The main roads traverse all types of land, mainly in straight lines, often on elevated banks through the paddy fields and in other low-lying areas. These are good roads close to Phnom Penh but their condition deteriorates further away, however, they are passable by sedan cars. The secondary road network is in very poor condition and generally only passable by four wheel drive vehicles. Deterioration of bridges and fords on river and canal crossings has rendered many of these roads impassable, especially in the wet season. Some secondary roads have been encroached upon by domestic structures and are now so narrow that they are only passable by motorcycles.

3.1.2 Existing Land Use

The existing land use are basically associated with topographic conditions, drainage conditions, moisture conditions and farmer's preference. The land use type of the study area is classified as follow:

Land Use Type	Kandal Stung		Tonle Bati	
(Map unit)	(ha)	(%)	(%)	(%)
(1) Villages or/and Upland				
Villages, upland crops (Vr)	1,130	10	360	5
Villages, upland crops, small rice field (Vp)	1,597	14	0	0
Villages, upland crops, cattle grazing (Vc)	344	3	84	1
Cattle grazing, bamboo, unused (Cb)	789	7	112	2
(2) Paddy field (Plain)				
Large paddy fields (Pl)	2,195	19	2,895	42
Medium to small paddy field (Ps)	3,962	35	2,530	37
(3) Low land				
Medium to small paddy field, inundated (Pw)	428	4	185	3
Swamps with dry season rice (Sp)	138	1	225	3
Pond(Fb)	344	3	84	1
(4) Unused area (O)	373	3	425	6
Total	11,300	100	6,900	100

A map of existing land use based on the land unit map is shown in Figures II-1 and II2.

3.2 Land Units and Soils of the Study Area

3.2.1 Soil Formation Factors

Soil is formed by six (6) environmental factors, i.e. climate, material, vegetation, geomorphology, time and human impact. Especially, the differences between soil units in the Study area might be resulted from geomorphology, human impact and vegetation.

(1) Geomorphology

The discussion that follows is based upon a very limited period of investigation confined almost entirely to the Study area, and the geomorphological outline given must be seen as tentative and subject to review.

In reading this section it is important that differences in scales of time be appreciated. Whilst people have lived in and modified the area for centuries, their impact is relatively recent in terms of the time over which events of geomorphological significance take place.

The whole of the Study area consists of alluvium of various ages except for a tiny area in the far south, which is an outlier of the rocky hill country that lies to the south west, around Phnom Thma Doh and Phnom Phdau Pam. Topographically the land is generally flat with some areas of slightly higher relief which appear to be river levees, either currently active or relict, and of various ages. Some areas may be prior landscape remnants.

Hydrologically, the area conducts tributary drainage water from the hills that lie to the west towards the Bassac/Mekong River system, receiving increments of sediment as it does so. Looked at broadly and over geological time the drainage system can be seen as fan-like, the streams subsiding, dividing and spreading out as they approach and are influenced by the swamps and backplains and floodflows of the main river system.

i) Kandal Stung Area:

In the Kandal Stung area there are five main streams; the Prek Thnot in the north, then two un-named streams referred to here as Stung 1 (the northern-most) and Stung 2, Stung Toch in the centre of the area, and Stung Tonle Bati in the south (Figure II-3).

An examination of aerial photographs and topographic maps supported by field investigation suggests that at various times the three central streams (Stung Toch, Stung 1 and Stung 2) were all either prior channels of a northwards-migrating Prek Thnot River, or are parts of a current Prek Thnot distributory system.

It is probable that Stung Toch is the oldest of these three and that it was originally contemporaneous with the Tonle Bati system. The land south of Stung Toch has more mature land forms, including a relict sandy levee along its right bank, now modified in shape by a period of erosion (land unit Hs), and an old sandy-clay levee now almost flattened by erosion along Stung Tonle Bati in the south-west (land unit Ht). In the south, Lake Tonle Bati is now depressed below the level of the plains and is flanked by a broad, sloping, eroded bank (land unit Le).

These landforms imply that the area is no longer active as an alluvial system and is essentially an older terrace, not naturally subjected to flooding with river water. Flooding by river water does occur today in some parts of this area but that is consequent upon human activities and not a natural phenomenon.

