DISTRIBUTION, CHARACTERISTICS AND UTILIZATION OF PROBLEM SOILS IN THAILAND

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Before discussing the distribution, characteristics, and utilization of problem soils in Thailand it is necessary to define the term "problem soils" clearly. Otherwise all soils of Thailand would have to be included in the discussion because all of them pose some kind of limitation. The problem soils in this report refer to the soils which have certain chemical or physical characteristics which restrict agricultural development. There are many problem soils such as Vertisol soils, peat and muck soils, acid sulfate soils, saline and sodic soils, sandy soils, and skeletal soils, etc. Most of these soils should not, in fact, be used for cultivation. But in developing countries such as Thailand the good soils are scarce and the competition for land is high. Most of the so-called problem soils have been cultivated for various crops. The yields of crops obtained from these soils are low as expected.

Thailand occupies an area of about 520,000 km^2. Fifty five percent of that area in considered to be suitable for cultivation of upland crops (24%), paddy rice (26%) and tree crops (5%). However the word suitable does not imply that these soils have no problems at all. In fact it only means that the soils can be used for agricultural purposes with small risk. Another fourty four percent is unsuited for cultivation due to unfavorable soil and topographic conditions. The rest of the area (1%) is of water bodies. In Thailand the total coverage of problem soils is approximately 108,846 km^2 or about 21% of the total country land (see Table 1).

This report intends to give information concerning the distribution, some characteristics, and present utilization of the problem soils found in Thailand.

1 Saline and Sodic Soils

Saline soils are defined by the electrical conductivity of a saturated extract of a certain soil horizon (FAO, 1978) or by soluble salt concentration. The salt content may fluctuate depending on the amount of rainfall, the evaporation rate and on the irrigation history of the area.

Sodic soils, previously called alkali soils, are those soils containing at least 15% exchangeable sodium. The pH of many sodic soils can be above 8.5 due to the presence of sodium carbonate.

In Thailand there are two major types of saline and sodic soils. One is the inland type which occurs in the Korat Basin of the Korat Plateau. The salt comes from salt-bearing rocks. The other type is tidal marshes occurring along the coastal areas (see map No. 1) where the salt derives from sea water. Natraqualfs and Halaquepts represent the inland saline and sodic soils while the Sulfaquents and Hydraquents represent the tidal marsh type. Brief descriptions of the soils are given below. The Natraqualfs and Halaquepts are used for paddy rice cultivation during the rainy season. The Sulfaquents and Hydraquents are mostly uncultivated and are covered by mangrove forests or Nipapalm. Some areas are ridged for tree crops such as coconut. Small areas are used for fish or shrimp culture, and salt flats.

1) Natraqualfs

Grey and mottled Alfisols that have a natric horizon. Ground water is perched above the natric horizon at one period during the year and the soil is saturated during the rainy season.

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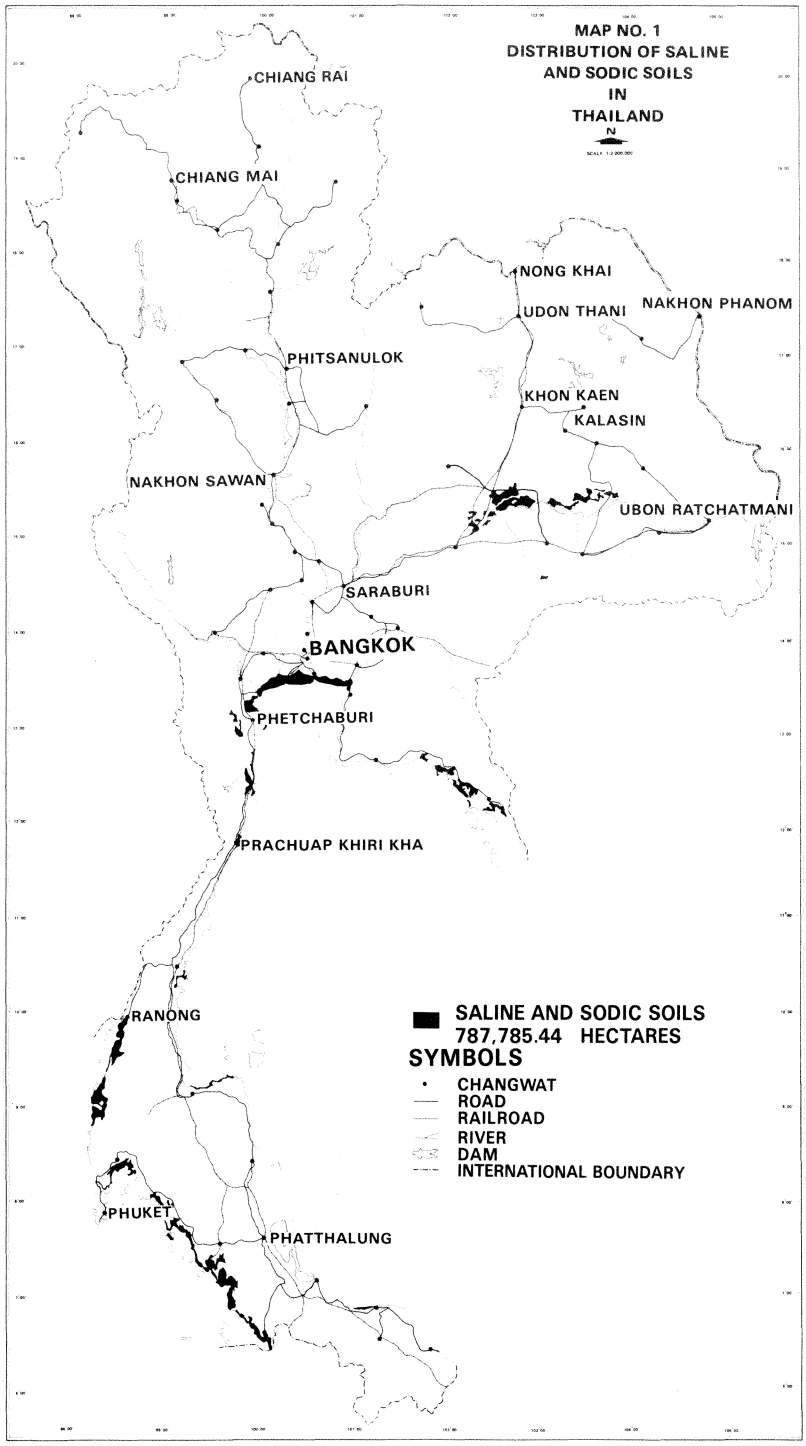
Table 1 Extent of the problem soils in Thailand

