Observations on soils, climate and current land use in areas of the PRC-ADB Red Soils Development Project in Hunan province, China

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T.A. No. 1573-PRC

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ROYAL TROPICAL INSTITUTE

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ABSTRACT

A rapid soil survey of several sites in three counties (Hengyang, Qiyang and Yongzhou) in Hunan province is executed to select demonstration plots for anti-erosion measurements.
A short climate inventory, comprising a study of waterbalances, variability of precipitation and temperature diagrams of meteorological stations, precede the soil chapters. The climate is characterized by extremes with respect to rainfall, evaporation and temperatures. Rainfall is erratic throughout the year, droughts occur making irrigation essential, and incidental frost causes harm to agricultural production (e.g. citrus).
Based on field observations description of landscape, soils, type and degree of erosion and land use of the sites are presented.
Soils are derived from red quaternary clay, purplish shale, slate/shale, limestone and sandstone. Major differences between soil types are effective soil type (depending on erosion degree), soil reaction (pH), texture, available nutrients, exchangeable cations, and available soil moisture.
All sites visited showed different erosion types, most striking is the heavily gullied bare land. However, this seriously effected land has a limited extent and it is assumed to be of less importance in comparison to the total erosion of vast areas of tea-oil bushes covered land with slight to moderate sheet and rill erosion.
Moderately eroded red quaternary clay soil and purplish soil types have the best land-use options with either low or high cost inputs. Low cost recuperation possibilities are minimal for severely eroded deep gullied land and for moderately eroded slate soil type.
Special attention is requested for:

- The formation of a "bio-soil seal" in tea-oil covered land, caused by complete removal of litter needed for kitchen fuel.
- The frequently in soil reports mentioned very high, toxic, exchangeable Aluminium level does not correspond with the soil reaction data (pH-level 5 or higher) in the same reports.
- The need for measurements of available soil moisture (e.g. pF curves), especially for irrigation design purposes.
- The need for updated maps showing distribution of land with different types and degrees of soil degradation.

1 INTRODUCTION

The Hunan Red Soils Development project was identified in October 1990 by an ADB fact-finding mission. The programme of the Inception Phase included a rapid assessment of soil and climatic conditions of a number of severely eroded sites in Hunan province. These sites were selected for the demonstration of several erosion combatting techniques.

The assessment of soils and climatic conditions comprised the following activities:

- As preparation for the field mission, an abbreviated english version of the 'Soil report of Hunan' (published in Chinese), including 10 small-scale maps, concentrating on the upland soils, was made (1)(2)[1]. In addition a number of soil/land resources reports and maps, all in Chinese, were consulted during the rapid survey (3)(4).

- Six pre-selected sites and seven, ad-hoc selected, additional ones were visited to make rapid surveys during the Inception Phase. A number of soil, landscape, erosion and land-use observations were made at, and in the surroundings of, these sites. Details are presented in this working paper. From each site one or more soil samples were taken to complete the limited, available soil analytical information.

2 AGRO-ECOLOGICAL CONDITIONS

2.1 General

Hunan province forms part of Subtropical Humid China. This climatic subdivision is characterized in winter by continental northeastern monsoons. Cold waves occur and result in quite low temperatures. The winter temperature is generally lower than in other parts of the world at similar latitudes. During the summer maritime southeastern monsoons predominate, causing high temperatures and heavy rainfall.

In addition to this climatic division, nine major physiographic regions are recognized. The greater part of Hunan province falls within the "South Changjiang hills and basins" physiographic region, while the mountainous western part belongs to the Guizhou plateau (5)[1].

Hunan province consists predominantly of low to middle high mountains which are separated by dissected basins composed of hills, broad valleys and plains. The distribution of mountainous areas and basins is distinguished easily from satellite imagery (6). The basins are in the altitude range of 50 to about 200 to 300 meter above sea-level, and the mountain and hill areas mostly in the 300 to 1000 meters range. Since ancient times the basins are used for agriculture and support the greater part of Hunan's population.
The Project area is located in these basins; the following sections describe the climatic and soil conditions in these areas.

2.2 Climate

Precipitation, evaporation and water balance

During the visits to the counties of Hengyang, Qiyang and Yongzhou monthly data were obtained by the team. Based on these data some diagrams were constructed to show the variability of the annual and monthly precipitation (Figures 1a,b to 3a,b) and the water balances of Qiyang and Yongzhou (Figures 4 and 5).

[1]See references.

Generally the annual precipitation ranges from about 1100 to 1500 mm, with extreme values of 900 and 1800 mm. Seasonal distribution is unbalanced. About half of the yearly precipitation is concentrated in the major monsoon months April, May and June (spring and early summer). On average these months have an excess of rainfall. Frequent droughts occur from July to September and are caused by the high potential evapotranspiration[2] and an erratic rainfall. On average this period has a moisture deficit for crop growth. A second less prominent increase in the rainfall occurs in October or November. During this period and the rest of the winter the water balance shows an excess.

Temperature

The temperature regime is characterized by cool winters and hot summers (Fig. 6 and 7). The lowest average temperature in January is about 2 to 4° C. However, temperatures below 0° C do occur. The absolute minimum temperature is -6° C [3]. Spring time and autumn periods are characterized by rapidly changing temperatures. The summer period is hot and average maximum temperatures of the months of July and August reach 33° C. Absolute maximum temperatures are about 40° C. The Subtropical Humid area ranks as one of the hottest areas in China (1).

Growing period

Figures 3 to 9 show the availability of moisture and the temperature regimes of the counties visited. The contrasting seasonal distribution of precipitation and temperature allows the cultivation of sub-tropical and temperate crops. The water balance indicates the necessity of supplementary irrigation in the months of July and August. Supplementary irrigation may also be required to overcome dry spells in other months. A general crop calendar of summer and winter crops is presented in paragraph 2.1.3.

2.3 Soils

Introduction

The soils in the Project area are derived from the following major parent materials: shales/slates, limestone, purplish shales, red quaternary clay and sandstone. These soils occur in the intermontane basin areas with rolling hills, slightly undulating terraces along the rivers and broad plain valleys. The area is drained by a network of rivers with the Xiangjiang river as largest.

The climax vegetation is an evergreen, broad-leaved forest, and the zonal soil is a thick, mostly clayey, acid red soil. However, heavy soil erosion has been induced in historic times, recently again in the early sixties, and many present day soils are shallow (1) and severely eroded.

Red soils are the dominant soil type of Sub-tropical Humid China. According to the official Chinese soil classification system these cover the following soil taxa: Red earth, Yellow red earth, Limestone soil and Purplish soils (7). In this document the term 'red soils' will be used, because this terminology is more common. In vast areas the original soil profile has been eroded and only the soil parent material remains. Yet the soil maps consulted made no subdivision in un-eroded (deep soil) and seriously eroded (very shallow) soils.

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[2]The evaporation data used in these diagrams are derived from the standard evaporation pan used in China. This pan is small (diameter of 25 cm) and 'oases' effects may cause higher evaporation than for the class A pan measurements, or for evaporation data calculated with the Penman formula. For irrigation purposes it is recommended to make a detailed comparison between the different evaporation methods.

[3]According to verbal information serious frosts, such as in December 1991, which caused severe damage to citrus, occur in one out of about 70 years. Less severe damage causing yield reduction during one year, occurs more frequently.

