# PROBLEMS OF UTILIZATION AND MANAGEMENT OF SOME IMPORTANT GREAT SOIL GROUPS IN SRI LANKA

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## Abstract

There is a wide range of climatic and soil conditions in Sri Lanka. Nine out of the ten soil orders of Soil Taxonomy (USDA) are encountered in the country. The general climate is tropical. The rainfall is distinctly bimodal for most parts of the country. The annual rainfall ranges from 875 mmto 5000 mm. The elevation ranges from sea level to 2,515 meter above sea level. Most important soil orders are Alfisols, Ultisols and Oxisols. The soil orders Histosols, Entisols, Inceptisols and Vertisols are also used for a range of agricultural purposes, the main use being rice cultivation. The important great soil groups of Sri Lanka with the equivalent great soil groups of Soil Taxonomy (USDA, 1975) are presented and the distribution of the soils is indicated. Most of the management problems are on Alfisols, Oxisols, Histosols, and Vertisols, and are related to the physical properties and their interaction with the climate especially the rainfall. Further the problems of irrigated agriculture on these soils are discussed. The problems of the use and management of the Histosols and the associated Inceptisols and Entisols are related to the rainfall, flooding, tidal movements and the general setting of these soils in the landscape in the coastal plain which has an advancing coastline.


## Introduction

Many problems have been encountered in the utilization and management of some widely spread, important great soil groups in Sri Lanka. The nature of the soil properties, the general setting of the soils in the landscape, the climatic environment, and their interactions usually determine the problems related to the use and management of these soil groups. The distribution of the great soil groups, and the wide range of climatic environments, as determined by the pattern of the rainfall distribution and temperature conditions obtained in Sri Lanka have provided the resources base for the adaptation of a wide range of agricultural uses and management practices.

Nine out of the ten soil orders (Soil Taxonomy, USDA, 1975) have been identified and mapped in an area of 64,000 $km^2$ – the total area of Sri Lanka. Agriculturally important and more widely spread soil orders are Alfisols, Ultisols, and Oxisols. Further, the soil orders Entisols, Inceptisols, Vertisols and Histosols also have been used for agriculture under suitable hydrological conditions as determined by the rainfall, irrigation and flooding.

Extensive Alfisol areas have been developed for irrigated agriculture during the last three or four decades. Further extent of 1 to 1.5 million hectares of good arable soils suitable for development under rainfed conditions are available in the Alfisol soil order. Traditionally in the absence of irrigation facilities shifting cultivation was the main land use type, for subsistence. The problems of management of these soils for rainfed settled agriculture have been studied in fair detail (Abeyratne, 1966 and Alles, 1962). The management problems of Alfisols under irrigation have been in the focus of the more recent research investigations, because of the important development projects undertaken by the Government of Sri Lanka, in the region.

Traditionally in the Ultisols soil region, the soils in inland valley systems have been in use for rice cultivation under rainfed, stream-fed and phreatic water supply conditions. The better drained soils on adjacent highlands, that can not be commanded by stream diversions were used for a shift-

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ing form of cultivation of other crops for subsistence, under rainfed conditions, until the advent of commercial plantation agriculture with crops like tea, rubber, coconut and cocoa, etc. Presently most of the Ultisols region except for the forest reserves, is developed for these perennial plantation crops. The management problems of Ultisols, are not as severe as those of the other soil orders, in Sri Lanka.

Experience on the use and management of Oxisols is quite new, except in the case of a subgroup of this soil order, that is underlain by a porous, water-bearing lime stone formation at shallow depth from the surface.

The other soil orders have been in use generally for rice cultivation. The problems related to the setting of these soils in the landscape, the hydrology, flooding, etc. severely limit the utilization of these soils.

## Soil physical environment

The problems related to the use and management of most of the soil orders arise from the interactions of soil properties, climate, specifically the rainfall, and the position of the soils in the micro-topographic sequence.