Problem Soils	Name of Great Group	Area involved (km^2)
Saline and Sodic soils	Natraqualfs Sulfaquents Hydraquents Halaquepts	2,099
Acid Sulfate soils	Sulfic Tropaquepts	8,404
Sandy Texture soils	Quartzipsamments	9,454
Ground Water Podzols	Tropohumods	894
Vertisols soils	Chromuderts Pelluderts Chromusterts Pellusterts	3,365
Organic soils	Tropofibrists	808
Skeletal soils	Ustorthents Troporthents Dystropepts Haplustalfs Plinthaquults Paleaquults Plinthustults Paleustults Haplustults Plinthudults Paleudults Tropudults	83,822
	Total	108,846

If undisturbed, these soils have a thin Al horizon overlying a thin albic horizon which in turn overlies the natric horizon. If ploughed the two upper horizons and the upper part of the natric horizon may be mixed.

2) Halaquepts

Wet Inceptisols that are sodic and in places saline with shallow ground water. In seasons with little rain, capillary rise and evapo-transpiration bring sodium or salts to or near the surface. They do not have a salic horizon that persists throughout the year but salt efflorescence is common on the surface in dry seasons. Halaquepts are normally grey and mottled to or near the surface. Sodium saturation is 15% or more in half or more of the upper 50 cm and decreases with depth below 50 cm. They have an *n*-value of 0.7 or less in some layers between 20 and 50 cm. They have no plinthite that forms a continuous phase or constitutes more than half of the matrix


MAP NO. 1
DISTRIBUTION OF SALINE
AND SODIC SOILS
IN
THAILAND
N
CHIANG RAI
CHIANG MAI
NONG KHAI
UDON THANI
NAKHON PHANOM
PHITSANULOK
KHON KAEN
KALASIN
NAKHON SAWAN
UBON RATCHATMANI
SARABURI
BANGKOK
PHETCHABURI
PRACHUAP KHIRI KHA
RANONG
PHUKET
PHATTHALUNG
SALINE AND SODIC SOILS
787,785.44 HECTARES
SYMBOLS
CHANGWAT
ROAD
RAILROAD
RIVER
DAM
INTERNATIONAL BOUNDARY

Map 1

within 125 cm of the surface and have no sulfuric horizon with an upper boundary within 50 cm of the surface.

3) Sulfaquents

Wet Entisols that have appreciable amounts of sulfides close to the mineral surface, and few or no carbonates. They are largely restricted to coastal marshes where the waters are brackish, and to the tidal marshes at the mouths of rivers, unless the river sediments are rich in carbonates. Sulfaquents are permanently saturated with water at or near the surface and the soils change rapidly to Sulfaquepts. They have sulfidic materials within 50 cm of the mineral surface if the *n*-value is more than 1, and within 30 cm if the *n*-value is 0.7 or less.

4) Hydraquents

Wet, primarily clayey Entisols of tidal marshes that are permanently saturated with water. Hydraquents have never been dry, and consequently the bulk densities are low and water contents high. Colours are usually bluish grey to greenish grey, and change to shades of brown if exposed to air. They have no sulfidic materials within 50 cm of the mineral surface, have *n*-values of more than 0.7 and at least 8% clay in all subhorizons between 20 and 50 cm of the mineral surface.

The presence of sulfidic materials in Sulfaquents and Hydraquents makes both soils acid sulfate in potential as well.

2 Acid Sulfate Soils

Acid sulfate soils of Thailand at present are classified as Sulfic Tropaquepts. These soils are located mostly in the central plain and cover about 8,404 Km^2 (see map No. 2). The most important characteristic of the acid sulfate soils is that they are strongly acidified by the oxidation of pyrite to sulfuric acid, pushing the field soil pH down below 4. Other characteristics are described briefly below.

Sulfic Tropaquepts

Wet Inceptisols that are mostly developed from brackish water deposits in the lower part of the central plain. They are characterized by a dark or black thick surface horizon underlain by an acidified B horizon or a cat clay at a depth of less than 1.5m from the soil surface. These, in turn, overlie a completely reduced, very soft mud clay that has a relatively high sulfur content, mainly in the form of pyrite. They are mostly grey and mottled with depth. The ground water fluctuates, but stands relatively high through most of the year.