Figure 1a

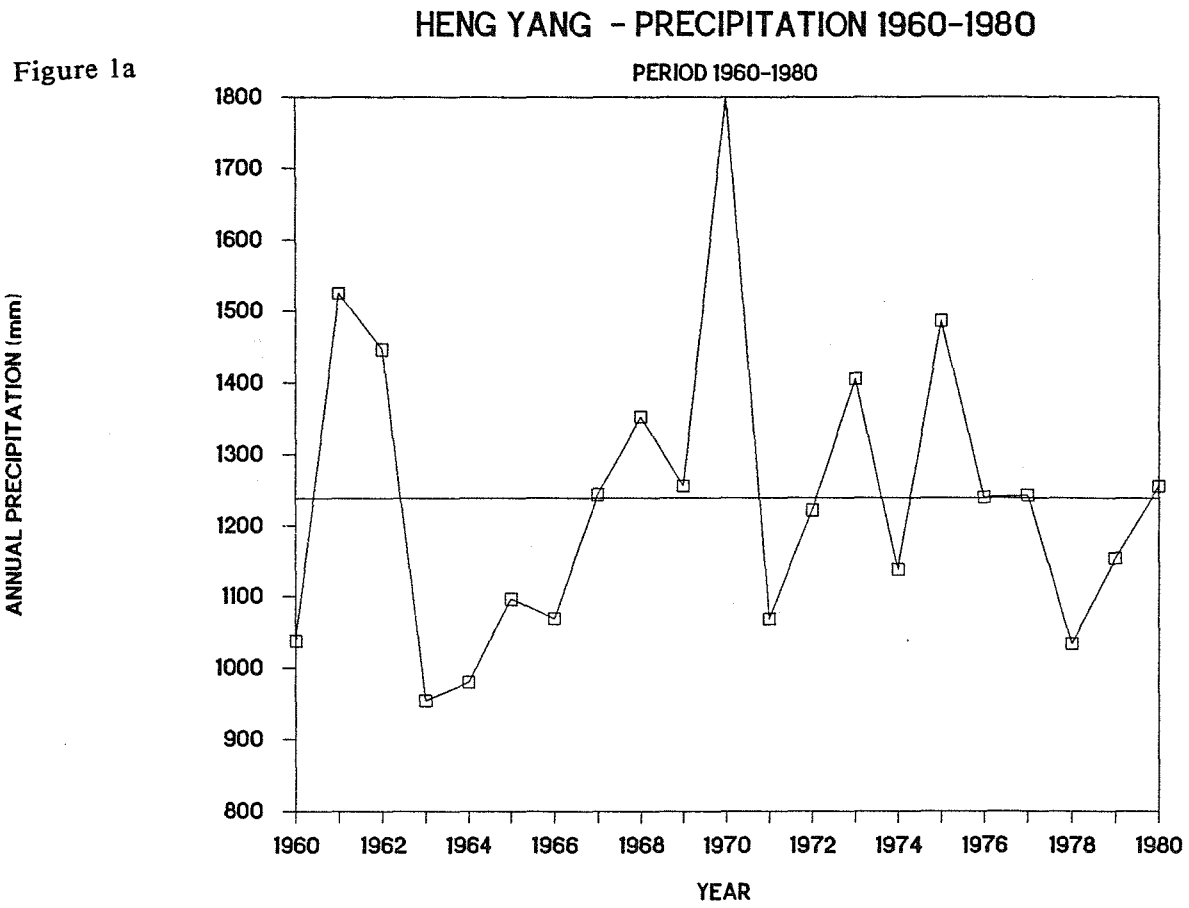


Figure 1b

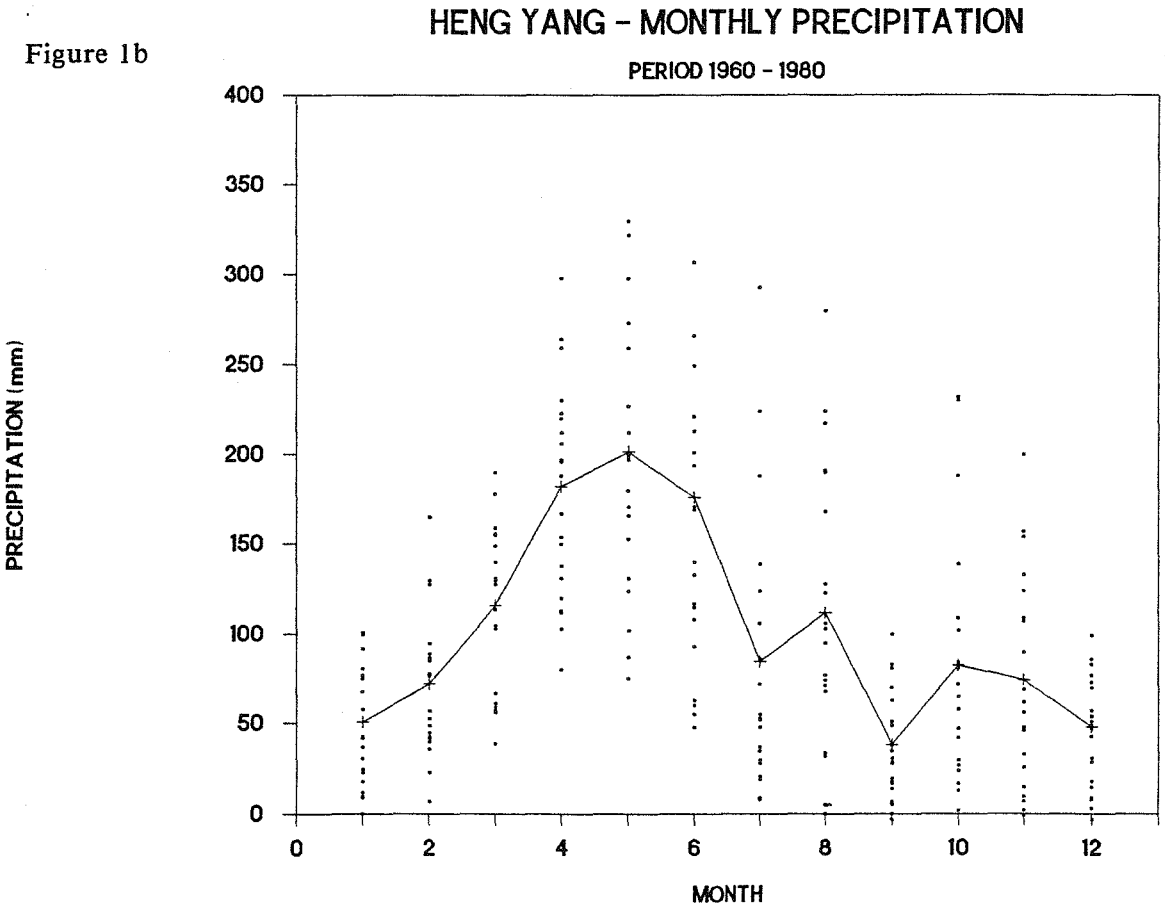


Figure 2a

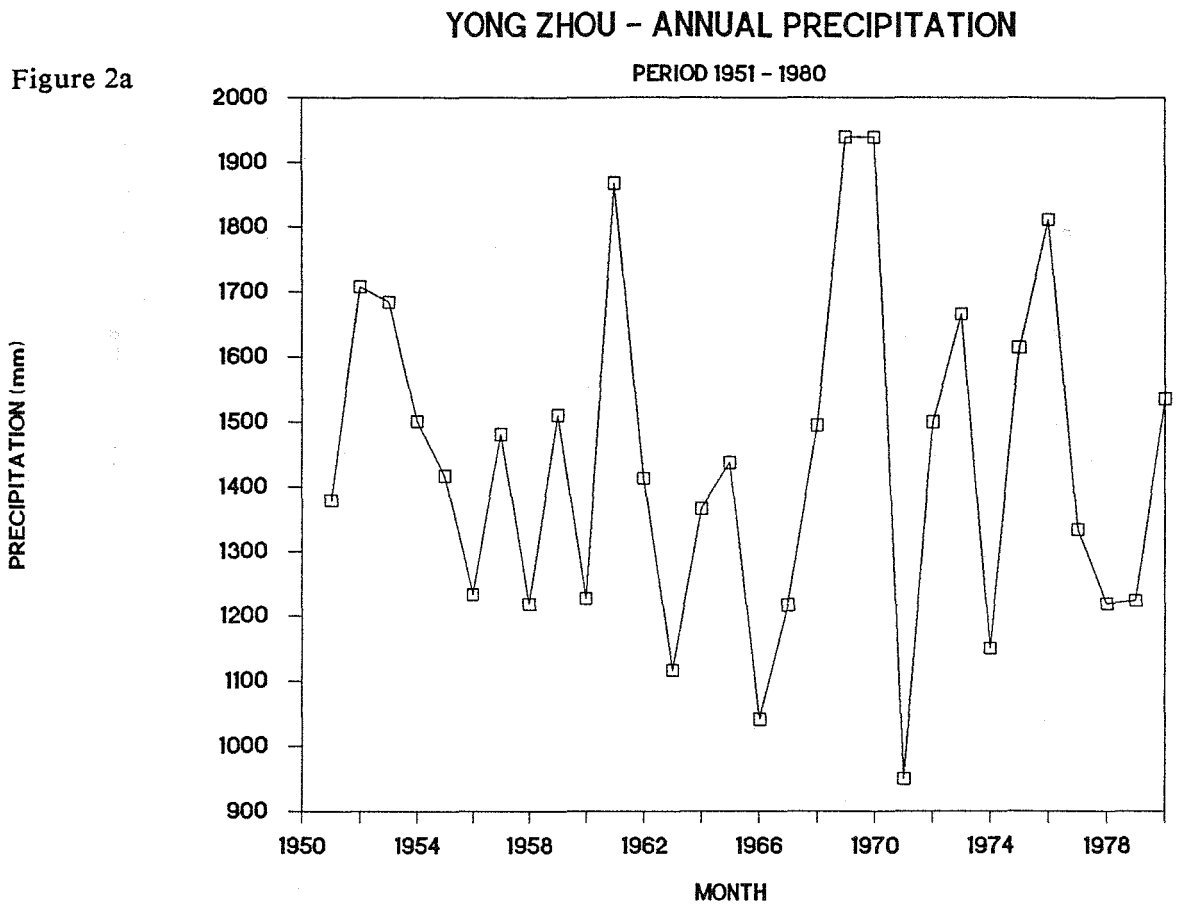


Figure 2b

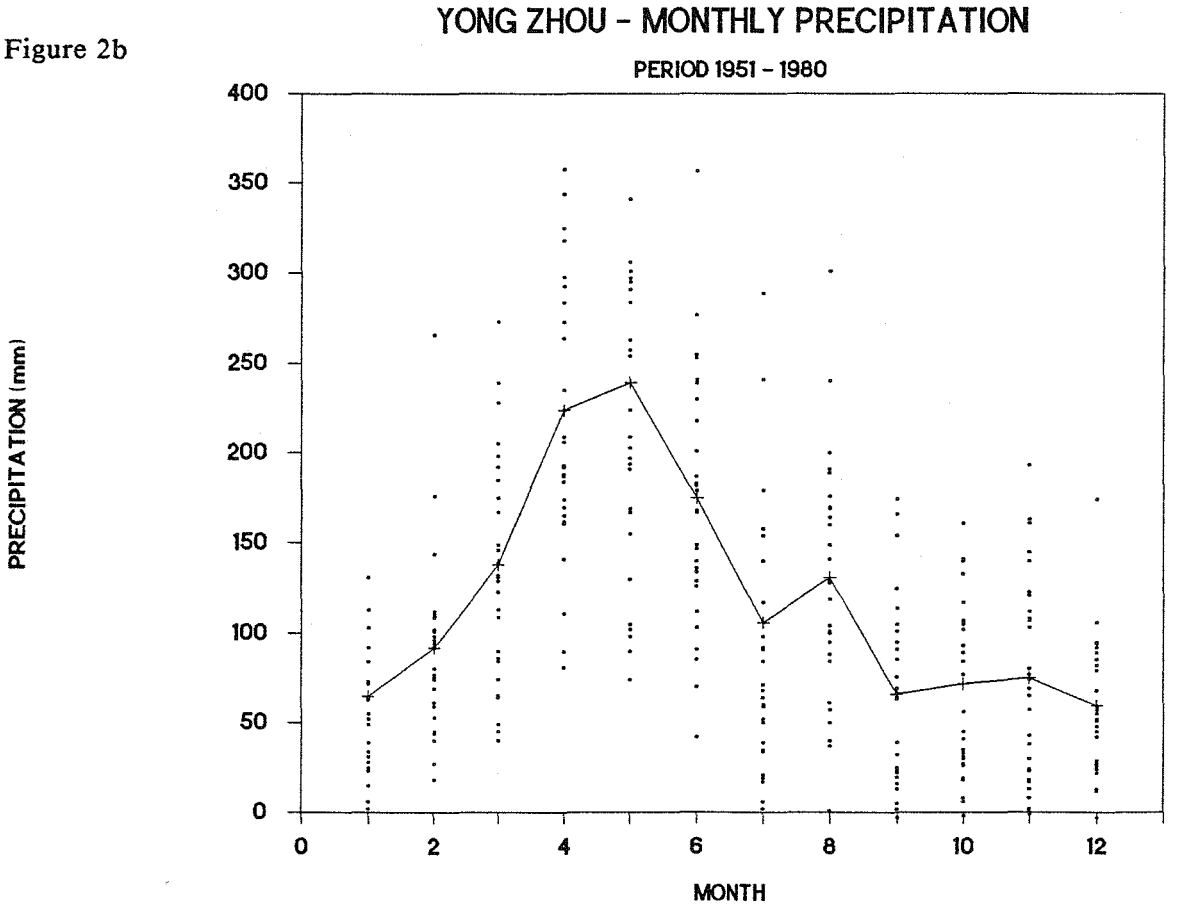


Figure 3a

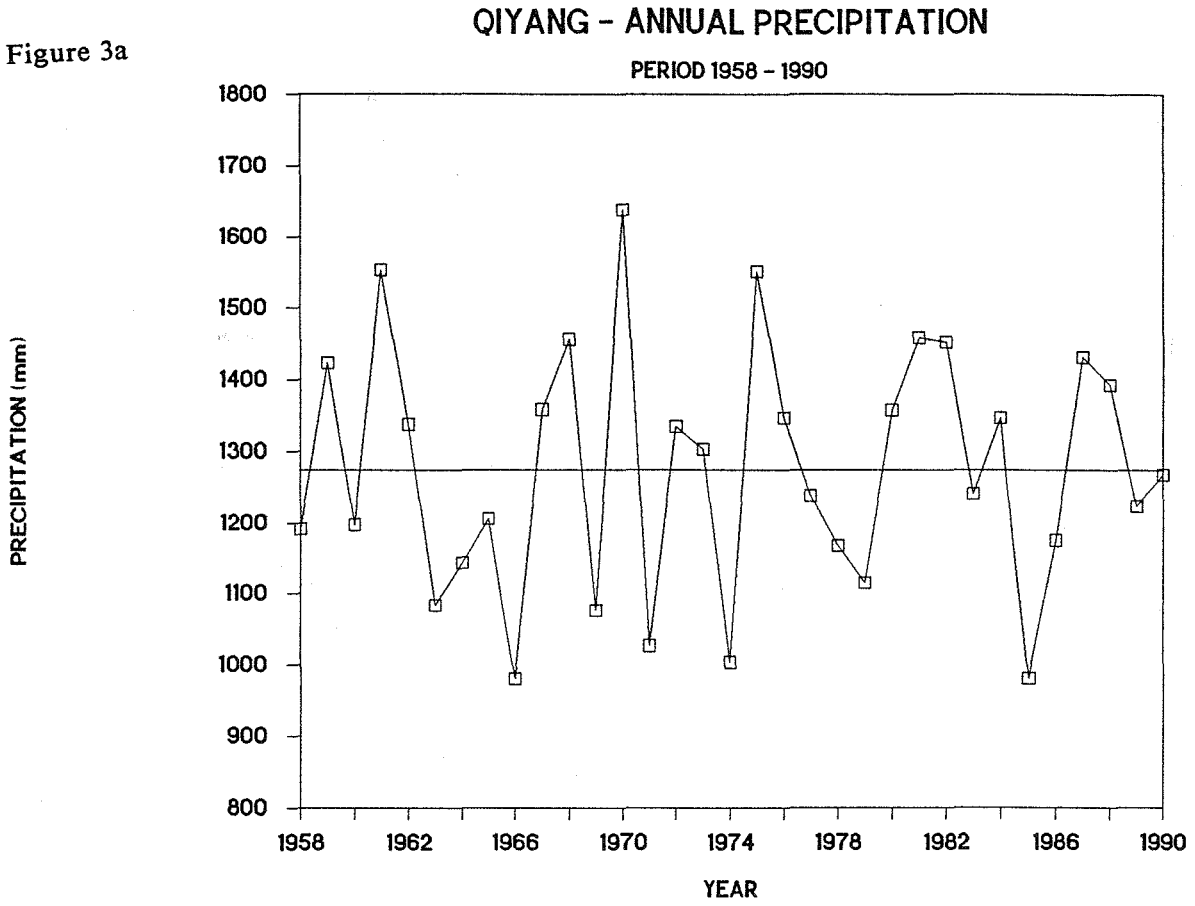


Figure 3b

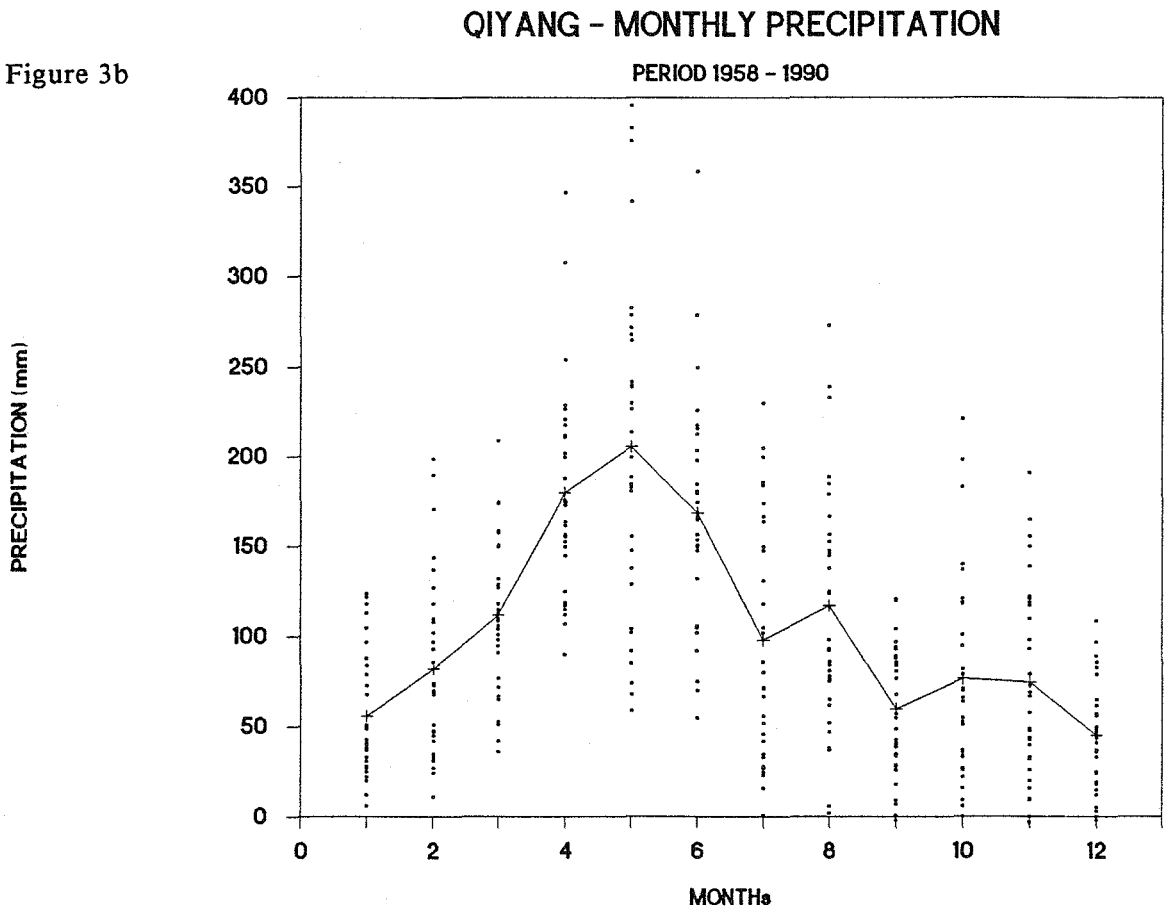


Figure 4

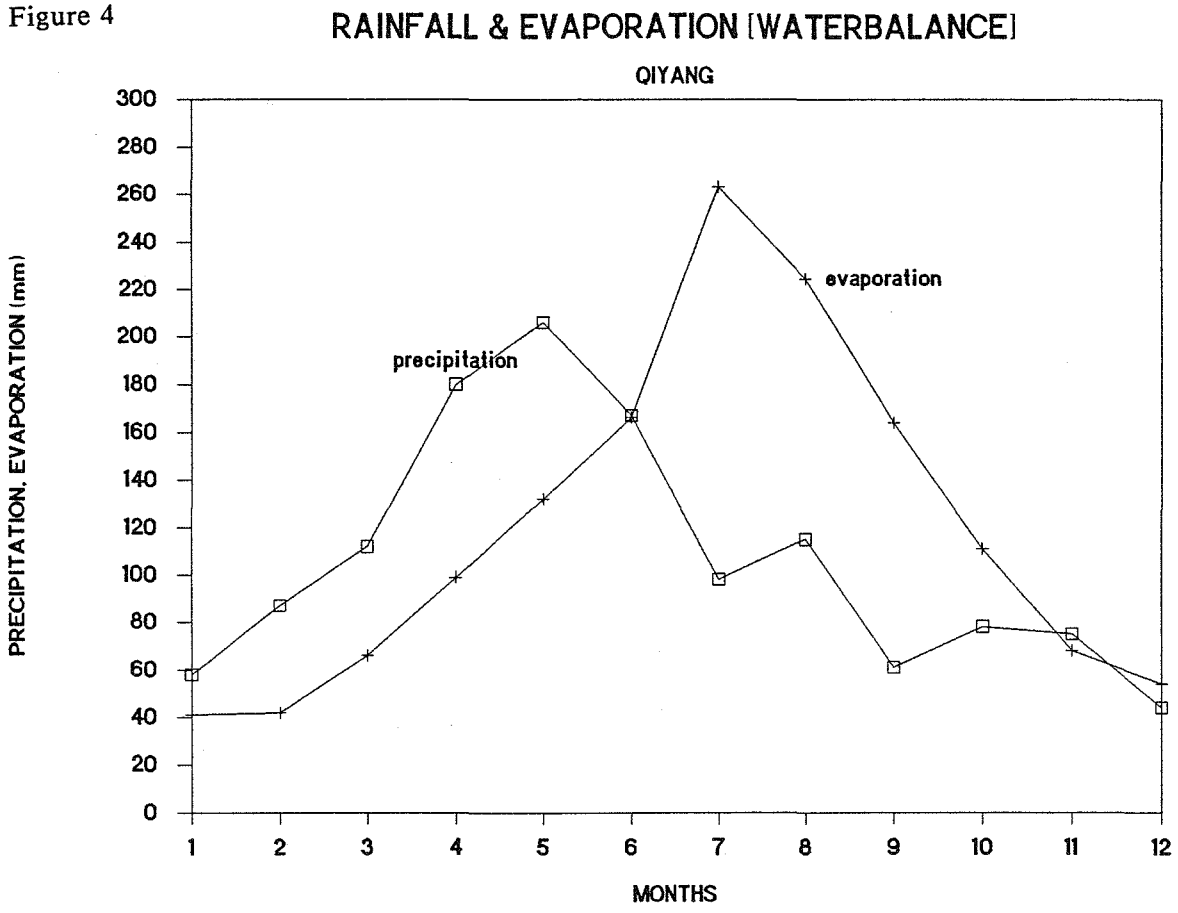


Figure 5

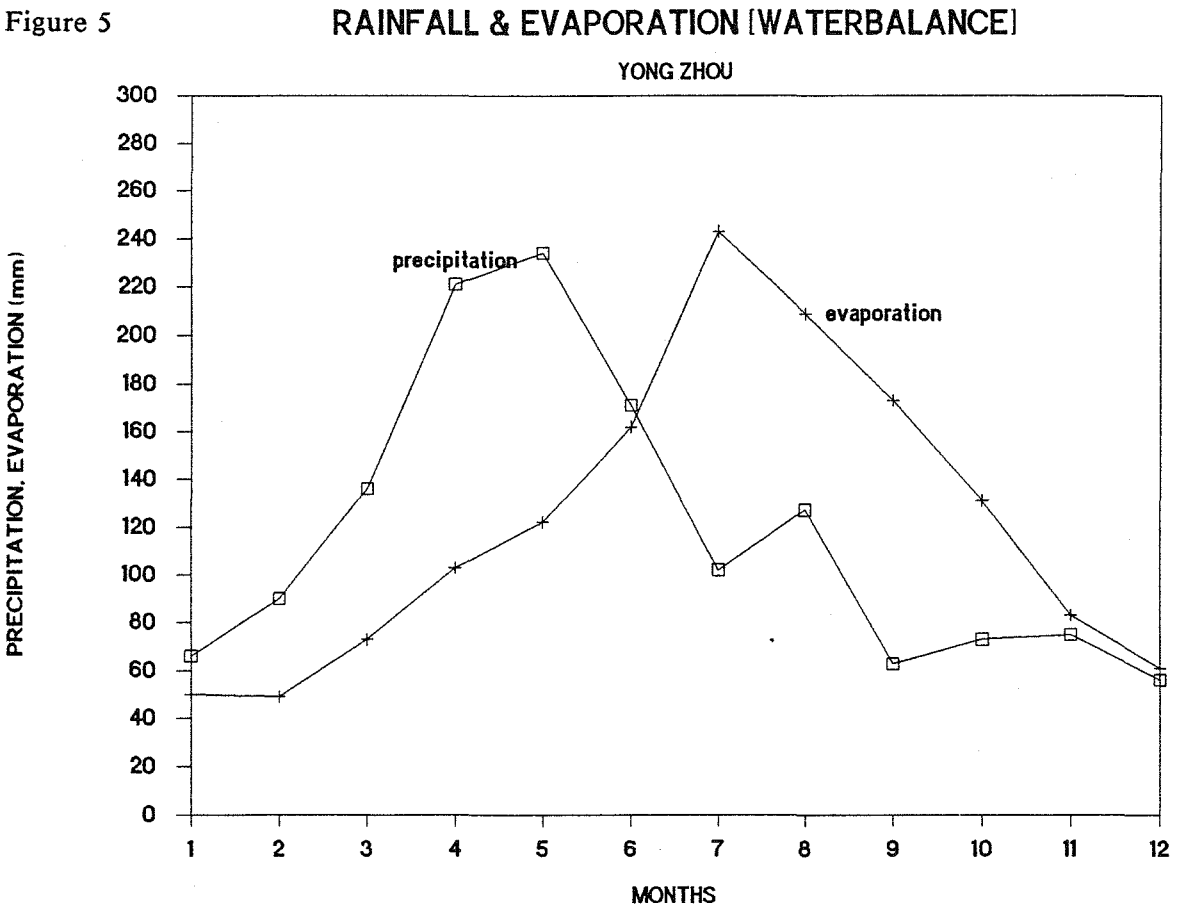


Figure 6

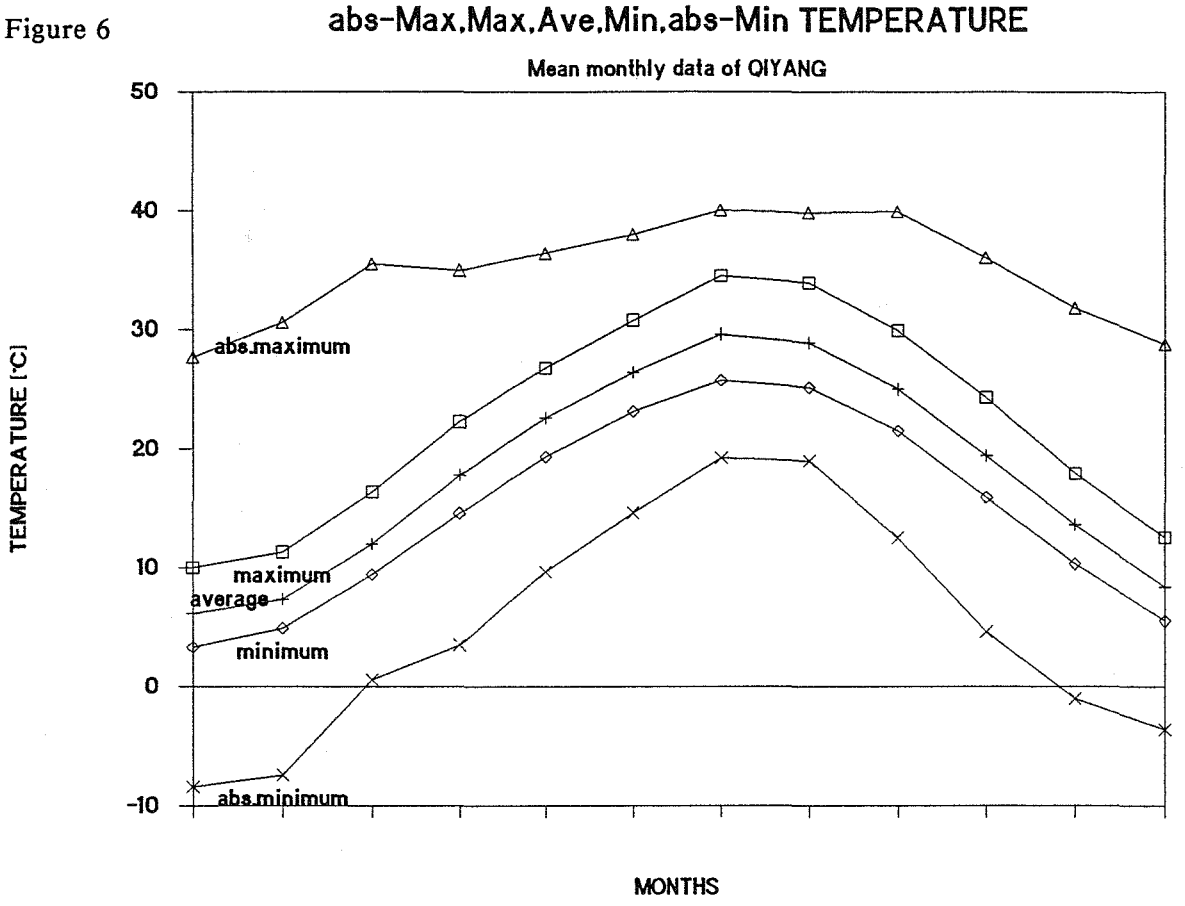
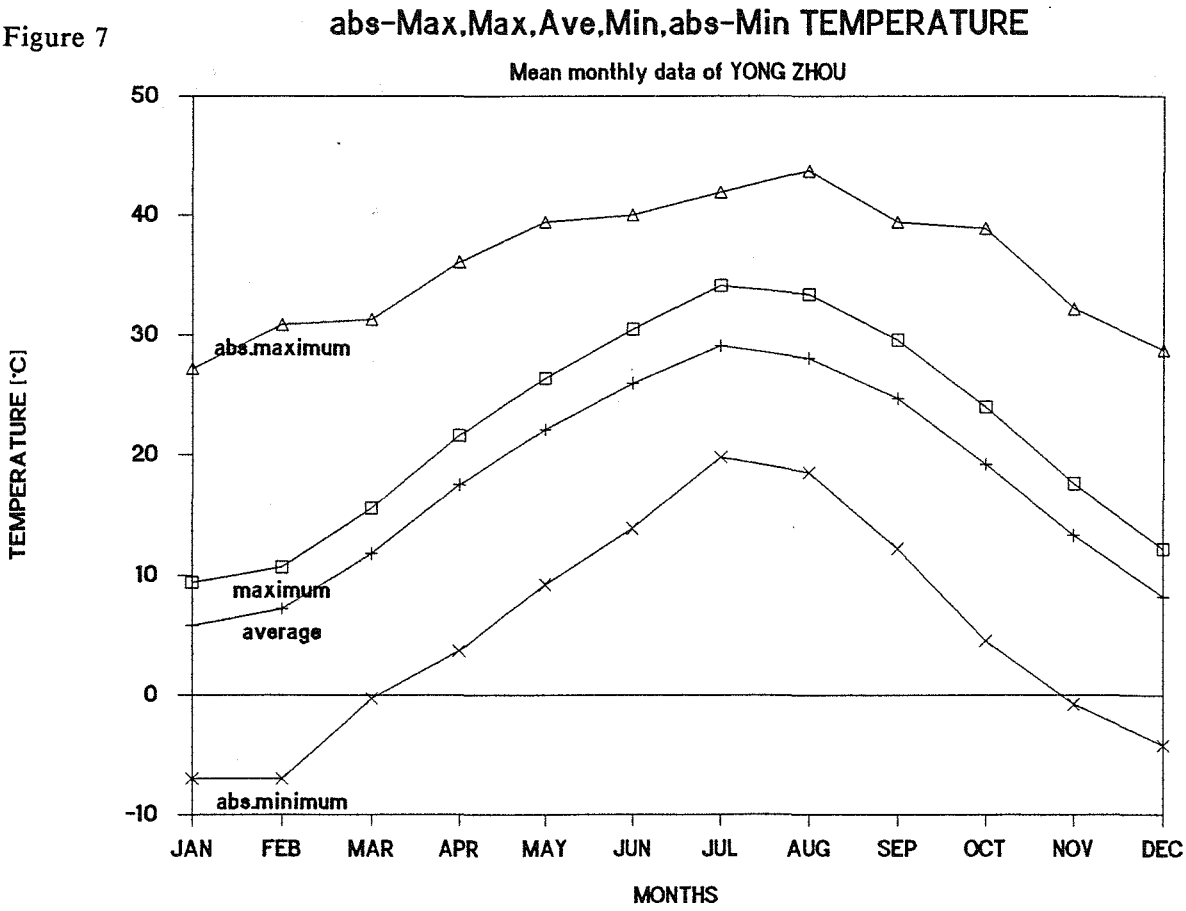


Figure 7



Major soils of the Project counties

The major soils of the counties visited during the rapid survey are derived from red quaternary clay, purplish shale, shale, slate, limestone and sandstone. Brief, general descriptions of these soils follow; details are covered in chapters 3 and 4.

Red Quaternary Clay soil

This soil type is common on low altitude land and occurred in several of the visited sites. For the various sites two types are important: the slightly or moderately eroded and the severely eroded.

The slightly or moderately eroded red clay soil (on tea-oil land and partly bare areas) is a very deep, well drained dark red clay soil; a strongly mottled clay subsoil, starts at a depth of about 1.5 to 2 meters. The soil is well structured and porous, and offers good rooting possibilities; yet its fertility is low. By liming and fertilizing, these soils can become highly productive as shown by Chinese and other research stations elsewhere in the world.