Sri Lanka is situated between the North Latitude 6° and 8° a few kilometers south of the Indian sub-continent. By its particular location in the Indian Ocean, rainfall in Sri Lanka is determined both by a regional phenomenon as well as a local phenomenon. The monsoon rainfall, North-East in mid-November to mid-January, and South West in May to mid-September periods, occurs as a regional phenomenon. The intermonsoonal, convectional rains effective during March–April and again during September–October occur as a local phenomenon. These intermonsoon thunderstorms, attain intensities of 25 mm in 8 to 15 min and 50 mm in 30 to 40 min in low elevations as experienced at Maha Illupallama Research Station. The annual rainfall distribution pattern is distinctly bimodal for most parts of the country. The mean annual rainfall ranges from 5000 mm in the wettest parts to 875 mm in the semi-humid to dry areas.

Based on the rainfall, vegetation, soils and present land use, three main agro-climatic zones have been demarcated. These three major climatic zones were further subdivided into 24 distinctive agroecological regions, on the basis of rainfall expectancy at 75% probability, elevation and soil conditions. (Fig. 1).

## Soils and soil distribution

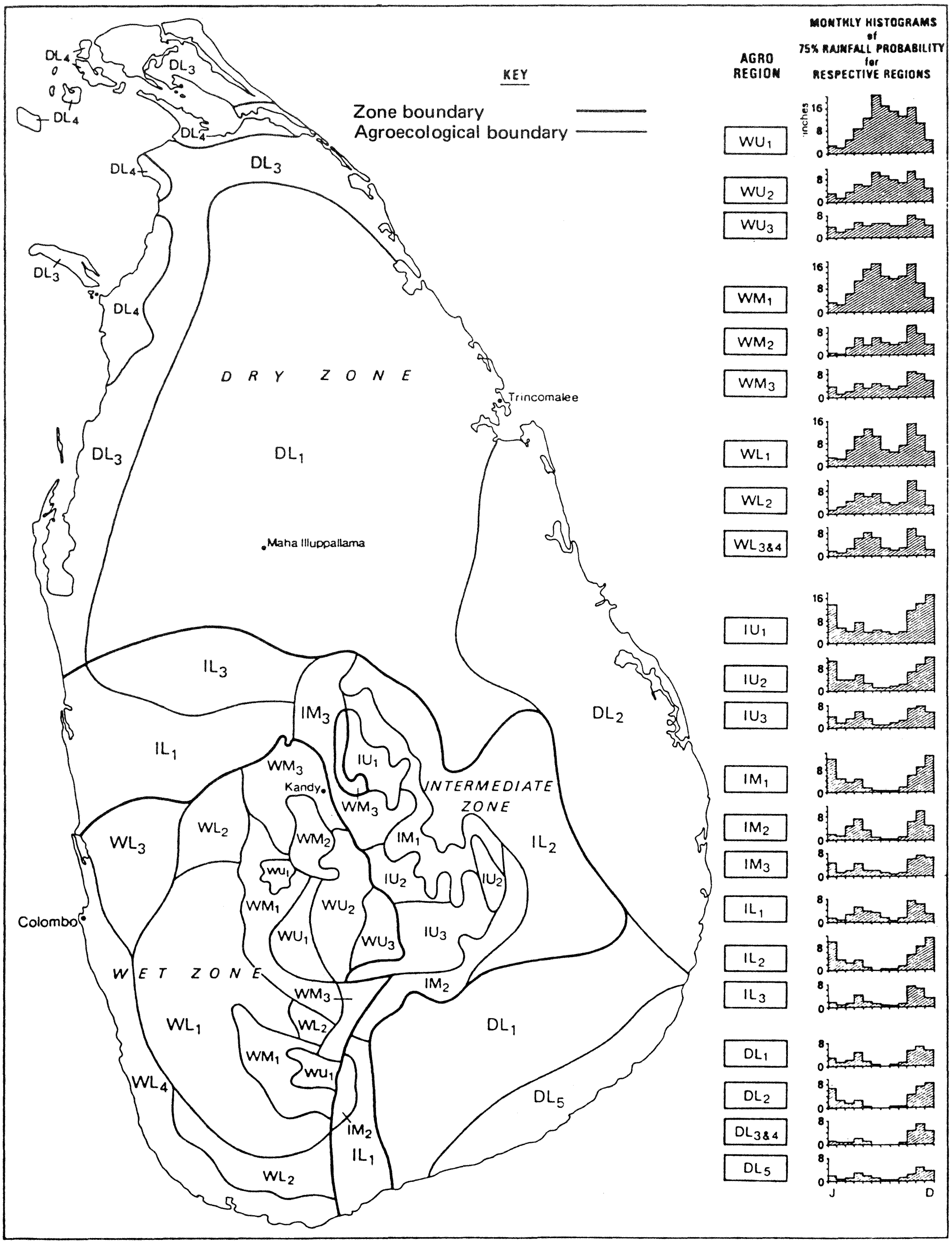
In the 1971 version of the soil map of Sri Lanka, there are 31 map units, which include 21 soil map units and 4 land mapping units, namely eroded lands, rock knob plains, steep rockland and lithosols and the erosional remnants. The soil map units consist of associations of great soil groups. The areal distribution of the more important soil associations is shown in the map of Fig. 2 which has been generalized from the soil map of 1971. The great soil groups identified are given in Table 1 with the equivalent great soil groups of Soil Taxonomy (USDA, 1975)