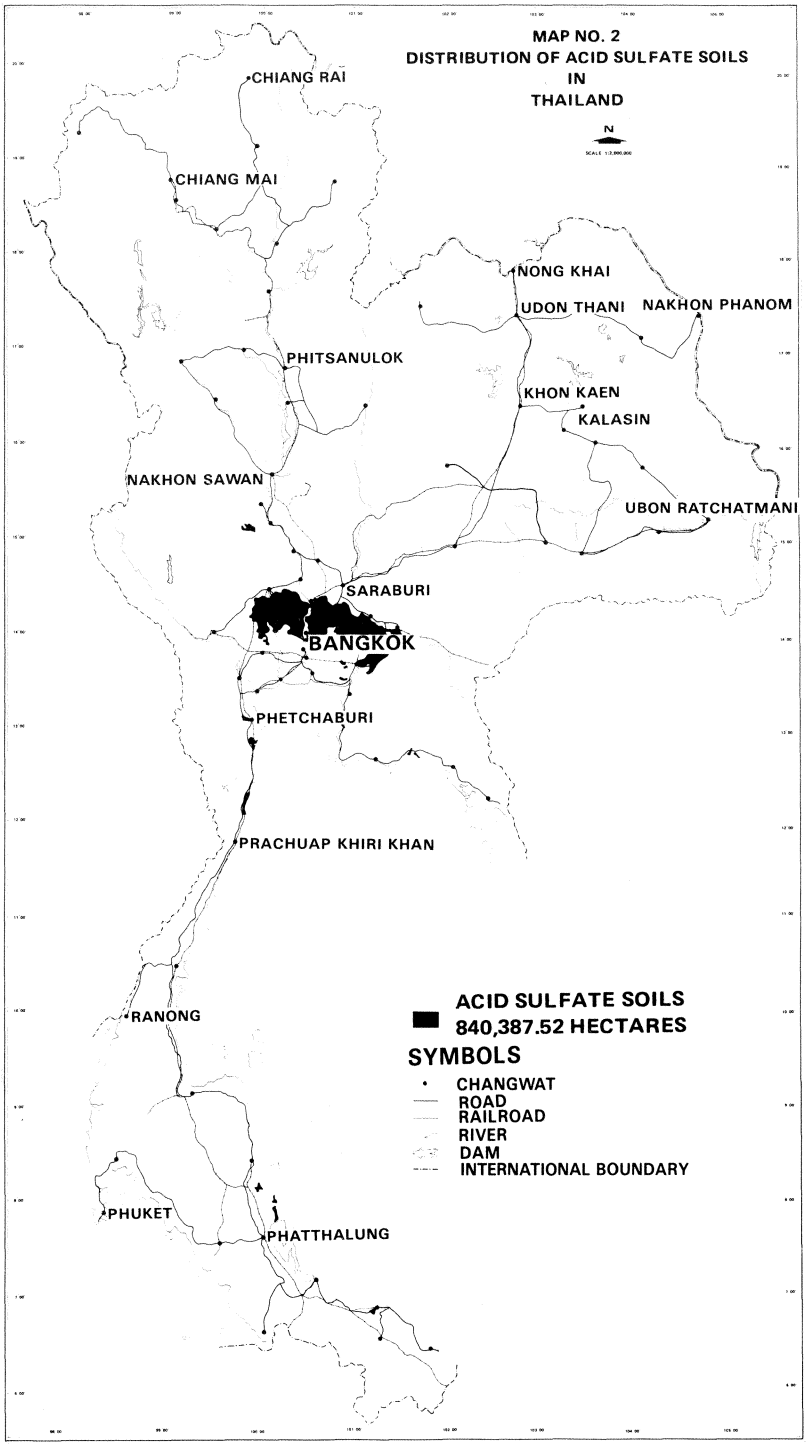
Although most of the areas have been used for cultivation of paddy, rice yield is relatively low, ranging from 1 to 1.5 ton per hectare.

The growth of plants grown on acid sulfate soils is restricted by the toxicity of aluminum and low availability of phosphorus. Despite all these problems the soils are used for paddy rice cultivation, however poor the yield. Some parts are ridged for fruit trees such as mango and citrus with heavy lime and fertilizer application especially nitrogen and phosphorus. Lately *Casuarina Junghuhniana* has been introduced into the acid sulfate soils and it is claimed that the outcome is beneficial. At present the government recommends marl as liming material for paddy cultivation incorporated wtih 125 kg/ha of ammonium phosphate at a rate of 13 ton/ha. This increased paddy yield from 300 kg/ha to 4,300 kg/ha.