Severely eroded strongly mottled clay soil (bare or sparsely vegetated soil) occurs on severely eroded land. There, the original thick red clay soil has been stripped off and the strongly mottled subsoil is near or at the soil surface. This soil has a poor internal drainage, low permeability, and its natural fertility is presumably worse than that of the red clay soil. Consequently its potential is very low. Semi-natural regrowth of a protective grass/herb cover will be needed to protect the neighbouring land from further degradation.

The infiltration capacity of a red clay soil, when covered with grass/herbs or mulch, is good. However, when bare the soil will form a seal. The lack of a protective vegetative cover is induced by the removal of grass sods and litter (for kitchen fuel). This results in a smooth bare soil surface which is sealed by a 'bio-seal', i.e. the soil surface contains a slimy film composed of algae and soil particles. This impedes infiltration of rainfall into the soil resulting in run-off.

Purplish Shale soils

Purplish shale derived soils are widely distributed in Hunan province. In all counties visited, especially Hengyang, vast areas of severely eroded hills were observed. Original soil profiles have been stripped off by erosion and moderately deep soils are restricted to a limited area.

Depending on the degree of erosion two soil types can be distinguished:

- Very shallow soil (purplish shales are exposed over vast areas).
  Because of its gravelly nature the soil fertility and moisture availability will be low. Thanks to the soft nature of the soil parent material, the calcareous shales can be turned into a new man-made soil by digging manually or using dynamite. A newly man-made soil will have a depth of about 50 to 60 cm and could support non-irrigated, drought resistant trees.
- Moderately deep soil (lower slopes, limited acreage).