There is evidence from the landforms and soils of the area north of Stung Toch that the main drainage has moved northwards in Recent times. A slight uplift or a northwards tilt of the plains is one factor that could have caused this movement. It is not known whether such an uplift occurred here, however about 5000 years ago the Bangkok Plain in Thailand which includes the delta of the Chao Phya and Tha Chin Rivers was slightly uplifted (ILACO/EMPIRE 1988; Van der Kevie 1970), and it is possible that a similar uplift also occurred in the Mekong Delta area.

In this area the rivers flow eastwards, across the direction of any such tilt that may have occurred. A northwards tilt could therefore have had the effect of causing the rivers to progressively change course towards the north.

North of Stung Toch the three main streams (Stung 1, Stung 2 and Prek Thnot) form a fluvial distributory system similar to an alluvial fan. They have quite young levees, almost unaffected by erosion. These levees appear to be currently active and silt deposition is still occurring on them.

The soils in this area are also young. On the levees, the soils are immature with almost uniform-textured silty clay profiles overlying almost unmodified silty alluvium. On the plains they are deeper but still youthful soils. Clearly, the streams in this area have continued to re-work their floodplains and are in a currently active condition. The rather coarse reddish sand typical of the area south of Stung Toch does not occur here.

Thus there are two distinct geomorphic provinces in the Kandal Stung area - a younger floodplain north of Stung Toch, and an older terrace to the south. These geomorphic provinces are shown in Figure II-3.

ii) Tonle Bati Area:

The geomorphology of the Tonle Bati area is not well understood and the following account is somewhat speculative. However, as for the Kandal Stung area, there appears to have been significant recent evolution of the drainage system, possibly related to the same slight uplift or tilt that has been proposed for the Kandal Stung area, and involving a generally northwards movement of the streams.

Prior to the uplift, it seems likely that the original Stung Tonle Bati flowed in a southerly direction through the centre of the Tonle Bati area. At this time Lake Tonle Bati may have been a lot smaller or may not have existed. In this central zone of the Tonle Bati area there is a pair of semi-linear, slightly elevated areas (land unit Hc) that seem to be old levees, probably levees of the original Stung Tonle Bati. Between these old levees the soil is formed on recent silty material, which is probably an infill of alluvium in the old river channel.

At this time Stung Toch was probably contiguous with what is now known as Stung Tonle Bati, east of Highway 2.

After the uplift, the north - south slope of the land in the Tonle Bati area was reduced, and in fact today this slope (from topographic maps) is zero. Consequently the ancestral Stung Tonle Bati could no longer flow southwards, and it abandoned its original course. Probably at about this time Lake Tonle Bati was formed, due to the inability of the water to drain away.

By this time Stung Toch had begun to migrate northwards, and its old channel had begun to carry less water, particularly less seasonal floodwater. Because the west - east slope remained significant (from topographic maps it is about 5 metres across the area today), seasonal overflow from Lake Tonle Bati also began to occupy the former Stung Toch channel, east of Highway 2.

Hence in the Tonle Bati area there are three geomorphic provinces. The first is a levee and floodplain system with good soils formed on recent silty alluvium along Stung Tonle Bati in the north; this area is an active alluvial system and correlates with the 'younger floodplain' geomorphic province in the Kandal Stung area.

The second one has plains with mainly good soils formed on recent silty alluvium plus old levee remnants. This geomorphic province is now relict and no longer subject to flooding due to the northward movement of the ancestral Stung Tonle Bati; consequently it is now an alluvial terrace and is referred to here as the 'younger terrace' geomorphic province.

The interfluves between these areas, and the western strip along Highway No. 2 are parts of an old alluvial plain similar to the old plains in the southern geomorphic province of the Kandal Stung area. These areas have old, leached soils with sandy topsoils and dense, mottled clay or sandy clay B horizons. These areas are now flood-free and represent an older alluvial terrace, which correlates with the 'older terrace' geomorphic province in the Kandal Stung area.

Lake Cheung Loung is now depressed below the level of the plains and is flanked by a broad, sloping, eroded bank similar to the one along Lake Tonle Bati, which supports the view that the plains here are a terrace rather than a floodplain.