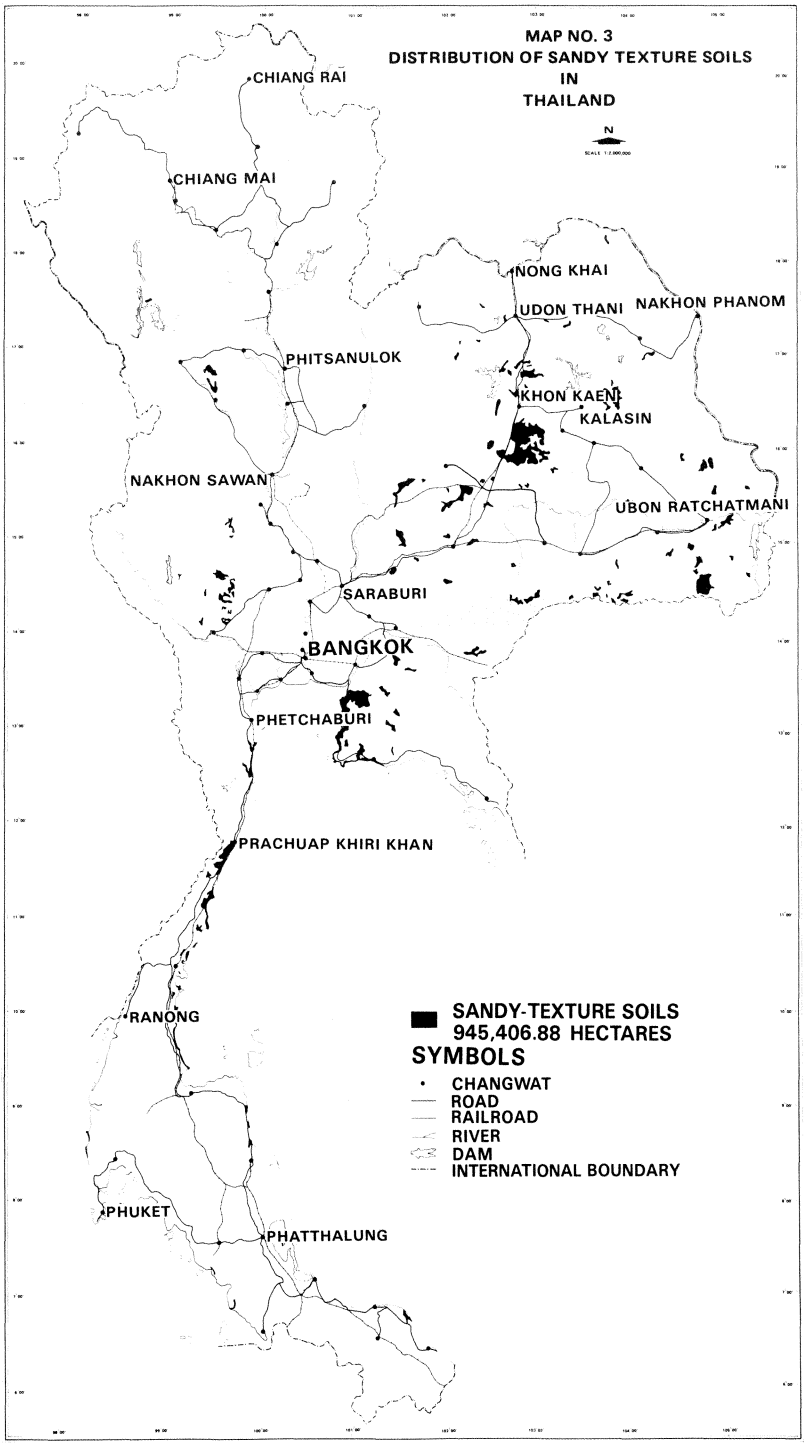
3 Sandy Texture Soils

Sandy texture soils are soils containing sandy material to a depth of more than 100 cm. The sand is mainly quartz. These soils are extremely low in plant nutrients, water holding capacity, and cation exchange capacity. They are classified in the Quartzipsamment great group in Soil Taxonomy.

The Quartzipsamment soils are found scattered in many parts of Thailand but are mainly


MAP NO. 2
DISTRIBUTION OF ACID SULFATE SOILS
IN
THAILAND
N
CHIANG RAI
CHIANG MAI
NONG KHAI
UDON THANI
NAKHON PHANOM
PHITSANULOK
KHON KAEN
KALASIN
NAKHON SAWAN
UBON RATCHATMANI
SARABURI
BANGKOK
PHETCHABURI
PRACHUAP KHIRI KHAN
RANONG
PHUKET
PHATTHALUNG
ACID SULFATE SOILS
840,387.52 HECTARES
SYMBOLS
CHANGWAT
ROAD
RAILROAD
RIVER
DAM
INTERNATIONAL BOUNDARY

Map 2


MAP NO. 3
DISTRIBUTION OF SANDY TEXTURE SOILS
IN
THAILAND
N
CHIANG RAI
CHIANG MAI
NONG KHAI
UDON THANI
NAKHON PHANOM
PHITSANULOK
KHON KAEN
KALASIN
NAKHON SAWAN
UBON RATCHATMANI
SARABURI
BANGKOK
PHETCHABURI
PRACHUAP KHIRI KHAN
RANONG
PHUKET
PHATTHALUNG
SANDY-TEXTURE SOILS
945,406.88 HECTARES
SYMBOLS
CHANGWAT
ROAD
RAILROAD
RIVER
DAM
INTERNATIONAL BOUNDARY

Map 3

concentrated in the northeastern and southeastern parts (see map No. 3). The total coverage of these soils is 9,454 km^2. The major characteristics of the soils are as follows:–

Quartzipsamments

Freely drained Entisols predominantly composed of quartz sands. They may be white or stained with shades of brown, yellow or red. They occur on Late Pleistocene and younger surfaces, or beach ridges but where they virtually lack minerals that can weather. They also occur on some extremely old land surfaces. In some places a spodic horizon may underlie white sands but occurs so deep that it is not practical to consider its presence. The important property of such soils is that the first 2m or so is uncoated quartz sand. The sand fraction of Quartzipsamments is more than 95% quartz, zircon, tourmaline, rutile, or other normally insoluble crystalline minerals that do not weather to liberate iron or aluminum.

The sandy textured soils are now used mainly for growing cassava during the rainy season with yields of about 6 ton/ha. Some places are still under dipterocarp forests.

4 Ground Water Podzols

These soils occur in relation to the Quartzipsamments in the high rainfall regions where the condition is ideal for formation of a spodic horizon. They are found mainly farthest south starting from Songkhla to Narathiwat. Although the extent of these soils is only 894 km^2 they create some difficulty for the agriculture of the area. The major problems of these soils are the compacted spodic horizon which prohibits root penetration.

The soils are classified as Tropohumods based on the following major characteristics.

Tropohumods

More or less freely drained Spodosols that have large accumulations of organic carbon relative to iron in some or all parts of the spodic horizon and which occur in southern regions or along the coastal line (see map No. 4). The spodic horizon has 0.6% or more organic carbon in weight within the matrix of the upper 30 cm. There is no more than 75 cm of a sandy epipedon (loamy fine sand or coarser) overlying the spodic horizon and there are no characteristics associated with wetness.

These soils are largely left to supporting natural vegetation such as bushes, shrub and grass. However some parts have been cleared for coconut plantations. The outcome is very poor. The cononut trees show signs of nutrient deficiency resulting in poor stands.

