL in texture, moderate SAB structure, pH–4.0 to 5.0, CEC–4 to 6. ASS–Malaboda, Homagama, Galigamuwa
Homagama	Moderately shallow to moderately deep, well–drained, gravelly SCL in texture, weak SAB, pH–4.0 to 4.5, CEC–5 to 8. ASS–Galigamuwa, Pallegoda, Dodangoda
Weddagala	Deep, well–drained, organic matter rich dark colour A horizon in 10 to 30 cm thickness, moderate SAB structure, gravelly in nature, gravelly loam in texture, pH–5 to 5.5, CEC– 8 to 12. ASS– Malaboda, Homagama, Pallegoda

(Source : Senarath and Dassanayake, 1998)

SAB–Sub angular blocky, ASS– Associated soil series, SCL– Sandy clay loam, CL–Clay loam, SL–Sandy loam, SC–Sandy clay, CEC–cation exchange capacity $cmole_c\ kg^{-1}$ soil

Table 5. The land characteristic classes of the ten soil series.

Soil Series	AE	SL	DR	GW	RK	GC	DP	TX	WM	pH	CEC	BS
Galigamuwa	1,2	4	1	1	1	1,2	1,2	1	3	2	2	3
Matale	3	2,3	1	1	1	1,2	1	1,2	2	2	1	2
Kiribathkumbura	2,3	3,4	3	1,2	1	1	1	2	1	2	2	2
Kandy	2,3	3,4	1	1	1	1,2	1	1	3	2	3	3
Mawanella	1,2,3	4	1	1	1	1	2,3	1,2	1	1	1	2
Akurana	2,3	4,5	1	1	1	1	1,2	1,2	1	2	1	2
Malaboda	1	4,5	1	1	1	1	1	2	3	2	2	3
Pallegoda	1	4	1	1	1	1,2	1	1,2	3	1	2,3	3
Homagama	1	4	1	1	1	2	1,2	1	2	1	2	3
Weddagala	1,3	5	1	1	1,2	2	1	1	3	2	1,2	3

AE : agro-ecological region, SL : slope (land form), DR : drainage, GW : ground water, RK : rockiness, GC : gravel content, DP : depth, TX : texture, WM : wetherable mineral, pH : soil reaction, CEC : cation exchange capacity, BS : base saturation.

Crop requirements

The total extent of tea growing area is about 231,000 ha and tea production is about 214 million kg made tea per year in Sri Lanka. Tea cultivation requires an evenly distributed mean annual rainfall of 2500–3000 mm. The ideal temperature for tea is 18–25°C (Watson, 1986). Soils consisting less than 10% of gravel content in the profile and less than 10%surface area covered by boulders or rock outcrops are ideal for the tea cultivation (Watson, 1986). Soils with the reaction of pH 4.5 to 5.5 are ideal for tea (Watson, 1986).

The growth of rubber plant is determined by soil texture, structure, drainage, cation exchange capacity, soil reaction, soil moisture retention and presence of wetherable minerals. The rainfall acts as one of limiting factors of rubber yield because it determines the number of tapping days (Peries and Fernando, 1983). In soils having poor water retaining capacities such as light sandy soils, and presence of excessive amount of quartz in soil profile can affect the rubber yields during long dry periods. Flooding and waterlogging can also affect the growth of rubber in clayey soils of low lying areas, despite good drainage during heavy rains. Phosphorous, Nitrogen and Sulfur are the nutrients mainly used for the growth of rubber plants.

Table 6. Suitability of each soil series for tea, rubber and coconut cultivation under the rainfed conditions.

Soil series	Suitability class		
	Tea	Rubber	Coconut
1. Galigamuwa	S-2	S-2 c	S-2 e
2. Matale	S-2 m	S-2 m	S-2 m
3. Kiribathkumbura	N	N	N
4. Kandy	S-2 m	S-3	S-2 e
5. Mawanella	S-2 m	S-1	S-2 e
6. Akurana	S-3 m	S-2 m	S-2 m
7. Malaboda	S-1	S-2 c	S-2 e
8. Pallegoda	S-1	S-2 c	S-2 e
9. Homagama	S-1	S-2 c	S-2 e
10. Weddagala	S-1	S-2 c	S-2 e

Coconut is cultivated in an extent of about 412,550 ha of land and is the plantation crop covering the largest area in Sri Lanka, and earns a considerable amount of foreign exchange. Coconut is cultivated from sea level up to an elevation of about 750 m. It needs high light intensity and at lower temperatures (20^{0}C) coconut yields are poor. The highest concentration of coconut roots is in the top meter of soil and within a radius of about 2 m from the base of the palm. Coconut requires an annual rainfall of at least 1500 mm, distributed uniformly throughout the year. Long dry spells are harmful. Generally the tall variety can tolerate a dry spell up to three months, but in the case of dwarf × tall hybrids, the dry spell should not exceed two months. Coconut can withstand occasional waterlogging up to about 7 days, but in marshy areas, drainage should be provided (Mahindapala and Pinto, 1996). Coconut performs best in well drained deep sandy loam soils and it require higher amount of Potassium and Nitrogen.

Soil requirements

Resistance to erosion depends on climatic factors (the amount, intensity), soil type, slope of land, vegetative cover, *etc.* Most lands of survey area is at higher altitudes, where the lands are more susceptible to water erosion. In some areas not only the slope but also intensity of rainfall greatly influence the soil erosion process. Soil conservation practices must be adopted if the slope is over 3% due to high rainfall intensity in this region. The total study area is over 3% of slope except Kiribathkumbura series and therefore erosion hazard is a limitation especially for coconut cultivation.

This land suitability evaluation is a physical evaluation of the suitability of the land mapping units for each of the land utilization types of tea, rubber and coconut.

Accordingly, lands of WM–1 region such as Malaboda, Pallegoda, Homagama and Weddagala series were classified as suitable for tea cultivation, while lands of Matale, Kandy, Mawanella, Akurana and Galigamuwa series were classified as moderately suitable considering the amount of rainfall. Mawanella series was classified as suitable for rubber due to no significant limitations in this land unit. Heavy rains in WM–1 region is a limiting factor for rubber production, as it could reduce the number of tapping days. Therefore, Galigamuwa, Malaboda, Pallegoda, Homagama and Weddagala series were classified as moderately suitable lands for rubber production. All the lands in mid country were classified as moderately suitable for coconut cultivation due to a number of limitations that may reduce the yield such as slope, moisture limitations, low sunshine hours, *etc.* Lands in Kiribathkumbura series are poorly drained paddy soils with certain limitations in aeration and was classified as not suitable for plantation crops.

CONCLUSIONS

Among the soil series studied Malaboda, Pallegoda, Weddagala and Homagama series were suitable for tea cultivation and only Mawanella series showed suitability for rubber cultivation. Among the studied lands, all soil series are moderately suitable for coconut cultivation except Kiribathkumbura series that was classified as not suitable for any of the plantation crops considered. If proper agronomic management practices can be followed, the moderate suitable lands can be used to get better production.

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