  This soil has less limitations and offers a better potential. Besides dry-land also irrigated farm land will be feasible.

Shale and Slate soils

The soils derived from shale and slate are widely distributed in Hunan province. Detailed observations were made in Yongzhou county. Depending on the degree of erosion and the parent material, shale or slate, two variations can be distinguished:

- Very shallow, severely eroded soils.
  The soil parent material is frequently exposed. If composed of the softer shale the soil permits soil preparation. However, no man-made soil, similar to the purplish shale, can be expected. The soil remains a hard gravelly shallow soil with poor fertility. Internal drainage is poor because of the slow permeability of the shale substratum. The

potential of this subtype is therefore low and only natural regrowth is recommended. Another option is low production woodland.

- Moderately deep shale soils (less steep hills and lower slopes, probably limited acreage). The soil fertility and available moisture are somewhat better in comparison to the very shallow soil, but is still classified as low. Limited field observations point to poor internal drainage, shown by water stagnation and a strongly mottled soil.
  The potential is therefore considered low, though wood production would be better as compared with the shallow soil.

Limestone soil

Black limestone covers large areas in the mountainous and hilly parts of the basin areas. Only one site with grassland was visited. The soil has an irregular pattern of (very)shallow dark brown clay soils (Rendzina soil), and moderately deep reddish brown clay soils both directly over hard limestone rock (Red soil).