### 1 Alfisols

Most extensive soil associations that occur in the dry zone consist of Rhodustalfs, Haplustalfs, and Tropaqualfs with some inclusions of Natraqualfs. On the toposequence of the rolling to undulating landscape, the Rhodustalfs and Haplustalfs occupy the well drained aspects, namely the convex crests, upper and mid slopes, and the Tropaqualfs occupy the imperfectly and poorly drained aspects, such as concave and flat bottom lands and valley floors.

Rhodustalfs and Haplustalfs consist of well drained to moderately well drained reddish to brownish sandy loam to sandy clay loam surface horizons underlain by reddish to brownish sandy clay loam subsurface horizons. Within the subsoil is a gravel horizon of variable thickness of 10 – 50 cm and the contents of quartz gravel vary from less than 10% to over 50%.

Haplustalfs that occur in the dry zone landscape consist of dark brown to dark greyish brown sandy loam surface horizons underlain by yellowish red to brown sandy loam to sandy clay loam




Drawn by: T M K Wijesinghe – JUNE 1981

Scale 1:2,000,000

**Fig. 1 Agroecological regions of Sri Lanka.**

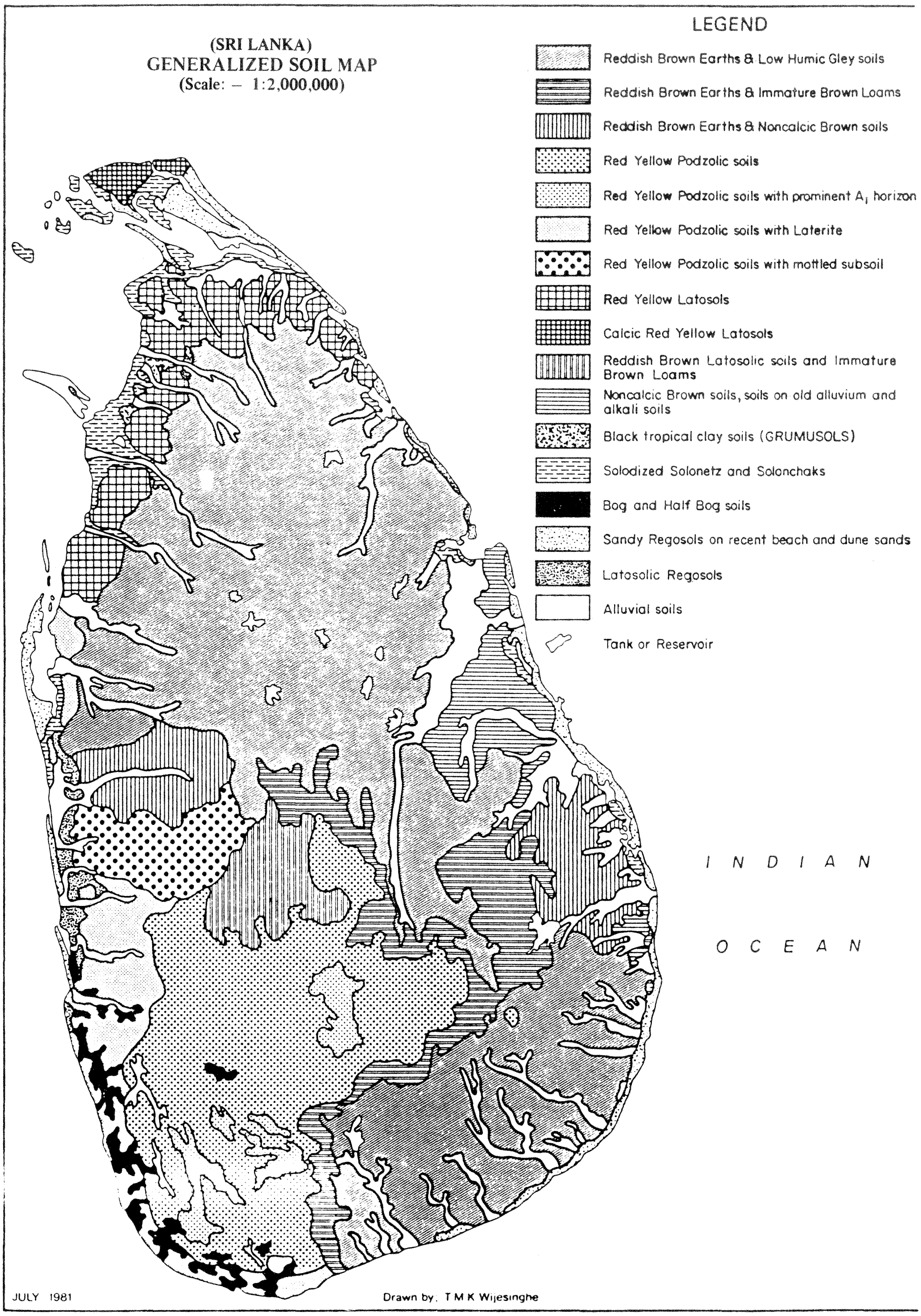

(SRI LANKA)
GENERALIZED SOIL MAP
(Scale: – 1:2,000,000)
LEGEND
Reddish Brown Earths & Low Humic Gley soils
Reddish Brown Earths & Immature Brown Loams
Reddish Brown Earths & Noncalcic Brown soils
Red Yellow Podzolic soils
Red Yellow Podzolic soils with prominent $A_1$ horizon
Red Yellow Podzolic soils with Laterite
Red Yellow Podzolic soils with mottled subsoil
Red Yellow Latosols
Calcic Red Yellow Latosols
Reddish Brown Latosolic soils and Immature Brown Loams