These prior streams and geomorphic provinces are shown in Fig. II-3. The area of the geomorphic provinces is given in as follow:

Geomorphic Features	Kandal Stung (ha)	Kandal Stung (%)	Tonle Bati (ha)	Tonle Bati (%)	Total (ha)	Total (%)
Younger Floodplain	6,275	56	1,187	17	7,462	41
Old Terrace	5,025	44	3,325	48	8,350	46
Younger Terrace	0	0	2,388	35	2,388	13
Total	11,300	100	6,900	100	18,200	100

(2) The Impact of Man:

Superimposed upon this natural system in recent years has been the activities of man, including the construction of at least two main generations of irrigation canals and drains. A very regular square pattern of old canals is superimposed on most of the land, together with a new generation of canals laid out in different directions. These have modified the natural flooding and drainage patterns.

Road construction has also affected flooding and drainage patterns, for example, Highway No. 2 appears to have insufficient culverts to allow unobstructed passage of wet season floodwaters and the land west of this road and north of Stung Toch is reported in the field to be flooded to a depth of 1 to 1.5 m several times a year.

(3) Native Vegetation

The natural vegetation of the whole Study area has largely been removed but some species remain, either as persistent regrowth or because they are cultivated by the farmers. Other plants have been introduced, including some weeds.

The paddy fields in many areas have scattered sugar palms (Borassus carambola) mainly growing on the paddy field bunds. These palms are similar to the ones that grow across the Indonesian island of Timor, known there as Borassus flabellifer. In the north, mainly north of Stung Toch but also on the better soils in the Tonle Bati area the shrubby tree Combretum quandrangulare is common naturally and is cultivated on paddy bunds for firewood; older men also use the half-dried leaves as cigarette paper. The spiky small tree Feroniella lucida also grows in these areas.

Some areas, mainly in the south-west of the Kandal Stung area, have a cover of bamboo and other natural (but secondary) vegetation, for example, land units Ht, Le and parts of Hs which occur in the catchment of the Tonle Bati lake. These areas have poorer soils.

Other important indicator plants include the tree Fugania jambolana which grows on acid soils on old plains, especially in the Tonle Bati area, and Barringtonia spp. which is a good indicator of swampy conditions.

3.2.2 Soils

Soil classification and description are according to the FAO system (FAO-UNESCO, 1974). Soil colors are Munsell colors (Munsell Color, 1975). Figures for the frequency and depth of flooding are based on local information obtained in the field at the time the profiles were described, plus geomorphological assessments.

A summary of the classification arrived at is given in following table.

Soil Unit (FAO)		Summary Description
Acrisols:	Gleyic Acrisols	Old, strongly mottled, sticky sandy loams over heavy clays with rounded sand grains and very poor drainage.
Arenosols:	Albic/Luvic Arenosols	Old, deep, somewhat leached reddish sands and clayey sands with a near neutral pH.
Cambisols:	Dystric/Ferralic Cambisols	Slightly elevated, poorly drained, dense, mottled heavy clay on old river levees.
	Eutric Cambisols	Shallow, yellowish brown, silty clay on recent alluvium of low permeability.
	Vertic Cambisols	Deep, yellowish brown, weakly structured, mottled silty medium clay on recent alluvium.
Fluvisols:	Eutric Fluvisols	Brown, massive, hard-setting silty clay on recent layered alluvium.
Luvisols:	Orthic/Albic Luvisols	Old, mottled, sticky loamy sands over sandy clays with rounded sand grains and very poor drainage.

Although some of the soils are very poor and have a low suitability for the forms of land use considered in Section 7 below, there appeared to be very few real 'problem soils' such as saline soils, alkaline soils, acid sulphate soils, and soils with laterite at shallow depth.

Tahal (1973) reported that more than a third of his 'high and medium level land' and almost half of his 'low level land' in his Pioneer area along the left bank of the Prek Thnot was affected to 'some degree' by salinity. From Tahal's descriptions the area appears to be similar to the older terrace areas of the present Study area. Similar salinity levels may therefore occur in these older terrace areas, however, in the high rainfall environment of the Prek Thnot area salinity is not expected to be a major problem.

Tahal also described significant areas of 'alkaline plains soils' in the Pioneer area. These had almost impermeable subsoils, very low cation exchange capacities, sodium absorption ratios of more than 15 % and a pH of about 9. A few other soils had a pH of 8-8.5 below about 60-85 cm depth, possibly indicating a tendency towards the development of alkaline soils. An only one profile fitted the above condition. These also occurred in the geomorphologically older areas. However these soils are very scattered and appear to be very much in the minority in this Study area and do not occupy a significant proportion of the land.