5 Vertisols Soils

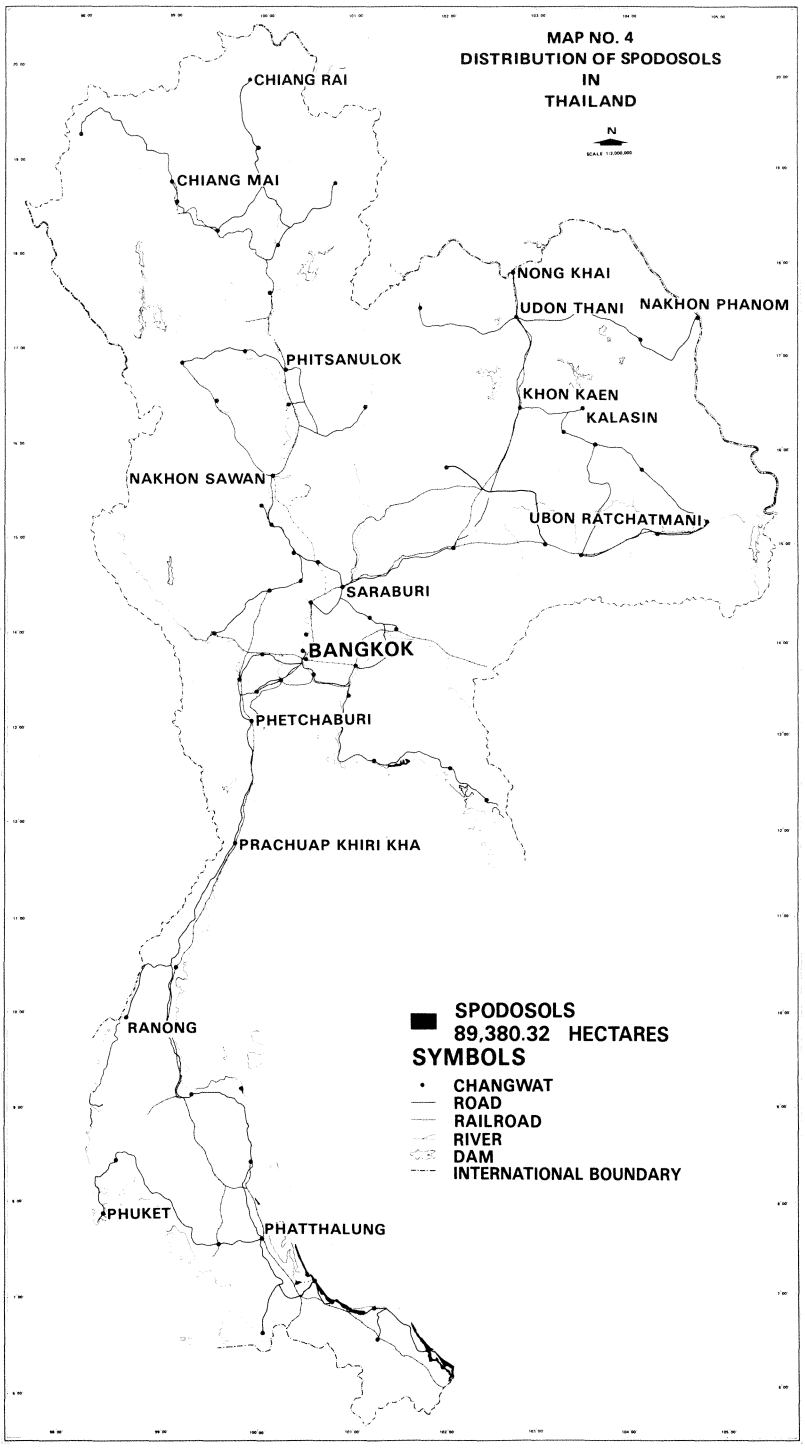
This group of soils refers to the dark, poorly drained, fine textured soils that are derived from alluvium containing expanding clay minerals on flat topography or in depressions. In some areas they are formed from basaltic rock on nearly level footslopes of remnants of small volcanic cones.

These soils are found quite extensively on the alluvial central plain and small areas in Nakorn Rachasima, Buri Rum, Surin and Sri-Saket. The overall area of the soils is about 3,365 km^2 (see map No. 5).

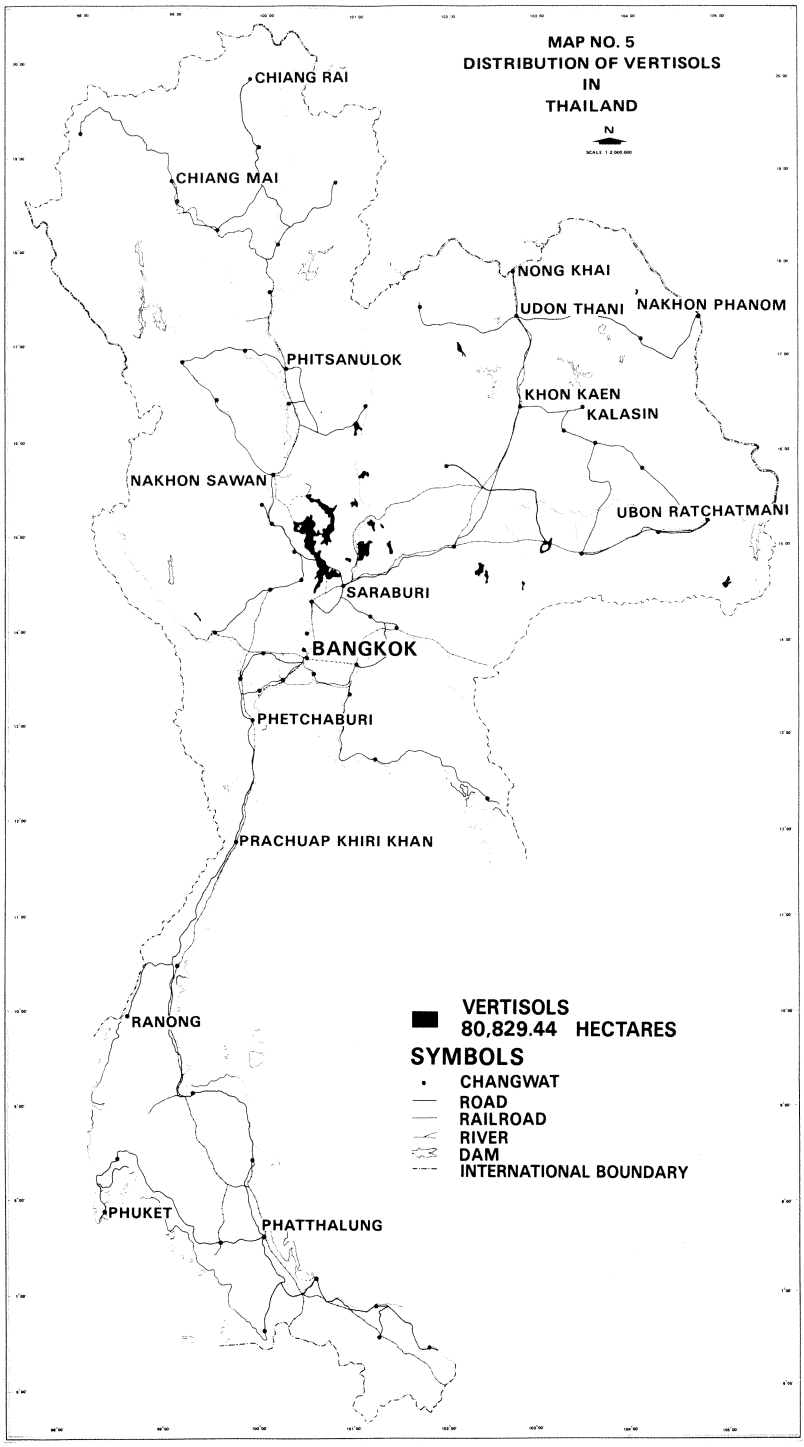
Taxonomically the soils are classified into the Great Group of (1) Chromuderts, (2) Pelluderts (3) Chromusterts, and Pellusterts. Brief descriptions of this great group are as follows:

1) Chromuderts

Vertisols that are usually moist in some parts and have cracks that open and close one or more times during most years, but that do not remain open for as many as 90 cumulative days. Chromuderts have readily visible colours. Many are brownish throughout, but hues may range from olive to red. Colour values are less than 3.5 when moist and less than 5.5 when dry throughout the upper 30 cm in more than half of each pedon. Low chroma mottles are normal in the lower horizons because aeration is very poor and cracks are closed. However, they typically lack distinct or prominent mottles within 50 cm of the surface in more than half of each pedon.


MAP NO. 4
DISTRIBUTION OF SPODOSOLS
IN
THAILAND
N
CHIANG RAI
CHIANG MAI
NONG KHAI
UDON THANI
NAKHON PHANOM
PHITSANULOK
KHON KAEN
KALASIN
NAKHON SAWAN
UBON RATCHATMANI
SARABURI
BANGKOK
PHETCHABURI
PRACHUAP KHIRI KHA
RANONG
PHUKET
PHATTHALUNG
SPODOSOLS
89,380.32 HECTARES
SYMBOLS
CHANGWAT
ROAD
RAILROAD
RIVER
DAM
INTERNATIONAL BOUNDARY

Map 4


MAP NO. 5
DISTRIBUTION OF VERTISOLS
IN
THAILAND
N
CHIANG RAI
CHIANG MAI
NONG KHAI
UDON THANI
NAKHON PHANOM
PHITSANULOK
KHON KAEN
KALASIN
NAKHON SAWAN
UBON RATCHATMANI
SARABURI
BANGKOK
PHETCHABURI
PRACHUAP KHIRI KHAN
RANONG
PHUKET
PHATTHALUNG
VERTISOLS
80,829.44 HECTARES
SYMBOLS
CHANGWAT
ROAD
RAILROAD
RIVER
DAM
INTERNATIONAL BOUNDARY

Map 5

2) Pelluderts

Vertisols that are usually moist in some parts and have cracks that open and close one or more times in most years, but that do not remain open for as long as 90 cumulative days. Pelluderts are usually grey to black in all subhorizons in the upper 30 cm in more than half of each pedon. Colour values are typically less than 3.5 when moist and less than 5.5 when dry throughout the upper 30 cm in more than half of each pedon. As a rule low chromas, except for some high chroma mottles, extend to considerable depths.

3) Chromusterts

Vertisols that have cracks that open and close more than once in most years and that remain open for between 90 and 150 cumulative days but that are closed for at least 60 consecutive days. Chromusterts have readily visible colours in the matrix of some subhorizon in the upper 30 cm or more in more than half of each pedon. They typically have colour values of less than 3.5 when moist and less than 5.5 when dry throughout the upper 30 cm. Clay skins on ped faces in soils with a prismatic or blocky structure do not have colour values lower than the matrix within 1m of the surface.

4) Pellusterts

Vertisols that have cracks that open and close more than once in most years and that remain open between 90 and 150 cumulative days, but that close for at least 60 consecutive days. Pellusterts are dominantly grey to black in all subhorizons throughout the upper 30 cm in more than half of each pedon. They typically have colour values of less than 3.5 when moist and less than 5.5 when dry throughout the upper 30 cm in more than half of each pedon. Low chromas, except for some high chroma mottles, generally extend to considerable depth. Clay skins on ped faces of soils with a prismatic or blocky structure do not have colour values lower than in the matrix within 1m of the surface.

The main problem of these soils is physical. They are very hard and crack deeply when dry but very plastic and sticky when wet. This condition creates difficulty in using machines for cultivation. When the soils are wet they become impermeable to water and hence drainage conditions become very poor.

At present the Vertisols are used mainly for upland crops such as corn, cotton and sorghum. Fruit trees are grown in some areas.