Noncalcic Brown soils, soils on old alluvium and alkali soils
Black tropical clay soils (GRUMUSOLS)
Solodized Solonetz and Solonchaks
Bog and Half Bog soils
Sandy Regosols on recent beach and dune sands
Latosolic Regosols
Alluvial soils
Tank or Reservoir
I N D I A N
O C E A N
JULY 1981
Drawn by. T M K Wijesinghe

**Table 1 Important great soil groups of Sri Lanka with the equivalent great soil groups of Soil Taxonomy (USDA 1975)**

| Soil Order | Sub-Order | Great Soil Group | Great Soil Groups of Sri Lanka |
|---|---|---|---|
| Alfisols | Ustalfs | Rhodustalfs | Reddish Brown Earths |
| | | Haplustalfs | Non-Calcic Brown soils |
| | Aqualfs | Tropaqualfs | Low Humic Gley soils (high base saturation) |
| | | Natraqualfs | Solodized Solonetz |
| Ultisols | Udults | Rhodudults | Reddish Brown Latosolic soils |
| | | Plinthudults | |
| | | Tropudults | |
| | Ustults | Tropustults | Red Yellow Podzolic soils |
| | Humults | Tropohumults | |
| | Aquults | Tropaquults | Low Humic Gley soils (low base saturation) |
| Oxisols | Ustox | Eutrustox | Red Yellow Latosols. |
| | | Haplustox | |
| Vertisols | Usterts | Pellusterts | Grumusols. |
| Aridsols | Orthids | Salorthids | Salonchaks. |
| Entisols | Aquents | Tropaquents | |
| | Fluents | Tropofluents | |
| | Ustents | Tropustents | Alluvial soils of variable texture and drainage |
| | Psamments | Quartzipsamments | |
| Inceptisols | Aquepts | Tropaquepts | Half bog soils |
| | Tropepts | Ustropepts | Immature Brown Loams |
| Histosols | Fibrists | Tropofibrists | |
| | Hemists | Tropohemists | Bog soils |
| | Saprists | Troposaprists | |