3.2.3 Description of the Land Units

Thirteen land units have been identified within the area. They are described in general terms below. Each description includes information on location, landform, soils, vegetation and land use. Detailed descriptions of the soils are given in Appendix II-1. It is important to note that the mapping units are not individual soils but land units, and some variation in soils occurs within them (consosiation or association). This is especially so for the land units identified as having internal complexity. The correlation between the soil units and land units are shown in Table II-1 and following table, and general features of each land unit are described below:

Physiographic Feature	Land unit	Map symbol	Associated type	Correlative soil unit
River Levee	Young levee	Hy	Consosiation	Eutric Fluvisols
	Older, relict levee	Hs	Association	Albic Arenosols, Luvic Arenosols
		Ht	Association	Orthic Luvisols, Albic Luvisols
	Low levee remnant	Hc	Association	Dystric Cambisols, Ferralic Cambisols
Levee & Plain	Active floodplain and low levee	A1	Complex	Eutric Fluvisols, Vertic Cambisols Regosols
Plain	Younger floodplain	Y1	Consosiation	Vertic Cambisols
		Y2	Complex	Eutric Cambisols, Vertic Cambisols Regosols
	Old plain	O1	Consosiation	Gleyic Acrisols
		O2	Association	Gleyic Acrisols, Orthic Luvisols, Albic Luvisols
		O3	Complex	Vertic Cambisols, Gleyic Acrisols Dystric Cambisols, Ferralic Cambisols
Low lying land	Poorly drained	Lw	Consosiation	Gleysols
	Swampy area	Ls	Consosiation	Gleysols

(1) River Levees With Positive Relief

i) Younger levees, mainly active (clayey)

Hy (167 ha): This land unit consists of low, currently active silty levees mainly along the Prek Thnot River. The soils are moderately well drained, moderately permeable, almost uniform- textured brownish silty clays with a slightly acid pH overlying layered silty alluvium (Eutric Fluvisols). Flooding (with silt deposition) occurs to 50 cm depth annually. Most areas are used for villages with intervening small paddy fields. Yields of rice are high; up to 6 tonne/ha if fertilizers are used.

ii) Older, relict levees (sandy)

Hs (755 ha): These are old, relict sandy levees which occur along the right bank of Stung Toch. The soils are deep, well drained sands (Albic or Luvic Arenosols) or sand over sandy clay (Orthic or Albic Luvisols) with rapid to moderate permeability, a neutral pH and some podzolic characteristics including leaching of clay and iron from the upper horizons and precipitation of ferruginous nodules in the B horizons. They are partly used for villages and as transport corridors, but some land is unused. Fruit trees, cassava and vegetables grow well but only with fertilizer application. Some farmers grow a post - wet season crop of sweet potatoes without applied water, but later in the dry season constant watering is essential. Some also try to grow rice with impounded rain water but the crops are very poor and sometimes fail completely.

Ht (330 ha): This land unit lies along Stung Tonle Bati in the south-west of the Kandal Stung area. It consists of low, almost flattened levees, now relict and no longer flooded. The soils have clayey sand or loamy sand topsoils grading up to sandy clay B horizons which are dense, mottled, poorly drained and of slow permeability (Orthic or Albic Luvisols). Soil pH rises from about 5.5 in the upper profile to about 8 in the subsoil. These areas have extensive bamboo cover and are mainly used for grazing cattle.

iii) Low levee remnants (clayey)

Hc (735ha): These are slightly elevated areas, probably old levee remnants from a pre-existing drainage system, now isolated from their parent stream and no longer active. Alternatively, they may be residuals of an old, formerly more extensive land surface now largely removed by stream rejuvenation. They mainly occur in the Tonle Bati area. These areas have yellowish, mottled, heavy clay soils with poor drainage and a neutral to slightly alkaline pH (Dystric or Ferralic Cambisols). Due to their slight elevation they are used mainly for villages and village gardens, and as transport corridors.

(2) Active Floodplains and Levees

Al (1,430 ha): This land unit occurs as a broad band along both Stung 1 and Stung 2. It consists of a complex of stream channels, active low levees and small, level floodplains. The levees are similar to those along Prek Thnot (land unit Hy) with similar brownish silty clay soils (Eutric Fluvisols) and are used for villages, orchards and gardens, also roads, and some small rice fields. The floodplains are similar to the plains of land unit Y1 with good silty clay to heavy clay soils (Vertic Cambisols). Some sandy old channel areas also occur (with Regosol soils). These areas have good wet season water supplies and are mainly used for rice fields.