No severely eroded bare land was observed. If erosion will happen this soil erodes easily and only hard limestone will remain, leaving the land without any further land-use options.

Sandstone soils

Soils derived from sandstone cover large areas in Hunan province and the counties visited. The deep red soils developed in this parent material appear rather similar to the red quaternary clay soils. However the sandstone soils are more sandy. Consequently their fertility is lower and their moisture retention somewhat better than for red clay. Erosion hazards will be more serious. Provided the soil remains protected by a vegetative cover on the steeper slopes, the more gentle sloping areas can be cultivated in spite of the presently on-going sheet erosion.

3 DETAILED DESCRIPTION OF THE MAJOR SOIL TYPES OF THE PROJECT SITES

3.1 Red Quaternary Clay Soils

Quaternary red clay deposits are restricted to the lower altitudinal range and were frequently observed on the hilly sites in all counties visited. In Hunan province these soils are widely spread in the counties around the lake Dong-ting, and in the counties of the low altitudinal range such as Heng Yang. A less prominent distribution is found in other counties.

The soil developed in this parent material is always very deep. However, considerable areas are effected by moderate to severe erosion. Slight and/or moderate erosion is mainly found on the tea-oil covered land, while severe rill and gully erosion is restricted to sparsely covered and bare soil areas. The bare severely eroded land is very spectacular, however, in terms of total erosion in Hunan province the much vaster area of the low to moderately eroded tea-oil land probably constitutes a far more serious problem.

A non-eroded soil has a relatively thin dark red topsoil followed by a thick (about 1 to 2 meters) red clay subsoil, below which the deeper subsoil consists of very thick (1 to several meters) strongly mottled clay soil. The homogenous red coloured soil is well structured, porous, and has good rooting possibilities. In severely eroded areas the uniform red clay soil has been eroded and frequently the mottled poorly drained subsoil is near or at the soil surface. The mottled subsoil is poorly structured and the mottling is indicative for water saturation because of low permeability.

The nutrient availability in natural conditions is low. Few analytical data are available of the sites. The soil is moderately acid, with pH-H_2O about 5 (the deeper mottled subsoil may be more acid). Generally at this pH level the exchangeable aluminium (Al) level should not be a problem (see comment below). The soil fertility status of the well drained red clay soil can be improved rather easily by adequate liming and N, P and K fertilizers.

Soil moisture availability is the result of climatic and soil factors. The soil moisture retention capacity of the deep red clay soil is judged to be moderate to low. However as the soil is deep, a deep rooted crop (e.g. trees) should overcome dry spells and even longer droughty periods. For annual crops, supplementary irrigation will be needed in the months of July and August. The soil moisture characteristics of the mottled clay soil are judged to be less favourable (see additional comments below).

The infiltration capacity of a red clay soil, when covered with grass/herbs or mulch, is good. However, when bare the soil will form a seal. The lack of a protective vegetative cover is induced by grass sods and litter removal. In e.g. tea-oil covered land this is caused by the collection of litter (leaves and branches) for kitchen fuel. The remaining smooth bare soil surface is then sealed by a 'bio-seal', i.e. the soil surface develops a slimy film composed of algae, mosses and soil particles. This impedes rainfall infiltration causing run-off. As the run-off concentrates and depending on slope length and slope gradient, rill and gully erosion develop. Although this process may be slow in tea-oil covered land, in the longer term it will result in severely degraded and gullied land.

3.2 Purplish Shale Soils

Purplish shales are found in the mountainous and low basin areas. The largest area is located in the northwest mountainous areas (Quizhou plateau). The basin area of the Heng Yang prefecture has the largest area of purplish shales in the project area.

The soil developed in this parent material is less thick and because of soil erosion large areas have (very) shallow soils; exposure of the parent material can be observed over vast areas. On

less sloping areas (e.g. low hills with vegetative cover, footslopes etc.) soil depth may be somewhat more.

Calcium, phosphorus and potassium levels are high, although phosphorus fertilizers may still increase the yield (8). The nutrient availability in terms of elements per kg soil is moderate to high. The soil is neutral or alkaline depending on its Calcium carbonate content (pH-H_2O ranging between 7 to 8)[6]. Available nutrients are judged to be low because of the restricted depth of the soil.

Water availability is low for the same reason and because of the low retention capacity. Infiltration rates of the man made soils are high, but the parent material below it has a low permeability. Therefore, shallow soils are rapidly over-saturated, and adequate drainage is required when bench terraces are used.

In the very shallow severely eroded purplish shale area, man-made soils have been developed by breaking. The relatively soft purplish shales are broken, either manually or by dynamite. Thus the soil parent material is transformed into a rootable gravelly loamy silt soil. Rapid weathering of the finely broken purplish shales, as well as cultivation and the addition of organic and clayey materials together yield a man-made arable soil in just a few years.

3.3 Shale and Slate Soils

Shale and slate cover large areas in the mountainous and basin areas of Hunan province. During the mission these have been observed in all counties visited. The largest extent of these soils in combination with considerable soil degradation occurs on the low to middle high hills of Yong Zhou county.

The soil developed in shales is somewhat thicker than the soils developed in harder slates. However, in all sites visited the original soil has been stripped by soil erosion and the deep, weathered gravelly mottled clayey subsoil is exposed to the surface. Both sheet and gully erosion occur.

The soil on steeper eroded hills is a very gravelly compact sub-soil which is hard to break. On less eroded sites and lower slopes the (slightly) gravelly mottled clay soils occur.

Nutrient availability is judged to be low, while the hydrological properties of this eroded soil are unfavourable. The infiltration and permeability of the (un)weathered shales is low, inducing water saturation with heavy rains. Therefore drainage is required when bench terraces are used. The moisture retention capacity is low, and in combination with the shallow soil depth lead to moisture stress in the dry season.

3.4 Limestone Soils

Black limestone covers large areas in the mountainous and hilly parts of the basin areas. Only one site having grassland was visited. The soil has an irregular pattern of (very)/shallow dark brown clay soil directly lying over hard limestone (Rendzina soil), and moderately deep reddish brown clay soil also directly over hard limestone rock (Red soil). This pattern is common for limestone; deeper soils are restricted to 'pockets' in the hard limestone. These soils have a good nutrient availability, reasonably rooting in the moderately deep soils and moderate moisture availability.
No severely eroded bare land was observed. If erosion will happen this soil erodes easily and only hard limestone will remain, leaving the land without any further land-use options.

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[6]There exists also an acid purple soil, derived from non-calcareous purplish shales. However, these sites are less common and not included in the project sites.

3.5 Additional Comments

Moisture availability

During the field mission no data could be obtained from the local agricultural institutions on the moisture retention capacity of the different red soils. Although it is generally concluded that red soils have low to moderate available moisture, it is judged that there are substantial differences between the red soils observed. It is recommended to measure the moisture retention capacity (pF curves) on undisturbed core samples of the major red soil types described before. This information is especially needed to make recommendations for irrigated agriculture.

Soil acidity and exchangeable aluminium

As mentioned before, most red soils are acid. Judged from the available pH-H_2O data, which are near 5, this is not strongly acid and the exchangeable aluminium (Al) should yet not reach toxic levels (8). However, the exchangeable aluminium data, given in table 5-14 of the Hunan soil report (1), show remarkably high levels, about 2 to 6 meq/100g. At present there are no generally accepted critical levels for exchangeable Al. High Al levels would restrict root development of a number of crops, limiting therefore the effective root depth thus enhancing the already low nutrient and moisture availability.
It is strongly recommended to verify the acidity and exchangeable aluminium levels of the soil samples taken during the field mission.

3.6 Summary of Project Sites Visited

Table 1 shows a summary of key information of all sites visited during the period 10-18/24 May 1992. In Chapter 4, the detailed descriptions of landscape, land use, soil characteristics and soil assessment is given. Table 2 presents the finally selected sites with a tentative assessment of some land qualities.

Table 1: Sites visited in the counties of Hengyang, Qiyang and Yongzhou

LOCATION**	PARENT MAT.	LAND USE	AREA/REMARKS
Hengyang County.			
Qingan (Qinping)			
Heng-pin (Ban-shi)	Purplish shale	Man-made soil	Large area *)
	Q. red clay	Eroded hill top	Small area (<10%)*)
He Shun (Ying Pi)		Grass land on hill top	
Renai Chun (Li Ren Xian)	Q.red clay & purplish	Eroded hill & tea-oil	Too developed
	Red clay	Eroded hill	Large area
Qiyang County.			
Da Hutan (Sha-madu)			
Daling (Mao Zhu)	Purplish soil	Eroded and tea-oil	Small area*)
Zhe Tang (DaZhong Qiao)	Red clay	Grass land	Large area*)
Xiang Mu Cheng (Jum Pan Tie)	Red sandstone	Eroded hill, grass, tea-oil	Too far from road
	Red sandstone	Eroded hill	Large area
Yongzhou Cty.			
Wen Dou Go (Tian Zhi Di)			
Mao Zhu-Yuan Zhi Di)	Red clay	Eroded hill	Small area*)
"(")	-?(Red clay)	Eroded hill	Small area*)
"(")	-Shale soil	Eroded hill	Large area*)
...(Jie Li Qiao)	-Purplish shale	Grass, few shrubs	Large area (at distance)*)
Fa Mi Pu (Jie Li Qiao)	Slate	Grass, trees on top	Small area
Ye Mu Tang (Jie Li Qiao)	Black limestone	Grass/trees/	Large area
	Shale	eroded	Large area

*) Pre-selected sites; others are additional ones
**) First the village name is given, followed by township name between brackets.

Table 2: Selected demonstration sites and summarized information

Site	Soil type	pH*)	Nutrients*)	Moisture*)	Remarks
Qingan	Purplish	7-8	low/mod.	low	1 or 2 sub-plots (soil depth)
Renai Chun	Red clay	5	low	mod./low	2 sub-plots (erosion grade)
Daling	Red clay	5	low	mod./low	2 or 3 sub-plots (erosion grade)
Mao Zhu-Yuan	Shale (+ R.clay)	5	low	low	1 (or 2?) sub-plots (soil depth)
Fa Mi Pu	Black limestone	6	mod./high	mod./low	re-growth site
Xiang Mu Cheng	Sandstone	5	low	low	2 or 3 subplots (erosion grade)

*) Estimates to be verified by analysis of soil samples taken during the rapid survey

With respect to the site selection the following general remarks are made:
- From the view point of soil erosion the protection of the vast area of tea-oil land with no grass/herb cover is more important than the spectacular, severely eroded bare soil land, having a much lesser acreage in Hunan province (at least in the counties visited).
- Adequate map information on the distribution of eroded land was lacking during the mission. If this information is not available, recent aerial photography and satellite imagery should be consulted for landform and extent of erosion type and degree.
- Attention should be given to the measurement of exchangeable aluminum and soil moisture retention.

Most of the selected sites are heterogeneous and, therefore, will require the utilization of combinations of technologies. Some preliminary land use options are summarized in Chapter 7.

4 DETAILED DESCRIPTIONS AND LAND USE IMPLICATIONS OF PROJECT SITES VISITED IN HUNAN PROVINCE

4.1 Site 1 - Qingan Village, Qinping Township, Heng Yang County [11/5/92]

Landscape	: Rolling hills and nearly plain valleys. The site comprises several hills.
Land use	: Paddy fields in the valleys and dry-land crops on the terraced lower hill slopes. The steep sloped hill consists partly of eroded bare land and dry land farming on narrow dug-out terraces. (see further SWCT).
Slope grad.	: Hills have maximum slopes of about 40 to 60 %
Slope length	: about 200 to 300
Soil parent mat.	: Purplish shales
Soil	
- strongly eroded	: (Very) shallow, excessively drained, purplish red gravelly loam soil;
- terracettes	: Moderately deep, somewhat excessively drained, purplish red gravelly loam
Soil classification	
- Chinese	: Calcareous Purplish soil
- FAO	: Lithosol, Eutric Cambisol
- Soil Taxonomy	: Ustorthent, Ustochrept
Top/subsoil	: The soil has little coherence and is easily washed away by run-off.