* Summarized from the Handbook of Soils of Sri Lanka, Alwis and Panabokke (1972).

subsurface horizons. As in the case of Rhodustalfs, very often, a gravel horizon is encountered within the subsoil horizons.

Tropaqualfs, occur in the same landscape as the Rhodustalfs and Haplustalfs in the dry zone. Tropaqualfs consist of dark or very dark greyish brown or very dark brown sandy loam to sandy clay over clay subsoil horizons. Occasionally, a gravel horizon is found in the subsoils. Tropaqualf is the hydromorphic member of the soil catena in the dry zone catenary landscape.

Natraqualfs occur as an inclusion within the Tropaqualf soil areas. Most commonly, the Natraqualfs occupy the inter flow positions in concave bottom lands. Fairly large extents of the Natraqualf great soil group are found in the coastal plain in association with Tropaquents, Tropofluents and Ustifluents. This soil consists of dark brown loamy sand to sandy loam surface horizons underlain by grey, with mottling and gleying, sandy clay loam to sandy clay, subsoil horizons with strong columnar structure.

### 2 Ultisols

Next to the Alfisols, the most widely distributed soils are the Ultisols. These soils occur in the wet and semi-wet intermediate zones. They occupy the well drained aspects of the undulating to rolling landscape in the low country and the hilly and mountainous slopes of the mid elevations (300 to 1,000m) and high elevations (over 1,000m). The main great soil groups encountered are Rhodudults, Tropudults, Tropohumults and Tropustults. Most commonly these soils consist of sandy loam to sandy clay loam surface soils underlain by sandy clay loam to sandy clay subsoil horizons. These soils are in the higher rainfall regions, where the dry periods are short and the profiles dry out rarely beyond the root zone of most crops. The soil physical properties are superior to those of the Alfisols. Most of these soil areas are developed for perennial crops, and managemen problems are not severe, except for the need to add fertilizer and liming depending on the crops. However, where annual crops are grown with clean cultivation, good erosion control measures are required.

### 3 Oxisols

The Oxisols occur in the same climatic environment as the Alfisols. Deep, well drained to moderately well drained soils occur on the well drained aspects of the undulating landscape, while imperfectly to poorly drained soils occur on the concave slopes. The soil consists of sandy loam to sandy clay loam; the clay content increases very gradually with increasing depth.

### 4 Vertisols

The Vertisols are imperfectly to poorly drained, dark grey brown to black, moderately shallow clayey soils. These soils occur on localised flat areas, probably elevated lagoon floors, and it is possible that the soils developed from lagoon muds.

### 5 Histosols

The soils of the Histosols order occur in drowned valleys, which are the ill drained lands in the low country wet zone. The great soil groups identified are Tropofibrist, Tropohemist and Troposaprist. These soils consist of dark brown to black organic layer overlaying strongly mottled and gleyed mineral alluvial soils.

## Soil properties and the problems of use and management

For tropical soils the Rhodustalfs have very good chemical properties. The soils are slightly acid to neutral in reaction. The cation exchange capacity ranges from 10 to 20 meq/100g soil, while the base saturation is high (60 – 90%) in subsoil. The soils contain a fair proportion of weatherable minerals.

Haplustalfs are quite similar to the Rhodustalfs in their chemical properties. However, agricultural potential is somewhat lower than that of the Rhodustalfs.