(3) Almost Level Plains

i) Younger floodplains

Y1 (1,435 ha): These are nearly level plains with almost uniform-textured, brownish silty clays and medium clays with a neutral pH overlying recent silty alluvium (Vertic Cambisols). Most soils are more than a metre deep over the parent alluvium but some are only 40-50 cm deep over silty alluvial deposits and these merge with the Eutric Cambisols. Under natural conditions these soils are moderately well drained and have a moderate permeability; however under paddy rice their permeability reduces to very slow rates. These are all good rice soils and produce satisfactorily even with only organic fertilizer. All areas are currently used for wet season rice.

Y2 (3,243 ha): This land unit has brownish silty clay soils that are essentially similar to those of land unit Y1 (Vertic and Eutric Cambisols). However, in addition there are remnants of old stream channels in about 5 % of the area (Regosols). These are not obvious but where they occur the soils are very sandy, and the rice crop very poor. The main disadvantage of these sandy patches is that they would allow leakage of a proportion of applied dry season irrigation water. Some small levee remnants also occur and these require terracing if rice is to be grown, which results in relatively small field sizes.

ii) Older plains (terraces)

O1 (3,655 ha): This is a widespread land unit, especially prominent in the older terrace geomorphic province of the Kandal Stung area, and in the Tonle Bati area. These are almost level old plains with leached, very poorly drained and very slowly permeable soils. Typically, the soils have sandy loam or fine sandy clay loam topsoils sometimes including an eluvial horizon, overlying strongly mottled, often gleyed heavy clay B horizons with some lateritic nodules (Gleyic Acrisols). Rounded sand grains are evident throughout the profile. Soil pH is acid (commonly 5.5 or 5). Some small patches of Tahal's 'alkaline plains soils' probably occur in this land unit. These areas are used for wet season rice but yields are low unless fertilizers are applied.

O2 (1,511 ha): Land unit O2 occurs only in the Kandal Stung area south of Stung Toch. Most of the soils are the same as in land unit O1 (Gleyic Acrisols) but in addition land unit O2 has about 20 % small remnants of the old sandy levee (land unit Hs), with soils having clayey sand or loamy sand topsoils grading up to sandy clay B horizons which are dense, mottled, poorly drained and of slow permeability (Orthic or Albic Luvisols). The small sandy remnants are slightly elevated and are not used, except for grazing cattle. However the soils at the edges of the remnants are often terraced into small fields and used for rice, although yields are very low. This landscape complexity militates against proper rice-field management and would cause a considerable loss of dry season irrigation water, if it were to be applied.

O3 (1,738 ha): This land unit only occurs in the Tonle Bati area. It has three main soils. One is the same as the soils of land unit O1 (sandy surfaced, strongly mottled, very poorly drained heavy clays - Gleyic Acrisols), and these occupy about 30 % of the area. The second soil is a younger, much better brownish silty clay soil similar to the soils of land unit Y1 (Vertic Cambisols), and these occupy about 60 % of the area. Sometimes these younger, silty soil materials were found to overlie the older, strongly mottled soils. The third soil occurs as scattered small remnant patches of land unit Hc, which are slightly elevated and have yellowish, mottled, poorly drained clay soils (Dystric or Ferralic Cambisols). This landscape complexity results in a pattern of small fields, some of which require terracing and some of which would not be not commandable.

(4) Low Lying Land

i) Poorly drained areas

Lw (613 ha): Land unit consists of relatively low-lying land and drainage floors with hydromorphic, poorly drained clay soils (Gleysols). Surface flood-water probably occurs several times a year, but because of man's interference with the natural drainage patterns some occurrences may now be inundated throughout the wet season. Some areas have been bunded for paddy rice which grows well, but the periodic inundations are a limitation. Most occurrences are around the margins of the swamps of land unit Ls.