Analytical data

Depth	OM	pH	N	P	K	Sand	Silt	Clay
topsoil	1.3	8.4	20	6.5	51	no data available (probably high % of silt and shale gravel)		

(Data taken from the synopsis of the Qingan village - distributed during the field mission).

OM = Organic matter content (%)
pH = soil reaction, pH-H_2O
N = Nitrogen
P = Phosphorus
K = Potassium

Two soil samples are taken of the terracettes, one of the bund (sample 1A) and one of the furrow (1B).

Summary

This man-made purplish soil has a good workability and a good rooting capacity.
Unfavourable properties are:

- High erodibility. The soil is not coherent and needs therefore terracing with bund and furrow. Surface run-off is very high for a bare sloping soil surface.
- Nutrient availability is probably low. The parent material contains weatherable minerals and releases a number of macro and micro nutrients. However, because of its gravelly texture and the low organic matter content, absolute levels are probably modest. However, few data are available. There are no data for cation exchange capacity, exchangeable bases and other exchange properties.
- Soil moisture retention capacity is assumed to be (very) low; however, no data are available. The soil will not have enough storage of soil moisture to overcome droughty periods in July and August. Therefore trees should be tolerant to droughts. During the field mission one augering in a furrow showed at a depth of 50 to 60 cm stagnant water. It is judged that the compact shale layers below have a low permeability and that excess of water in the furrow may happen during the top rain months.

Soil and water conservation

The steeps hills were originally covered by forests with a soil layer. After forest clearing and cutting of the grass sods the silty clay soil has been eroded over large areas and the purplish relative soft shales are exposed over vast areas. The soft purplish soil parent material makes it possible to prepare a new rootable "man-made soil" by breaking the thick massive soft shale and the thin hard massive sandy shale layers which are sandwiched between the soft shale. The breaking of the purplish shales can be made manually with the hoe and pick-axe, however, as this is a labour intensive job, it is generally done by using dynamite. The shales are dynamitized at regular intervals. With this technique simple planting holes can be made, but also small bench terraces can be constructed. The narrow terraces consist of a broad furrow and a relative high bund. The man-made soil of the terracettes is improved by adding soil materials from the valleys, inorganic fertilizers and organic materials (rapeseed stalks, manure etc.). Because of the low permeability of the shale the terraces should have a slight tilt to make drainage of excess water from the furrow to a collecting drain feasible.

Representativity of the site

According to the soils map on scale 1:250,000, the area around site 1 is covered extensively with mostly severely eroded alkaline purple soils.
It is roughly estimated that about 30 to 40 % of the area consists of hills strongly affected by erosion. It is therefore concluded that the site is representative for the area.

Pictures (slides)

Landscape, eroded bare soil surface (gullied), terracettes (dynamite technique)

4.2 Site 2 - Heng-Ping Village, Ban-Shi Township, Hen Yang County [11/5/92]

Landscape	: Undulating low hills with broad gentle sloping and nearly flat valleys. The site comprises the peak of the hill.
Land use	: Mainly paddy fields in the valleys and dry-land crops on terraced lower hill slopes, the hill top consists of severely eroded bare land.
Slope grad.	: Hill has a maximum slope of about 15 to 20 %
Slope length	: about 100 to 200
Soil parent mat.	: Red quaternary clay
Soil	: Very deep, well drained, reddish brown clay soil; from about 2 m onwards is present a strongly mottled clay (red matrix with white/grey). On strongly eroded sites the mottled subsoil is near the soil surface.
Soil classification	
- Chinese	: typical Red Earth
- FAO	: Presumably Haplic Acrisol [no Base saturation data available]
- Soil Taxonomy	: Presumably Paleudult
Topsoil	: When wet, the soil falls easily apart.
Subsoil	: well structured (weak to moderate sub-angular blocky), good porosity and well rooted when vegetation is present. The deep mottled subsoil is compact, poorly structured and has low porosity and permeability.

Analytical data

Depth	OM	pH	N	P	K	Sand	Silt	Clay
topsoil	0.7	5.3	28	17	91	no data available (high % of clay + silt)		

(Data are from the synopsis of the Hengping village).

Three soil samples are taken: topsoil (0 - 15), shallow subsoil (15 - 50) and deep subsoil (60 - 120 cm).

Summary

The soil has a good workability, good rooting capacity and is well aerated.
Unfavourable properties are:

- The soil coherence is weak and the soil falls apart easily by water. Surface run-off is very high for a bare soil surface. The run-off concentrates and rill erosion starts which quickly turns into deep gullies lower on the sloping land.
- It is judged that nutrient availability (natural fertility) is low. However, few data are available, no data for cation exchange capacity, exchangeable bases and other exchange properties.
- Moisture retention property is assumed to be medium to low (however, no data are available). The soil should give enough storage of soil moisture to overcome droughty periods in July and August for deep rooted trees (it will be necessary to check this with reliable pF data).

Soil and water conservation

The high erodibility of the soil in combination with the high slope gradient makes soil and water conservation techniques necessary. A permanent protective vegetative cover will be the most effective such as trees with a herb/grass undergrowth. Remnants of an abandoned tree planting trial are observed, i.e. Chinese fir trees and a great number of hand-dug pits (about 60x60x50). The trees appearance was reasonably, however, the trial was abandoned because of lack of investments and anticipated profits. The hand-dug pits are not optimally used. The soil is placed around the pit so that surface run-off is preventing from entering the pits. It is recommended to improve this situation by replacement of the dug out soil in contour bunds, the latter to be stabilized with grasses.

Representativity of the site

According to the soils map on scale 1:250,000, the area around site 2 is covered extensively with mostly alkaline purple soils. This is confirmed in the field. Only the higher hill tops are covered with the contrasting red quaternary clay soils.
It is roughly estimated that about 10 % or probably less of the area consists of these hill tops with red quaternary clays. The expansion possibilities into these red soil uplands is therefore considered minimal for the region as a whole. It is therefore concluded that the site is <u>not</u> representative for the area as a whole, but is only representative for the eroded higher hill peaks.

Pictures (slides)

Landscape (red soil hill tops and terraced valleys), eroded bare soil surface (gullied), hand-dug pits and planted trees.

4.3 Site 2A - Renai Chun Village, Li Ren Xian Township

One alternative site for a demonstration plot was visited. This site shows the range of tea-oil covered land with non, slight or moderate sheet & rill erosion, next to severely gullied land on which an attempt has been made to plant pine trees (about 50% dead).

The soil consist of a typical red earth derived of Quaternary red clay and is comparable to the Heng Ping site described before.

No analytical data available.
One soil sample taken of the severely eroded mottled clay soil. The exposure of the mottled clay at the soil surface reveals that the original well drained uniform red coloured top and subsoil (about 1 to 1.5 meter) has been stripped completely by water erosion and only the very deep strongly mottled subsoil remains. The mottling is indicative for water stagnating because of compactness and low permeability.

Representativity

From the field observation alone it is difficult to judge the extension of the severely eroded and slight to moderately eroded tea-oil land. From the extension of the red clay soils on the soil map as well the extension of the tea-oil land (see before) it is judged that the site is representative for a large region in and outside Heng Yang county.

4.4 Orientation Trip North of Heng Yang County [12/5/92]

This additional trip was included in the programme because the sites visited on 11/5 are not completely in line with the ADB project criteria: i.e.

- the soil type of the site should be representative for a wide region around the site
- the site should pose possibilities for the application of extensive technologies and
- a large area of degraded red soils should be available for reclamation and development.

The Heng-ping site is not in agreement with these criteria, while for the Qingan site only an intensive technique, i.e. the use of dynamite, has to be applied to make literally a new man-made soil.

The administrative unit Jibin was visited. This unit comprises 6 townships and 1 small town.

Total area	330,000 mu	
Uplands	260,000 -->	17,000 cultivated
		32,000 waste land
		170,000 tea-oil bushes
		50,000 forestry-woodland

The area was crossed from east to west in which plain paddy land, low and high hills were observed.

The lower hills frequently have dominantly quaternary red clays and the middle high hills have soils derived from shale. Two types of soil erosion are observed:

1. The area comprises some large severely eroded (sheet, rill and gully) bare red soil hills. The area of this barren land is substantially larger in comparison to the township of Hengping, although, still being limited.
2. From the view point of erosion control, probably more important is the tea-oil land. There are vast areas with a more or less dense cover of tea-oil bushes with frequently a sparsely vegetated soil surface in between these bushes. The soil degradation can be classified as nil or slight when the soil surface between the tea-oil shrubs is covered with grass/herbs, low to moderately if the soil surface has only a sparse vegetative cover, and moderate and occasionally severe in the case of a barren soil surface between the tea-oil bushes. The bare soil surface shows a sealed appearance. The Chinese team members indicated that the erosion from these areas is considered to be more serious for the province as a whole than the prominent severely eroded bare red soil surfaces. It is said that 20 % of the hilly area of Hunan province has a tea-oil exploitation of which a substantial part needs to be protected against erosion.

Remark

Erosion control by farmers is only of interest if the generally labour intensive input will generate on the short term benefits. In practice this means a relative high input package consisting of terracing and/or the making of deep and large planting holes for fruit trees, application of lime, organic and inorganic fertilizers, green manure etc. According to the Chinese team members the farmer will be only interested to invest his labour if such a package becomes available, i.e. if enough credits are available. The importance of adequate technical guidance was emphasized (an example of poorly laid out terracing was observed). Basically the constraints to transform the barren severely eroded land of the degraded tea-oil land by the farmers into well protected, productive land are:

- no access to adequate and reasonable interest loans,
- not enough availability of suitable seed and tree species (variety and seedlings),
- lack of comprehensive technical knowledge and technical assistance.

4.5 Site 3 - Da-Hutan Village, Sha-Madu Township, Qiyang County [14/5/92]

Landscape : Overall landscape consists of rolling hills with nearly plain valleys. The site is situated on and around several hills.
Land use : The steep sloped hill consists partly of severely eroded bare land and dry land farming on narrow dug-out terracettes (see further SWCT).
Slope grad. : Hills have maximum slopes of about 20 to 40 %
Slope length : about 200 to 300 Relief: about 40 meter
Soil parent mat. : Purplish shales
Soil
- strongly eroded : (Very) shallow, excessively drained, purplish red gravelly loam soil;
- terracettes : Moderately deep, somewhat excessively drained, purplish red gravelly loam

Soil classification
- Chinese : Alcaline Purplish soil
- FAO : Lithosol, Eutric Cambisol
- Soil Taxonomy : Ustorthent, Ustochrept

Top/subsoil : The soil has little coherence and is easily washed away by run-off water.
Available soil moisture: [no pF data available]; due to its gravelly and light loamy texture it is assumed that the soil has a (very) low moisture retention capacity.

Analytical data

Depth	OM	pH	N	P	K	Sand	Silt	Clay
topsoil	0.4	7.8	no data available (probably high % of silt and shale gravel)					

One soil sample was taken: topsoil 0 - 30 cm (shallow soil, no subsoil).