The physical properties of Rhodustalfs and Haplustalfs are more significant in relation to the problems of management. Most of these soils belong to moderately fine textured class of soils. The available moisture holding capacities are low; the values range from 12 to 20% by volume, and 85% of the available moisture is lost at a suction of one atmosphere. The air porosity at field capacity is 12 to 13% by volume. The average infiltration rates vary from 25 mm to 87 mm per hour after 4 hrs. The structural bonds are weak (Panabokke, 1975), and slaking of the structural units takes place very rapidly on sudden wetting. The erodibility of the soils as derived from the nomographs prepared by Wischmeier *et al.* (1971) ranges from 0.27 to 0.35.* The permeability of these soils ranges from $1.5 \times 10^{-6}$ to $5 \times 10^{-5}$ m/sec on the average. The soil consistency is extremely hard when dry and sticky and plastic when wet.

Rhodustalfs and Haplustalfs are used both for irrigated farming and rainfed farming. However, there had been no spontaneous development of a settled system of farming under rainfed conditions, in these soil regions. Both the attributes of the soils and the environment appeared to have limited the continued use of the same plot of land for crop production. The soil properties, namely the unfavorable soil consistency, erosional hazards manifested by the poor structural stability and surface sealing and the highly erosive rainfall and heavy weed infestations, together with the short growing period (75 to 80 days) available are the key factors that control the farming operations. It is extremely difficult to get a good seed bed prepared early in the season, when the soils are in a dry state, with the traditional implements, in order to plant with the initial rains so that the short growing period is fully used for crop growth. The tillage of Rhodustalfs creates conditions which favor soil erosion. Over 60% of the annual rainfall in the Alfisols region is erosive.** With the impact of rain drops the bare soil breaks up the aggregates, causing splash erosion and surface sealing, which in turn reduces the infiltration and increases the runoff causing soil loss from the farmlands. The conservation of soil and water is a key factor for the establishment of rainfed settled farming in the Alfisols region.

Rhodustalfs have been used for irrigated crops, including rice, chillies, onion, pulses, etc. Earlier the water management was not considered critically, however for the management of the projects for economic benefits efficient water management and growth of economic food crops on the irrigable Rhodustalfs have become very important. The soil physical properties of the Rhodustalfs and Haplustalfs and the landscape and climatic environment place severe limitations on the choice and design of irrigation systems. The shallow rooting depth in the case of annual crops, low available moisture, rapid intake rates, erodibility of the soils and the short slope lengths on the landscape allow very little flexibility in the design of surface irrigation systems. The loss of most of the available water at low suctions necessitates the frequent application of water. The high percolation and permeability of the Rhodustalfs and Haplustalfs on the upper slopes increase the water loss, which in turn builds up the ground water table in Tropaqualfs on the bottom lands. The poor drainage of the bottom lands creates acute problems in most of the irrigated Alfisol areas. In some situations, the alkaline and marshy conditions are developed by the high water tables. The lands that are waterlogged on the irrigation of the Rhodustalfs and Haplustalfs can not be easily reclaimed. Further on these soils on lower slopes high value crops can not be grown, because of the high water tables, and there is an annual increment of such areas in the irrigated zones.

The properties of Tropaqualfs are quite similar to those of the Rhodustalfs, except for some chemical and physical properties like infiltration rates and permeability. Generally cation exchange capacities are higher, 15 – 30 meq/100g soil; base saturation is 90 – 100%; the soil reaction tends to be neutral to alkaline. The infiltration rates are as low as 2.5 mm/hr to 25 mm/hr after 4 hrs. By the location of these soils in the lowermost positions of the landscape, the agricultural uses are limited to crops like rice, for which high water tables have no adverse effects. Tropaqualfs have the physical properties that are best suited for rice cultivation. Normally these lands are formed into level basins with perimeter bunds, thus maximum soil and water conservation is achieved.

Natraqualfs that occur in the coastal plain in association with Tropofluents, Ustifluents and Tropaquents and the Natraqualfs that occur in association with Tropaqualfs are used only for rice cultivation. The higher sodium percentage in the exchange complex of these soils renders them quite unsuitable for most crops. Even for rice, varieties that can tolerate the high sodium level are required. The poor physical conditions due to the clay dispersion in Natraqualfs is a major problem in the management of these soils. The lack of adequate and good quality water for reclamation of the Natraqualfs and the lack of suitable drainage outlets because of their position in landscape, make these soils marginal for agriculture.

