IDENTIFICATION OF SOILS WITH DIFFERENT NUTRIENT AND MOISTURE STATUS INDICATED BY VEGETATION USING INFRARED AERIAL PHOTOGRAPHY - A STUDY IN THE EASTERN REGION OF SRI LANKA.

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INTRODUCTION.

A large area in the eastern region of Sri Lanka has been considered for agricultural development - particularly for irrigated agriculture. For project identification, feasibility studies and detailed planning of the intended agricultural projects in this area, land resource surveys were being made in 1978 using 1:20,000 black and white panchromatic aerial photographs. In these surveys it was often observed that a vast number of ground observations had to be made in order to achieve the required level of accuracy in photointerpretation, particularly for soil resource mapping. This was a difficult and expensive exercise as the area was covered with natural forest, and there existed the connected problem of accessibility.

The need for a large number of ground observations arose mainly because of the geomorphological characteristics of the region and the irregular distribution of soils. It has a very subdued relief and very often, significantly useful basic geomorphologic units such as relief units and slope facets cannot be identified. Morphological mapping could be done only to a limited extent. For the same reason the geomorphology was useful only to a limited extent in identification and mapping of different soils.

In soil surveys, attempts were made to relate the vegetation with the moisture and nutrient status of different soils in the area so that the natural vegetative cover could be made use of in soil mapping. Later, 1:20,000 infrared photographs for some parts in the region were obtained. In this study they were used with the ground observations on soils and vegetation, in developing a method of identifying and mapping of soils using differences in vegetative cover..

NATURAL VEGETATION.

The natural vegetation of the area has been classified as tropical dry mixed evergreen forest. Perrenial species dominate the natural vegetation. They can be large deep-rooted trees with prominent crowns, medium deep-rooted trees with small crowns or shrubs. Grasses and a variety of annuals are found.

Characteristically the tropical dry mixed evergreen forest faces a low soil moisture period in the drier parts of the year. In the study area, the dry periods are from mid-February to mid-March and May to September. The growth is retarded in these periods. However local soil moisture conditions vary according

to the soil. These variations and variations in availability of nutrients which is another soil characteristic, were found to be related to the vigour of vegetation, the tree density and the distribution of species. This relationship provided the basis for identification and mapping of soils which could be characterised according to their nutrient and moisture status. The nutrient absorption and moisture uptake by trees are related functions and their combined effect can considered to be indicated by variations in vigour, tree density and species distribution of natural vegetation. The differences in these three features of natural vegetation could be identified on both panchromatic and IR aerial photographs. However, using IR photographs was found to be more advantageous for the reasons discussed in the next section.

SUPERIORITY OF INFRARED (IR) PHOTOGRAPHY OVER PANCHROMATIC PHOTOGRAPHY IN IDENTIFYING DIFFERENCES IN VEGETATIVE COVER.

The spectral range of the IR photographs taken included near infrared (700nm-1100nm) region. High IR reflectance by vegetation in this range facilitates the identification of differences in vigour more prominently than in panchromatic (300nm-700nm) photography. Healthy vegetation with vigorous growth shows higher IR reflectance than the vegetation which show evidence of periodical moisture stress and nutrient defficiency. It was observed that the tonal and textural differences of vegetative cover on IR photographs are more enhanced than those on panchromatic photographs. Their differences were used in making assessments of the tree density and species distribution.

Another useful feature is the high IR absorption by poorly drained areas which show surface wetness. The IR photographs used for this study were taken in March, about one month after the end of the major rainy season. At this time poorly drained areas still remain wet at the surface while well drained and imperfectly drained areas have dry surface.

Higher IR reflectance by tree crowns which bear high proportions of buds and tender leaves was also observed. Most of such trees were found in areas which had higher nutrient and moisture supply at the time the photographs were taken. Areas with such trees are more easily distinguishable on IR photographs.

SOILS OF THE AREA AND THEIR DISTRIBUTION.

Soils in the study area have derived from a mixture of basic and acid rock. Soils derived from acid rock have low inherited nutrient levels and low clay contents. Their nutrient and moisture retention abilities are low. Soils derived from basic rock are richer in clay minerals and have higher nutrient levels. Their nutrient and moisture retention abilities are high. Both kinds of soils are structurally unstable. This structural instability with the high intensity rain has led to the removal of these soils from the sites at which they were originally formed. In this erosion process separation has taken place as indicated by water-borne sand deposits and alluvial clays distributed in the region.

In some places the residual soils remain on low ridges. Short distance removal of soils, or colluviation, has taken place at these sites. Redistribution of inherited nutrients and clay minerals has occured with time. The present day distribution of the soils is a result of all these processes. The distribution is irregular and not easily predictable. These activities which have taken place over a very long period of time has also resulted in the less enhanced geomorphology of the area.

The moisture status of the soils depend on their drainage characteristics and moisture retention abilities. Alluvial soils are poorly and imperfectly drained while residual and colluvial soils are mostly imperfectly and moderately-well drained.

IDENTIFICATION OF SOILS WITH DIFFERENT MOISTURE AND NUTRIENT STATUS ON IR PHOTOGRAPHS.

Ground truth in relation to the reflectance characteristics and textural variations on IR photographs was established in representative sites. Most of the ground observations were made during the feasibility study surveys of the region. Soil profile studies, analytical data studies and studies on vegetation were made during the same surveys. Later, the ground observations were studied with the IR photographs of the selected sites.