Erosion and soil & water conservation

The steeps hills were originally covered by forests with a soil layer. After forest clearing and cutting of the grass sods the soil has been eroded over large areas. At present a large part of the hills is seriously eroded by sheet and gully erosion. The site is similar to Qingan, see further Qingan site 1.

Summary

This man-made soil has a good workability and good rooting capacity (although limited depth). Unfavourable properties are:
- High intrinsic erodibility. The soil is not coherent and needs therefore the bund furrow technique. Surface run-off is very high for a bare soil surface without terracettes.
- Nutrient availability is not optimal (see Qingan site 1)
- Moisture retention property is assumed to be (very) low (however, no data are available). (see Qingan site 1).

Representativity of the site

According to the soil map of Qiyang county on scale 1:300,000, the area around site 3 is not representative for the region. The purplish soils cover only a minor percentage of Qiyang county and occurs in relative small areas.

Pictures (slides)

Landscape (only 1 as the atmosphere is to misty because of low rain clouds), eroded bare soil surface (gullied).

4.6 Site 4 - Daling Village, Mao Zhu Township, Qiyang County [14/5/92]

Landscape : Overall landscape consists of low to middle high hills with nearly flat broad valleys. The site is situated on and around the summit of Mao zhu 'mountain'.
Land use : Major land-use is tea-oil, the hill top and upper slopes of the site and of surrounding hills consist of eroded bare land.
Slope grad. : Hill has a maximum slope of about to 20 to 40 %
Slope length : about 200 to 400 meters
Soil parent mat. : The soil appears as if derived from a red quaternary clay
Soil
- slightly eroded : (very) deep, well drained, reddish brown clay soil; from about 2 m onwards is present a strongly mottled clay (red with white/grey).
- severely eroded : Deep mottled clay (the original A and B horizon are completely removed).

Soil classification
- Chinese : typical Red Earth
- FAO : Acrisol [no Base saturation data available]
- Soil Taxonomy : Ultisol (typic Paleudult)

Topsoil : The soil surface of slightly eroded land has a sealed appearance, which strongly diminishes the infiltration of rain water. The seal is enhanced by the growth of algae and mosses. This seal induces run-off and as water concentrates the soil is easily eroded. The barren soil surface shows a dense pattern of rill and gully erosion.

Subsoil
- slightly eroded : (red clay) well structured (weak to moderate sub-angular blocky), good porosity and well rooted when vegetation is present
- severely eroded : (mottled clay) massive and moderate (sub)angular blocky, low porosity and probably difficult root penetration. It is not known whether this exposed deeper subsoil will develop a good soil when cultivated.

Available soil moisture: [no pF data available]; presumably low or moderate water retention capacity for the red clay, (very) low for the mottled clay.

Analytical data

No data available
Two soil samples were taken: red clay soil 0 - 50 cm and mottled clay deep subsoil (about) 150 - 250 cm

Summary

The slight to moderately eroded soil has a good workability, good rooting capacity and is well aerated.
Unfavourable properties are:
- High intrinsic erodibility. Surface run-off is very high for a bare soil surface.
- Nutrient availability is probably not optimal, natural fertility is moderate to low. However, no data are available.
- Moisture retention property is assumed to be medium to low (however, no data are available). The soil should give enough storage of soil moisture to overcome droughty periods for deep rooted trees (it will be necessary to check this with reliable pF data). It is not known how fast the mottled clay will develop into a suitable soil when cultivated.

Erosion, Soil and water conservation

The immediate area around the site shows tea-oil covered land which is moderately and severely eroded. The down-slope farmers have problems with the high run-off, and silt may covering the crops.
The high erodibility of the soil in combination with the high slope gradient makes soil and water conservation techniques necessary. Different technique have to be applied depending on the degradation grade. The most severely degraded barren land needs the most drastic measures and a permanent vegetative cover must be maintained. If terracing is not economically recommendable the covering of the barren land with grasses or herbs is required to prevent further soil degradation downslopes.

Question: are there native grass/herb species capable of fixing this severely eroded barren land?
Less seriously degraded tea-oil covered land needs other inputs. The most simple measurement seems to be a ban on the removal of the litter fall (leaves and branches), which is used by the farmer for kitchen fuel. This litter removal results in a bare soil surface, inducing the 'bio-soil seal', giving high run-off, which causes sheet and rill erosion between the tea-oil bushes.
Other measurements were mentioned by the farmers: ploughing, fertilizing, tea-oil improvements. The FAO-project South of Heng Yang county should be consulted for these and other improvements of the slight and moderately degraded tea-oil covered land.
According to local verbal information, the earlier made bench terraces in the severely eroded red clay soils were abandoned because the pine trees did not give the expected results. Probably because of a low fertility in combination with poor rooting. Therefore tree planting should be accompanied with soil improvement (lime, NPK fertilizers).
When terraces are being made in the mottled soil type, a slight gradient should be given, in order to make drainage of excess water possible to a collector drain.
The county officials indicated that a preferable reclamation plan is: pine on top of the hill, Jujube and tea-oil on the middle slopes.

Representativity of the site

According to the soils map on scale 1:300,000, the area around site 4 is covered extensively with red soils.
It is concluded that the soil and land-use is well representative for the region. Although nearly all the hills around the site show obvious severely and moderately eroded tea-oil land, it is not clear whether this type of degraded tea-oil land covers very large areas in this county and elsewhere in Hunan province. Information on the acreage can possible gathered at the FAO low-yielding tea-oil project and by consultation of aerial photography available in Changsa.

Pictures (slides)

Landscape bare red soil surfaces, gully eroded soil, tea-oil on severely eroded and slightly eroded land.

Various (statistics of Mao-zhu township)

total area	92,000
Population	17,555
Households	5,575
Mountainous	5,600 mu
Paddy	14,100 mu
Tea-oil	38,400 mu
Waste	18,000 mu
Water	2,300 mu

Houses, roads
Number of Orange trees is 160,000

4.7 Visit to Dazhong Qiao Town at the Foot of the Tai Ping an Mountain

This is an additional visit to a township with a large area of not used upland red soils. The area of not cultivated upland is mainly fallow grass land. The area does not show moderate or severe erosion. Being too far away and not having serious erosion problems the area will not be further described.

4.8 Site 5: Wen Dou Ge Village, Yong-Zhou County [16/5/92]

Landscape : Overall landscape consists of low to middle high hills with nearly flat valleys. The hills covering the major part of the land in the direct surroundings.

Land use : Overall land-use is waste land, the hill top and upper slopes consists of severely eroded bare land. Near the site citrus is planted on mal contour ditches land.

Soil parent mat. : The soil resembles a red quaternary clay

Soil

- slightly eroded : (very) deep, well drained, reddish brown clay soil; from about 1.5 m onwards is present a strongly mottled clay (red with white/grey).
- severely eroded : Deep mottled clay (the original A and B horizon are completely removed).

Soil classification

- Chinese : typical Red Earth
- FAO : Acrisol [no Base saturation data available]
- Soil Taxonomy : Paleudult

Topsoil : The soil surface of slightly eroded land has a sealed appearance (bio-seal), which strongly diminishes the infiltration of rain water and thus enhancing run-off water. It is estimated that about 50 to 100 cm original soil has been stripped off by erosion.

Subsoil : well structured (weak to moderate sub-angular blocky), good porosity and well rooted when vegetation is present. The very deep mottled clay soil is compacter and less porous. This subsoil is outcropping in the most severely eroded parts of the site.

Available soil moisture: [no pF data available]; presumably low or moderate water retention capacity for the dark red clay and (very) low for the mottled clay subsoil.

Soil & water conservation techniques: remnants of abandoned shallow pits for tree planting are visible.

Analytical data

No data available
Two samples were taken: topsoil 0 - 25 cm and mottled deep subsoil (about) 100 to 150 cm.

Summary
See site 4 - Daling village

Erosion, soil and water conservation techniques

See site 4 - Daling village

Representativity of the site

A reconnaissance soil map is not available. The 2.500,000 soil map shows the site is not representative for the region.

Pictures

Landscape and eroded soil surface; near the site short interval ditches, poorly laid on the contour [picture].

4.9 Site 6: Mao Zhu-Yuan Village, Dian Zhi Di Towhnsip [16/5/92]

From the top of the severely eroded hill 3 soil types could be observed on other eroded hills in the surroundings:
- Dark purplish soils (large distance),
- Dark red quaternary clay soils (centre of the project site) and
- yellowish red shale soils (project site and immediate surrounding hills).

The history of this severely eroded land is comparable with the history of sites earlier visited. In the end of the fifties, the forest was cut, thereafter the grass sods were removed by the farmer to fertilize his paddy land, run-off started and serious degraded land with still active gully erosion prevails till today endangering new land.

The purplish soils could not be observed, being to distant.

For information on the red quaternary clay soil see the Daling site.

The seriously eroded slate soil is very shallow. The weathered slate parent material is frequently exposed. The soil contains some clay, is mottled and has a large percentage of weathered slate gravel. In the rills and gullies a low density natural vegetation of very low shrubs is observed.

Two samples taken: 1 topsoil of the seriously eroded shallow slate soil and 1 topsoil of the eroded red clay soil.

Representativity

The red clay soil is a-typical for the region. The shallow slate soil is more dominant, at great distance of the site a vast area of purplish soil was also observed.

Pictures

Landscape having red clay and slate soil.

5 VISITS TO RESEARCH FACILITIES

5.1 Visit to the Agricultural Research Station (13/5 - South of Heng Yang city)

Introduction by Mr. Wang
The soil of this station belongs to the characteristic red soil type derived from Quaternary red clay. The soil profile shows a thin weakly developed organic matter containing topsoil (A horizon), a very deep well structured porous red clay subsoil (B horizon till about 1.5 to 2 meter), underlain by a strongly mottled deep subsoil (gleyed C horizon).

The following measures are developed and recommended by this station for the development of this red soil:
1. Soil water conservation structures to overcome the droughty period in July and August (=reservoirs for irrigation)
2. Terracing as the only effective soil and water conservation technique
3. Application of organic manure, mainly to be collected from pig raising
4. Liming of the soil in order to raise the pH and the Calcium content of the soil

A short field visit showed neatly terraced land, narrow bench terraces with a furrow at the backside of the terrace and a small bund at the drop of the terrace. Citrus was observed, severely pruned down because of the frost damage. At present water melon was planted.
Citrus can be grown without irrigation, however for optimal yields supplementary irrigation is needed in the drier season. If no irrigation is applied, mulching is necessary to improve the moisture retention of the soil.

5.2 Visit to the Heng-Yang Red Soil Experimental Station [15/5/92]

For soils and general information see hand-out, distributed at arrival.

Various observations:

A very interesting tree for the reclamation of the red soils could be the Chinese chestnut. It requires relative low fertilizer inputs, it is drought resistant and the yield will give an income of 450 Yuan per mu (prices 1992).

The natural regrowth of seriously eroded red soil is an interesting technique. Inputs are digging of ditches on the contour and the application of phosphate.

In the immediate surrounding of the station, farmers are using two techniques of using the sloping red soil for arable farming.
1. Contour ditches and sloping relative small parcels. This method needs limited labour input, but is not effectively for soil and water conservation.
2. Bench terraces with grass planted bund and a water collecting furrow at the base of the terrace step. This terracing is an effective technique of soil and water conservation.