The great soil groups of the Histosols soil order, namely Tropofibrists, Tropohemists and

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Troposaprists and the associated great soil groups of the soil orders Entisols and Inceptisols of the coastal plain in the wet zone have severe limitations in their use. These soils are mostly used for rice cultivation and to a limited extent for leafy vegetables and sedges. The soil properties, such as soil reaction, salinity levels and the presence of highly reduced ions and the low physical strength create significant limitations in the choice of the crops. However, the real problems on these soils in the drowned valleys of the South-East coastal plain, are best understood by the examination of the landscapes where these soils occur and the interactions of the hydrology in relation to the rainfall, flooding and tidal movements with the distribution of the soils in the topographic sequences. During the rainy season, most of the Histosols remain submerged due to overflow of the major river systems and the sand bars that block the local drainage. During the periods of high tides the intrusion of saline water occurs, and the areas most affected are the Histosols that occupy the lowest positions in the landscape. By good control of the hydrological conditions, by drainage reclamation and maintaining the outflow of the streams and rivers into the sea; the prevention of sea water intrusion; and the breeding and selection of salt and flood tolerant rice varieties, better use of the soils of this region may be possible.

Eutrustox have excellent physical properties, but their chemical properties are very poor. They are deep sand to fine sandy loams, friable when moist and soft when dry. Water holding capacity is low, but the average infiltration rate after 4 hours is as high as 30 cm/hr. The CEC is as low as 16 meq/100g. The organic matter content is low and the rate of mineralization is high.

**Table 2 Important soil properties of selected soil groups in Sri Lanka**

| Soil | Texture surface | pH | CEC meq/100g | Base sat % meq/100g | C% | C/N | Available moisture mm/meter | Average intake rate after 4 hr in cm |
|---|---|---|---|---|---|---|---|---|
| Rhodustalfs | Sandy loam, Sandy dry loam | 5.5–7.0 | 10–20 | 60–90 | 0.5–2 | 8–12 | 132–166 | 2.7–9 |
| Haplustalfs | Sandy loam, Sandy dry loam | 5.2–6.5 | 8–12 | 50–70 | 0–2 | 8–12 | 120–150 | 2.7–12 |
| Tropaqualfs | Sandy loam Sandy dry loam | 5.5–8.5 | 15–30 | 70–80 | 1–4 | 7–8 | 120–196 | 0.3–2.5 |
| Natraqualfs | Loamy sand, Fine sandy loam | 7.0–8.5 | 15–30 | 100 | 0–2 | 10–15 | – | Low |
| Rhodustults | Sandy loam, Sandy dry loam | 5.5–6.6 | 12–20 | 20–30 | 3–5 | 10 | – | 7–20 |
| Tropudults | Sandy loam, Sandy dry loam | 4.0–5.6 | 8–15 | 4–6 | 0–2 | 8–12 | – | 2.5–10 |
| Eutrustox | Sandy to fine sandy loam | 5.5–7.0 | 2–6 | 40–60 | 0–2 | 6–10 | – | 30–40 |
| Pellusterts | Dry loam to dry | 5.0–6.0 | 55–65 | 65–90 | 2–3 | 10–15 | – | Low |
| Histosols | – | 4.5–5.5 | 40–100 | 2–25 | 30 | – | – | – |

The key factor controlling the use of this soil unit is the seasonal and low rainfall and high intake rate. There are serious limitations to the use of conventional surface irrigation. The most practical methods of water application are sprinkler and hand-watering. The low retention of added nutrients is an additional problem. The maintenance of organic matter is an important element in the management of this soil. The soil is excellent for high value crops.

Pellusterts have the best chemical properties out of all soils in the country and are highly productive. They are clay soils consisting of expansible layer silicates. The cation exchange capacity and base saturation are high. The physical properties are very poor; therefore, these soils are mainly used for growing rice under puddled cultivation, which is the most practical way to prepare the seed bed. Under irrigation, the Pellusterts are capable of producing 7 to 8 ton per hectare per crop.

Main physical properties of these soil groups are summarized in Table 2.

## Acknowledgements

The information on the physical environment, soils, and soil properties has been obtained from both the published and unpublished data of the Land and Water Use Division of the Department of Agriculture and Land Use Division, Irrigation Department, Sri Lanka.

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