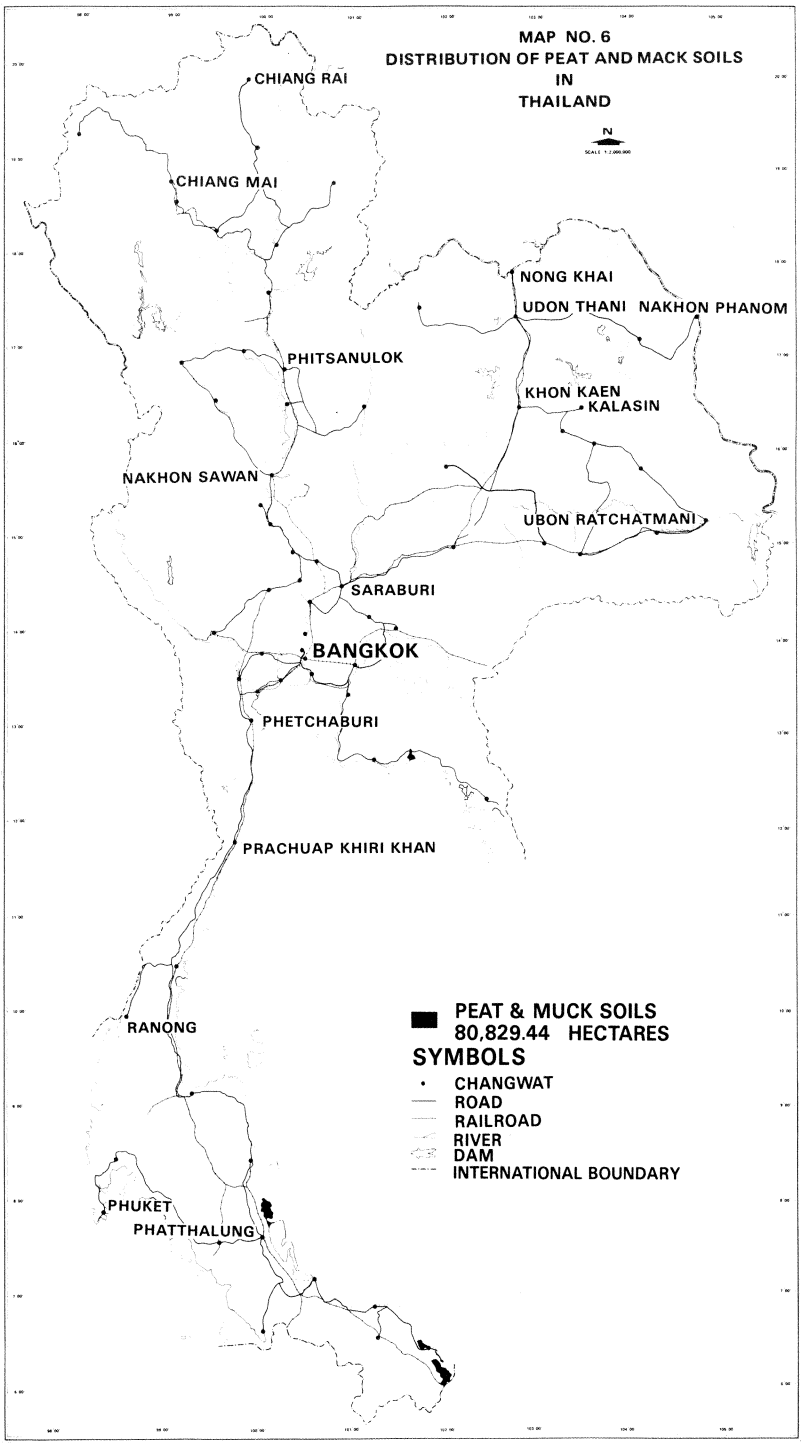
6 Organic Soils

Organic soils or peat soils that contain more than 65% or more of organic matter to a depth of not less than 50 cm. The soils are waterlogged and very acid. In Thailand two major areas of peat and muck soils are found in Pattalung and Narathiwat province (see map No. 6). These areas occupy about 808 km^2. Small areas of peat and muck soils are also observed in other regions but the sizes are too small to show on this report's map.

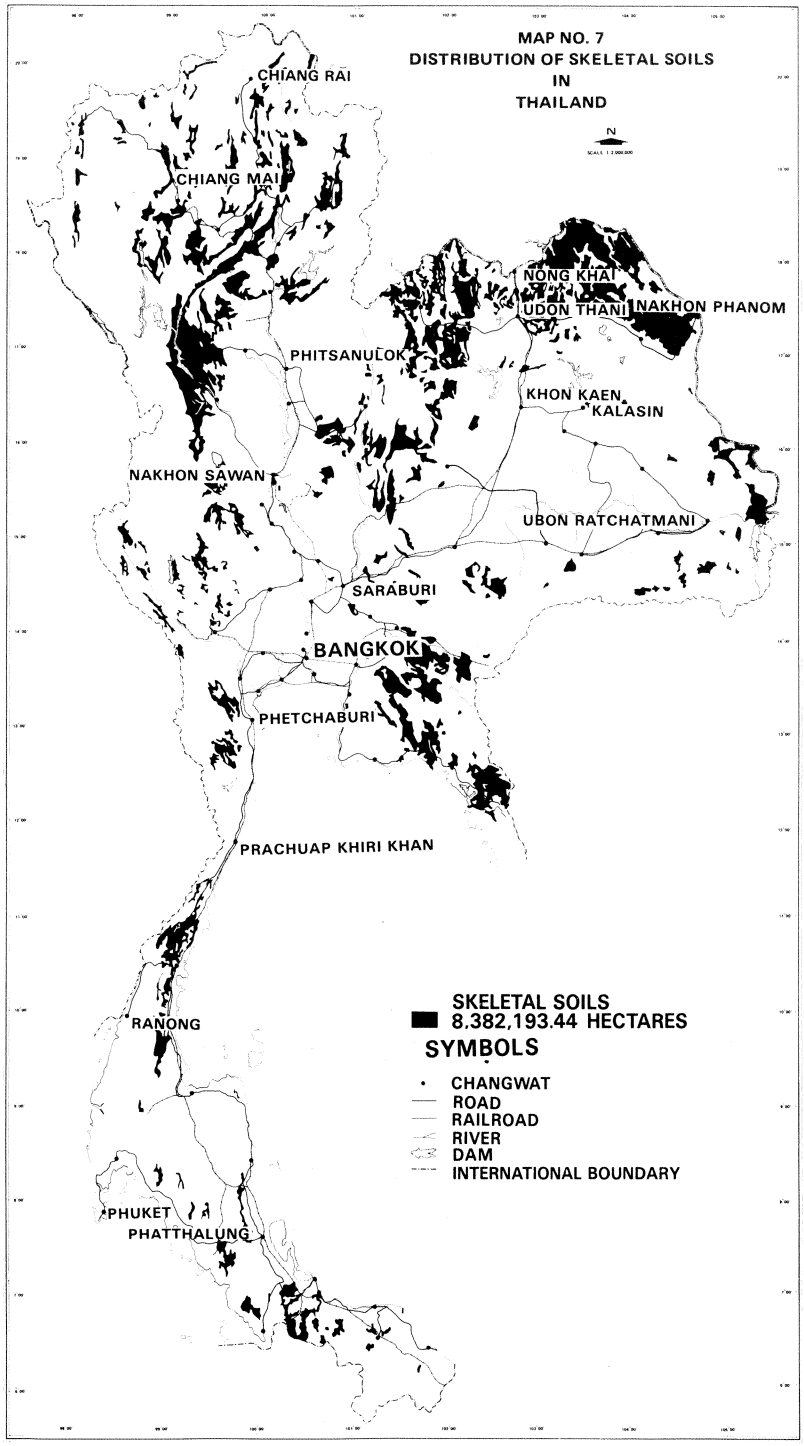
The peat soils are classified as Tropofibrists having major characteristics as described below:

Tropofibrists

Histosols consisting largely of plant remains so small that they are not destroyed by rubbing and their botanic origin can readily be determined. Most of them occur in coastal swamps in peninsular Thailand. Many of the areas are still under native vegetation with *Melaleuca leucadendron,* and *Maranta arundinaceae* as the dominant species.


MAP NO. 6
DISTRIBUTION OF PEAT AND MACK SOILS
IN
THAILAND
N
CHIANG RAI
CHIANG MAI
NONG KHAI
UDON THANI
NAKHON PHANOM
PHITSANULOK
KHON KAEN
KALASIN
NAKHON SAWAN
UBON RATCHATMANI
SARABURI
BANGKOK
PHETCHABURI
PRACHUAP KHIRI KHAN
RANONG
PHUKET
PHATTHALUNG
PEAT & MUCK SOILS
80,829.44 HECTARES
SYMBOLS
CHANGWAT
ROAD
RAILROAD
RIVER
DAM
INTERNATIONAL BOUNDARY

Map 6


MAP NO. 7
DISTRIBUTION OF SKELETAL SOILS
IN
THAILAND
N
CHIANG RAI
CHIANG MAI
NONG KHAI
UDON THANI
NAKHON PHANOM
PHITSANULOK
KHON KAEN
KALASIN
NAKHON SAWAN
UBON RATCHATMANI
SARABURI
BANGKOK
PHETCHABURI
PRACHUAP KHIRI KHAN
RANONG
PHUKET
PHATTHALUNG
SKELETAL SOILS
8,382,193.44 HECTARES
SYMBOLS
CHANGWAT
ROAD
RAILROAD
RIVER
DAM
INTERNATIONAL BOUNDARY

Map 7

7 Skeletal Soils

Skeletal soils refer to the soils that contain 35% or more by volume of rock fragments, gravel, laterite having diameter greater than 2 mm within the shallow depth (less than 50 cm). This group is widely distributed, covering about 83,822 km^2 or 16% of the total area of the country (see map No. 7). There are 12 great groups listed below, which have skeletal Subgroups:

1. Ustorthents
2. Troporthents
3. Dystropepts
4. Haplustalfs
5. Plinthaquults
6. Paleaquults
7. Plinthustults
8. Paleustults
9. Haplustults
10. Plinthudults
11. Paleudults
12. Tropudults

The presence of rock fragments, gravel and laterite at shallow depth in these soils impedes root growth, water permeability and also causes trouble for cultivation practices. At present the soils are used for various purposes depending on the moisture regime and other parameters. The Orthents soils are still covered by deciduous or dipterocarp forests. Aquults are used for paddy rice cultivation. Udults which are found in the southern and southeastern regions where rainfall is high are mainly used for rubber plantations. Ustalfs or Ustults are used for growing upland crops such as corn, cassava, sorghum, sugar cane etc.

Conclusion

In Thailand, the agricultural soils do not only lack plant nutrients but many of them have certain chemical and physical properties which prohibit plant growth. To overcome these problems special reclamation techniques are required. These techniques always call for large capital investment which most farmers can not afford. The limitation factor of the reclamation is therefore an economical rather than a technical one. The farmers recognize the situation very well. They are hence using these problem soils only when they are assured of beneficial return.

Acknowledgement

The valuable assistance from Mr. P. Vicharnsorn, Mr. P. Micheale and the drafting section of the Soil Survey Division is gratefully recognized.

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Discussion

Kyuma, K. (Japan): You listed Vertisols as one kind of problem soils. However, from our field observations in the Pasak river basin, Vertisols are better utilized than other soils because of their high fertility and resistance to erosion. Should they still be classified as problem soils?

Answer: It is true that Vertisols in the Pasak river basin have been well utilized. However problems relating to their physical properties, such as drainage should be tackled. We also find it difficult to classify these soils as we have been able to grow paddy on them although a udic moisture regime cannot be easily recognized.

Imai, H (Japan): How could you improve sandy soils such as Reddish Yellow Podzolic soils and Grey Podzolic soils which are characterized by severe erosion and low nutrient content? How could you improve some of the sandy soils from North East Thailand which become very hard after drying due to clay-coating on the soil surface. Can you improve somehow the drainage properties?

Answer: Economic considerations make it difficult to improve them through the use of fertilizers. The sandy texture soils in my presentation refer to Regosols or Quartzipsamments and do not include Red Yellow Podzolic or Grey Podzolic soils which contain some clay responsible for the characteristics you mentioned. Attempts have been made to improve these soils by fertilizer application, liming and by selecting appropriate cropping systems. The data could be made available to you by the Land Development Department in Bangkok

Zahari, A.B. (Malaysia) Comment: I agree with Dr. Panichapong that cultivation of the sandy soils requires large capital investment. Our experience in Malaysia indicates that the cultivation of tobacco is quite profitable (net income of $1,200 for a family which can easily manage up to 4,000 crops every season).

Somasiri, S. (Sri Lanka): I believe that Spodosols are not suited to the cultivation of coconut.

Answer: I agree with you and presently the government attempts to use the Spodosols for pasture development. Unfortunately the results do not appear too promising.