Poorly drained soils with high clay contents are characterised by sparsely distributed large and medium perrenials, shrubs and grass cover. The trees show high IR reflectance which indicated healthy growth. The sparse distribution of perrenials is a result of low moisture availability in the driest part of the year, although the soils are rich in nutrients. In most cases each crown can be detected on 1:20,000 photographs. Grass and shrubs have a lighter tone and smooth texture.

Imperfectly drained sandy clay loams of alluvial origin are associated with streams. These soils are rich in nutrients and they have an optimum level of moisture availability throughout the year. Areas occupied by these soils are densely populated by large deep-rooted perrenial trees with prominent crowns. They show vigorous growth and the crowns bear a high proportion of buds and tender leaves, as indicated by higher IR reflectance by them. It makes the crown appear mottled with brighter grains. Continuous growth and vigour indicate the high moisture and nutrient availability. The vegetative cover has a coarse texture on IR photographs where each crown can be distinguished though they are very close to each other. Dense vegetative cover made of large trees is another indication of little competition the trees have for nutrients and moisture throughout the year.

Areas occupied by imperfectly drained sands and loamy sands have a mixed vegetative cover. Medium perrenial deep-rooted species with small crowns are dominant. Large perrenials with prominent crowns are sparse. Perrenial shrubs, annuals and grasses are found in abundance. Vegetative cover is not dense but occurrence of shrubs and grasses with medium trees give a smooth texture to these areas on aerial photographs. Crowns of large trees are easily visible. Apart from large trees the

vegetation does not show much vigour as the nutrient availability and moisture availability of these soils are low. However, the existance of a slowly permeable layer of sandy clay in the soil profile below the sand prevents percolation of water and keeps high soil-moisture levels for considerably long periods after rain, although the moisture retention ability of sand is low..Deep-rooted large trees are able to obtain sufficient amounts of nutrients and moisture even in dry periods as shown by their vigour. But they compete with each other for nutrients and moisture and for this reason they are sparse. Medium trees and shrubs clearly show signs of moisture stress.

Residual soils derived from basic rock can be well drained, moderately well drained or imperfectly drained. They are fairly rich in inherited fertility. The imperfectly drained soils have a high moisture availability in most part of the year. The soils have a high nutrient retention ability. A mixture of deep-rooted large and medium trees make the dense vegetative cover. Very few shrubs and grasses are found. Evenly distributed large trees with prominent crowns and medium trees with small crowns appear as a continuous cover which has a medium texture on photographs. Trees show high IR reflectance which indicate vigorous growth. Crowns of large trees have brighter spots with higher IR reflectance which indicate the existance of high proportions of buds and tender leaves.

Well drained and moderately well drained members of these soils do not occur in large extents in the region.. The areas occupied by these soils are somewhat densely populated by large deep-rooted trees with prominent crowns. Few medium trees and shrubs occur. The vegetation shows a similarity to that on imperfectly drained alluvial sandy clay loams. The soils occur on upper slopes and crests of low ridges and they could be identified by their position in the landscape. Possibility of making predictions is often lowered by the existance of shallow and gravelly areas where vegetative cover does not indicate consistant evidence on IR photographs. A similar situation can be observed in the areas occupied by moderately well drained and imperfectly drained residual soils derived from acid rock. The distribution of trees and the tree density were observed to be irregular. This can be a result of the differences in the levels of inherited nutrients in the parent rock, variations in the degree of colluviation and illuviation of clay and nutrients, and existance of shallow and gravelly areas. In the case of the residual soils more ground observations and information on the position of the landscape has to be used in mapping.

SUMMARY AND CONCLUSIONS.

In this study it was revealed that IR reflectance and textural characteristics of vegetative cover can be used in identification and mapping of poorly drained clayey soils, imperfectly drained alluvial sandy clay loams, imperfectly drained alluvial sandy soils and imperfectly drained residual sandy clay loams derived rrom basic rock which have significantly different moisture and nutrient status.

The results of the study are summarised in Table 1.

TABLE 1. CHARACTERISTICS OF NATURAL VEGETATION IN RELATION TO SOILS

Soil	Moisture Availability.	Nutrient Availability.	Species Distribution.	Tree density	Vigour	IR reflectance and texture.
Poorly drained clayey.	Very high in rainy season. Low in dry periods..	High.	Sparse large trees with prominent crowns. Sparse shrubs and abundant grasses.	Low.	High.	High reflectance by large trees. Smooth texture of shrubs and grasses. Each crown of large trees distinguished.
Imperfectly drained alluvial sandy clay loams.	High.	High.	Large trees with prominent crowns dominant. Few medium trees. Very few shrubs and annuals.	High.	High.	High reflectance with brighter spots of tender leaves and buds. Coarse texture.
Imperfectly drained sands and loamy sands.	High.. Becomes very low close to surface in dry periods.	Low.	Sparse large trees with prominent crowns. Medium trees with small crowns, shrubs and annuals dominant.	Medium.	Low.	Medium reflectance. Crowns of large trees distinguishable. Rest of the cover has smooth texture.
Imperfectly drained sands and loamy sands.	High.	High.	Even distribution of large and medium trees.	High.	High.	High reflectance. Medium texture.