Ls (725 ha): This land unit is located in low-lying areas where wet season runoff water is impounded annually to a depth of two or three metres. It occurs north of the old sandy levee of land unit Hs, at either end of Lake Tonle Bati, and near Lake Cheung Loung. The soils are hydromorphic, wet, very poorly drained gleyed clays (Gleysols). The surface water dries up in the dry season, but the soils remain wet. These areas are essentially swamps. Some areas are used for dry season rice, grown as water levels recede at the end of the wet season. Planting begins in late November and yields of up to 4 tonne/ha can be obtained if fertilizers are used.

ii) River banks and lake margins

Le (1,428 ha): These are gently sloping, erodible and sometimes actively eroding banks cut from 2 to 5 m below the plains along the flanks of the main streams and lakes. Soils vary, depending on how deeply incised the area is but they are unsuitable for agricultural use. An intermittent cover of secondary vegetation including bamboo is common. This land unit does not occur along Stung 1 or Stung 2.

iii) Water bodies

La (435 ha): Lakes with permanent water; Lake Tonle Bati, Lake Cheung Loung, and Lake Saoa.

Soil maps is shown in Figs. II-4 and II-5. The areas of the land units and of the geomorphic provinces is shown in Table II-2 and summarized as follow:

Map symbol	Kandal Stung (ha)	Kandal Stung (%)	Tonle Bati (ha)	Tonle Bati (%)	Total (ha)	Total (%)
Hy	167	1	0	0	167	1
Hs	755	7	0	0	755	4
Ht	330	3	0	0	330	2
Hc	375	3	360	5	735	4
Al	1,430	13	0	0	1,430	8
Y1	1,435	13	0	0	1,435	8
Y2	2,451	22	792	11	3,243	18
O1	760	7	2,895	42	3,655	20
O2	1,511	13	0	0	1,511	8
O3	0	0	1,738	25	1,738	10
Lw	428	4	185	3	613	3
Ls	275	2	450	7	725	4
Le	1,148	10	280	4	1,428	8
La	235	2	200	3	435	2
Total	11,300	100	6,900	100	18,200	100

3.2.4 Other Information

(1) Soil Permeability

The permeability of the soil is important in determining water requirements for irrigation. Water may be lost by downwards percolation, lateral movement through paddy bunds, or from unlined channels. All these losses are much more significant in the dry season.

Rice requires a very slow soil permeability for best yields and to conserve applied irrigation water. Rice soils are 'man made' soils due to the effects of flooding and puddling, which together can reduce soil permeability by a factor of 1,000 times, for example, from initial rates of about 200 cm per day down to about 2 mm a day. Puddling is an important soil management practice, and if properly carried out can dramatically reduce soil permeability. Ideally, puddling should be carried out progressively as soil moisture contents decline from total saturation to about field capacity, as it is only in this moisture range that cohesion between soil aggregates is greater than cohesion within the aggregates, and disintegration of the aggregates is favoured.

The permeability of the soils in the Study area was assessed on the basis of the pedological features and the results of field infiltration test. In most of paddy field, even sandy surface soil, the permeability ranged slow to very slow due to formulation of plough pan. Higher level lands which are upland area with silty to sandy texture soil have moderately rapid to slow permeability.

(2) Moisture Storage

Soil moisture holding capacity is a more important limitation for upland crops than for rice, because rice is grown on inundated, saturated soils. Horticultural and other upland crops grow best on soils that are permeable and freely drained, with a high moisture storage capacity.

Tahal (1972) carried out measurements of soil moisture holding capacity for soils in the 'Pioneer' area, which lies to the west of the Study area along the left bank of the Prek Thnot. Euroconsult (1992) considered the results to be representative of most of the soils in the Prek

Thnot area. From Tahal's results, Euroconsult calculated the average water holding capacity of five broad soil types in millimetres per metre of soil depth, and also the available water within the plant rooting zone. The rooting zone was considered to vary from 30 cm in clayey soils to 50 cm in sandy soils, which allow deeper root penetration. The results are given in the following table.

Soil type	Water holding capacity (mm/m)	Available water within the rooting zone (mm)
sandy hill soils	76	38
loamy hill soils	192	77
acid plain soils	154	46
alkaline plain soils	158	47
loamy river soils	115	46

* Source: Euroconsult (1992)

(3) Soil Fertility and Toxicity

According to existing information (by Tahal), the soils have a very low content of plant nutrients, especially phosphorus, and responses to phosphatic fertilizer are quite marked at the Prek Phdau experiment station. The most fertile soils are the young alluvial deposits along the rivers and lakes which are replenished by annual increments of silt, and these support a satisfactory rice crop even without fertilizer application. All other soils need fertilizer if yields are to be improved.