5.3 Forestry Research Station [16/5/92]

Landscape	: rolling hilly landscape
Soil	: red loamy/clayey soil derived from sandstone

A number of tree planting locations were visited. Especially the pine trees parcels show a bare soil surface. This is caused by the collecting of the litter (needles and branches) by the farmer, using it as kitchen fuel.
This results in a smooth bare soil surface which is sealed by a 'bio-seal', i.e. the soil surface contains a slimy film composed of algae, mosses and soil particles. This hinders the rainfall to

infiltrate in the soil which results in run-off. The run-off concentrates and depending on slope length and slope gradient, causes rill and gully erosion.

LITTER REMOVAL -> BARE SOIL WITH BIO-SEAL -> RUN-OFF -> RILL/GULLY EROSION

Although this process may be a slow one, it results in the longer term in a seriously degraded land. From the field observations it is clear that only tree planting does not protect the soil. How to break this causal chain? The farmer should have access to fuelwood, by planting fuelwood trees on the uplands.

Even on land with contour ditches or even bench terraces having furrows, soil erosion will happen as described before when the farmer is allowed to collect the litter. Although ditch and bench terracing slow down the erosion rate, rill and gully erosion was observed in several parcels having tall pine trees and a bare soil surface.

Pictures

Landscape, bare soil surface close-ups of the bio-crust, rill and gully erosion in Pine tree plots with ditch and terrace techniques.

The lack of vegetative cover was observed as well in a citrus plantation on the road from the Forestry Research station to Yong Zhou. In this bare terraced land with 3 years old citrus three aspects of anti-erosion measurements were lacking:

1 the lack of grass/herb cover on the bunds of the terraces
2 the contour water levelling of terraces. The inclination of the terraces frequently substantial deviating from the contourline. Although a slight gradient will be necessary for draining excess water to collecting drains, the gradient was too strong.
3 a collector drain for excess water during heavy rain storms.

[one picture]

6 VISIT TO WORLD BANK PROJECT SITES IN JIANGXI PROVINCE

6.1 Chongren [5/5/92]

Landscape : undulating low hills
Slope gradient : gentle slopes, generally 3 to 5 %, max. about 8%
Slope length : about 200 to 400 metres
Soil parent mat. : Quaternary red clay
Soil : Very deep, well drained, reddish brown clay soil
Soil classification
- Chinese : typical Red Earth
- FAO : Acrisol(Luvisol?) [no Base saturation data available]
- Soil Taxonomy : Ultisol(Alfisol?)

Topsoil : soil slakes easily and formes a thin seal
Subsoil : well structured (moderate to strong sub-angular blocky)
Available soil moisture: no data available
Soil & water conservation techniques
: very deep land preparation (manually); narrow vegetation strips, terracing (sloping bench terraces); however contour-lines are not followed (substantial deviations).

Analytical data

Depth	OM	pH	N	P	K	Sand	Silt	Clay
0-5	3.3	5.3	med	low	high	20	38	42
5-32	0.6	5.0				19	31	48
32-100	0.4	5.1				15	40	43

Summary

The soil has a number of favourable properties, such as a good workability, good rooting capacity and is well aerated.
Unfavourable properties are:
- High intrinsic erodibility due to high silt and low organic matter content. The soil coherence is therefore weak and the soil slakes easily by water (irrigation or precipitation). Surface run-off is very high for a bare soil surface.
- Nutrient availability is not optimal, natural fertility is moderate to low, especially for available Phosphate. However, few data are available, no data for cation exchange capacity, exchangeable bases and other exchange properties.
- Moisture retention property is assumed to be medium to low (however, no data are available)

Soil and water conservation techniques (SWCT)

The high erodibility of the soil makes soil and water conservation techniques an absolute must for this soil type. A permanent protective vegetative cover will be the most effective such as forest with herb/grass undergrowth. In this case the soil is cultivated. The following soil and water conservation techniques were observed:
- to prevent a bare soil surface green manures, leave crop residues and mulch at the surface (not in all fields) were used.
- to reduce the erosive action of the run-off mechanical protections are implemented at the farm, such as a sloping bench terrace with attention to a storm drain channel to discharge the excess water. The bench terrace-bunds are or will be planted with Vetiver grass.
- several cropping practices, such as very deep land preparation more or less parallel to the contour and fertility improvement.

Discussion

The intrinsic high erodibility of the soil can in practice not be overcome. Although a higher organic matter content will certainly create a more stable soil, a substantial increase in the organic matter content is a very difficult and long time requiring process. When annual crops are considered, a permanent treatment with a variety of techniques, such as described before, will be required.

6.2 Wa Dian (Linchuen county) [6/5/92]

Landscape : undulating low hills
Slope grad. : gentle slopes, generally 4 to 5 %
Slope length : about 200 metres
Soil parent mat. : Sandstone (fine grained)
Soil : Deep, well drained, bright reddish brown fine sandy loam
Soil classification
- Chinese : typical Red Earth
- FAO : Acrisol [no Base saturation data available]
- Soil Taxonomy : Ultisol

Topsoil : soil slakes easily and formes a thin crust/seal
Subsoil : weakly structured (massive blocky, inherited from the sandstone). The deep subsoil is mottled, this is a sign of water stagnation caused by a low water permeability in the massive structured subsoil.
Available soil moisture: no data available
Soil & water conservation techniques
: terracing (irrigation bench terraces); narrow terraces (3 to 4 metres width) divided by low check dams into small irrigation parcels.

Analytical data

Depth	OM	pH	N	P	K	Sand	Silt	Clay
0-4	2.5	5.7	med	low	low	fine sandy loam (field estimation)		
4-100	0.3	5.1						

Summary

The soil has a number of favourable properties, such as a good workability, good rooting capacity (although not very deep) and is well aerated.
Unfavourable properties are:

- High intrinsic erodibility due to high silt and low organic matter content. The soil coherence is therefore weak and the soil slakes easily by water (irrigation or precipitation). Surface run-off is very high for a bare soil surface.
- Nutrient availability is not optimal, natural fertility is low for available Phosphorus and Potassium. However, few data are available, no data for cation exchange capacity, exchangeable bases and other exchange properties.
- Moisture retention property is assumed to be low (however, no data are available)

6.3 Differences between conditions in Jangxi World Bank sites and proposed sites in Hunan

Based on the before presented field observations and the initial available analytical data the following comparison between conditions in Jiangxi World Bank sites (WB) and proposed sites in Hunan is tentatively given.

The landscape of the WB sites has lower relief and slopes are very gentle or nearly flat. Seriously eroded red soils with no or sparse vegetation cover has a much vaster extension in Jiangxi province. Such areas have in Hunan nowadays a limited acreage. However, as indicated

before, this observation should be verified by consultation of recent satellite imagery and/or aerial photography.

The intrinsic soil erodibility of the red soils of the WB sites in Jiangxi appears to be higher and have therefore a higher risk for erosion. It seems that a higher silt content and lower organic carbon content of the WB sites are probably the major causal factors for this higher intrinsic soil erodibility.

7 SOME OPTIONS FOR LAND-USE ON THE DIFFERENT SOILS OF THE DEMONSTRATION SITES (based on soil qualities)

7.1 Heng Yang county, Qingan village

a Purplish soil, severely eroded, very shallow soil or exposure of parent material
1-Natural regrowth, no grazing and cutting of grass and shrubs.
2-Terracing (dynamite) no irrigation, drought resistant (fruit) trees (e.g. Jujube).

b Purplish soil, slightly eroded, less shallow soil mostly on lower slopes
1-Terracing, no irrigation, less water demanding fruit trees (plum?), annual crops
2-Terracing, irrigation, water demanding fruit trees (citrus) and annual crops.

7.2 Qiyang county, Daling village || Heng Yang county, Renai Chun village

a Red clay soil, severely eroded (sheet, rill and gully), bare soil, mottled clay at shallow depth or at the surface
1 Semi-natural regrowth, seeding/planting of stabilizing grass/herb species, no cutting of grass and shrubs. Objective is to stop further erosion, probably no other benefits expected.
2 Other uses e.g. terracing, inputs of fertilizers, tree planting etc. are risky, because the soil has many limitations: low water permeability, low moisture retention, poor rooting and low fertility. If terracing is used, the bench slope parallel to the contour should have a slight gradient for improved drainage of excess water.

b Red clay soil, moderately eroded (sheet and rills), open stand of shrubs/trees (tea-oil or pine) and bare soil surface, the well drained red clay layer has a thickness of about 50 to 100cm over the mottled clay.
1 Recuperation of the grass/herbs cover between the trees, no cutting of grass and collecting of litter fall, when completely bare seeding/planting of grass/herb.
2 Recuperation package for low-yielding tea-oil land [see FAO project recommendations; ploughing, fertilizing, improving tea-oil species]
3 Terracing, soil fertilizing, fruit trees and annual crops

Sandstone soil
[Awaiting information]

7.3 Yong Zhou county, Mao Zhu Yuan village

a Shale soil, severely eroded, very sparse vegetation and bare soil surface, very shallow soil and mottled shale parent material is exposed.
1 Semi-natural regrowth, seeding/planting of stabilizing grass/herb species, no cutting of grass and shrubs. Objective is to stop further erosion, probably no other benefits expected.
2 Other uses e.g. terracing, inputs of fertilizers, tree planting etc. are risky because the soil has many limitations, low water permeability causing water stagnation in the rainy season, low moisture retention inducing moisture stress, poor rooting and low fertility. If

terracing is used, the bench slope parallel to the contour should have a slight gradient for improved drainage of excess water.

b Shale soil, less eroded, sparse vegetation, shallow soil and deeper subsoil or exposing shale is weathered and relatively soft.
1 Semi-natural regrowth, seeding/planting of stabilizing grass/herb species, no cutting of grass and shrubs. Objective is to stop further erosion, probably no other benefits expected.
2 Terracing, inputs of fertilizers, tree planting, no irrigation. Although the soil poses limitations similar to the very shallow shale erosion discussed before, it is expected to have better development perspectives. Attention should be given to the gradient of the bench slope parallel to the contour to guaranty draining of excess water. Furthermore as the soft shale will be easily eroded into gullies, collector/storm drains should be vegetated.

7.4 Yong Zhou county, Fa mi pu village

Limestone soil, irregular pattern of (very) shallow to moderately deep soil, natural grassland
1 Natural regrowth, no grazing, no cutting of grass and shrubs.
2 Tree planting in the spots having a moderately deep soil.

REFERENCES

(1) 1989 "Soil report of Hunan province", Agricultural Department of Hunan province, published by National Agricultural Press (Chinese language).

(2) Abbreviated version of the " Soil report of Hunan province", summary and translation by Guo Linhai, Wageningen, April 1992.
The original report comprises 20 maps related to topography, soil distribution, soil parent material and a number of soil fertility parameters such as organic matter, macro-nutrient etc. An abbreviated english version of this report, concentrating on the upland soils, was made for this project and a limited number of copies distributed to the project team members. 10 maps were selected and the titles and legends translated. The maps were slightly enlarged and reproduced by colour-photocopying and included in the text report.

(3) A number of thematic maps were taken from the Agricultural atlas of Heng Yang county.
Topographic map, Soil map, Organic matter content, etc. all on scale 1:250,000

(4) Agricultural atlas of Qiyang county
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(5) Songqiao Z. (1986). Physical Geoography of China. Science Press Beijing, China / John Wiley & Sons, New York.

(6) Atlas of satellite images of China, scale 1:500,000
From the satellite images atlas of China, colour reproductions were made of a number of images (on scale 1:500,000) covering the project area and surrounding regions.

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(8) J.T. Landon (1991) Booker tropical soil manual: a handbook for soil survey and agricultural land evaluation in the tropics and subtropics.