Soil nitrogen and available phosphorous is very significant for rice and other crop also. The both elements present level in the Study area is very low.

Soil cation exchange capacities, (which measure the capacity of a soil to accept and hold applied nutrients, and release them again to plants) are reported by Tahal to range from about 1.5 meq/100 gram of soil on the very sandy soils (very low indeed) to about 25 meq/100g on more recent alluvial soils (high, and amply sufficient).

Salinity, in terms of water soluble salts within the soil profile (especially in the root zone) appears not to be a problem, probably due to the annual leaching effect of the wet season rains and floods. Deep-rooted plants may be affected.

However, sodicity, or alkalinity, which is measured by the sodium absorption ratio (SAR) or the exchangeable sodium percentage (ESP) of the soil, was reported by Tahal to be fairly common. Exchangeable sodium percentages considerably over the 15% critical limit and soil pH values of up to 9 have been measured in the broader Prek Thnot area. The high sodium concentration associated with these values is toxic to plant roots. It also facilitates the dispersion and downward movement of clay particles, together with iron and manganese oxides, which leads to degeneration of the soil profile and over long periods of time contributes to the development of a totally impermeable subsoil.

The chemical destruction of clay due to alternate reduction and oxidation of iron associated with wet and dry seasons (or long repeated flooding and drying out) allows some exchangeable cations or plant nutrients to be leached out of the soil, reducing its cation exchange capacity. In addition, a net loss of hydrogen ions from the clay exchange complex, which are replaced by aluminium ions, eventually causes a rise in soil pH and an increased aluminium toxicity hazard to plant roots.

(4) Clay Dispersion and Soil Erosion

Although it is more an infrastructural or engineering problem than an agricultural one, the tendency of soils to disperse can be important for rice-field management. On dispersible soils paddy bunds, irrigation canal banks, roads and other structures can be subject to quite serious erosion by flowing water, and piping can lead to breaching of the banks. Piping can also allow water in flooded fields to escape to lower fields or back into irrigation canals or drains, and shallow gullies may work back into the field rendering that land unusable.

Dispersion of the clay component of a soil when wet is characteristic of sodic or alkaline soils. These have a significant proportion of monovalent cations especially sodium on the clay exchange complex, as distinct from in the soil water. Alternate wet and dry seasons favour the development of sodic soils. They form because as the soil dries out by evaporation of soil moisture, divalent cations including calcium and magnesium, which are only sparingly soluble, precipitate as carbonates. Over long periods of time this removes many of the divalent cations, and their place on the clay exchange complex is taken by the more soluble sodium ions. When the exchangeable sodium percentage reaches 15% or more the soil is classed as sodic. Hence this problem is restricted to older soils. As a rule, it is also restricted to soils formed on transported materials, especially flood-plain deposits such as occur in the Study area.

The soils have been rated into three categories according to the likelihood that their subsoil materials will disperse; highly likely to disperse, moderately likely and unlikely . This rating applies only to soil materials to a depth of 1.2 m, the depth to which the soils were inspected. Placement into the categories is based on field observations of existing gullies (particularly where the B horizons had been undercut), tunnels, high soil pH, and the presence of the dense cloddy clay typical of sodic soils. Soil classification categories known to be dispersible were also identified. Tendency of the soils and parent materials to disperse are shown below:

Rating	Soils	Parent Materials
Highly Likely	-	Hs, Ht, O1, O2, Le
Moderately Likely	Gleyic Acrisols, Orthic/Albic Luvisols, Dystric/Ferralic Cambisols.	Hc, O3 (60%)
Unlikely	(all others)	(all others)

However, within the Study area the problem of dispersion appears to be more closely related to the parent materials of the soils than to the soils themselves. As outlined in section 3.1 (Geomorphology), the parent materials are relatively old in the Older Terrace geomorphic province of the Kandal Stung area and in parts of the Tonle Bati area. In these areas the soil parent materials appear to be sodic and dispersion is quite likely to be a problem in structures built from them.

Graphic examples of piping in dispersible materials can be seen in the banks of the Pol Pot era canal that runs southwards from Stung Toch in the west of the Kandal Stung area, where materials have been excavated to a depth of several metres. On the same soils, however, there is no significant erosion of the rice-field bunds, which have been formed from much shallower materials within the soil profile. It is important to realize that the parent materials of the soils, or the underlying alluvium, have had a complex history and considerable variation can occur over short distances. Hence dispersion may occur only at intervals along a structure built of these materials; and some patches of dispersible material may occur in areas of younger parent materials.

3.3 Land Suitability

3.3.1 Nomenclature and Methodology

Land suitability' is assessed in relation to the requirements of specific forms of land use; i.e.. it is based on the degree to which the characteristics of the land satisfy the environmental requirements of specific crops. In this report the land is assessed in terms of its ability to support three particular forms of land use - wet season paddy rice, dry season (irrigated) paddy rice, and dry season (irrigated) upland crops, so the term suitability is appropriate.

In this Study the soil suitability for paddy rice and horticultural crops are assessed according to the FAO (1985) system for the evaluation of land for irrigated agriculture. This system is compatible with the USBR (1953) system, which is also in widespread use.

The FAO system uses five classes of suitability for use:

S1 (highly suitable):

Land having no significant limitations to the sustained production of the crop

S2 (moderately suitable):

Land having limitations which will reduce production levels and /or increase costs but which is physically and economically suitable for the crop

S3 (marginally suitable):

Land having limitations which will reduce production levels and/or increase costs such that it is economically marginal for the defined crop

N1 (currently not suitable):

Land having limitations which may be surmountable in time but which cannot be corrected with existing knowledge at presently acceptable costs, and which preclude successful sustained use in the defined manner

N2 (permanently not suitable):

Land having limitations so severe as to prevent any possibility of successful sustained use in the defined manner

Subscripts can be applied to each class to indicate which particular limitations apply in that area, for example, w = wetness limitation, t = topographic limitation, etc. Thus suitability class S2w would indicate land that is only moderately suitable for that crop because of a wetness limitation.

Land suitability assessments are usually based on two main lines of evidence. Firstly, the environmental factors likely to limit each form of land use can be enumerated, and assessed against soil profile descriptions, soil analysis results, geomorphological lines of evidence and other base data. Thus areas of land likely to be capable of supporting these forms of use can be identified.

Secondly, the results of field trials, and observations of the performance of plants in the field can be related to soil and land characteristics. In this area both approaches have been used.

Other things were also considered, including factors such as the potential for soil erosion that may be a hazard to the land itself rather than to the crop.

3.3.2 Environmental Requirements of the Crops

The environmental factors of importance for the production of wet season paddy rice are taken to be:

a. adequate water supply
b. suitable soil physical conditions (soil depth and permeability)
c. suitable soil chemical conditions (fertility, salinity, toxicity, nutrient fixation)
d. minimum landscape complexity
e. no serious flooding

For dry season (irrigated) paddy rice the factors are the same except that flooding is deleted and replaced with a commandability requirement.

The horticultural and field (upland) crops considered include vegetables, maize, soybeans, mung beans and groundnuts. The environmental requirements of these crops under dry season irrigated conditions are:

a. adequate water supply
b. suitable soil physical conditions (soil depth, soil moisture holding capacity, topsoil tilth, and drainage)
c. suitable soil chemical conditions (fertility, salinity, toxicity, nutrient fixation)
d. minimum landscape complexity
e. commandability

The environmental requirements of the crops and the limitations likely to be imposed on crop yields by the characteristics of the land are discussed below.

(1) Water Supply:

Constraints regarding an adequate water supply for dry season irrigation are discussed in detail in other parts of the Interim Report and are not analyzed here. However, it is useful to note that for wet season rice the requirement for an adequate water supply is very similar to the dry season requirement of commandability - low level land has both rainwater and floodwater, but higher land must rely on whatever rainwater can be impounded on the site. Dry periods within the wet season can affect crops on this higher land adversely. No rating is given in this Annex for adequacy of water supply.

(2) Soil Physical Conditions:

One requirement of all crops is for an adequate rooting depth. All the soils in the Study area are formed on deep alluvial deposits and there are no hard rock constraints, so rooting depth is only limited by depth to a plough pan, or to a saline or toxic layer, or to an impermeable layer.

Low soil permeability is very important for rice, both to conserve applied irrigation water and to allow anaerobic (reducing) conditions to develop in the soil when it is flooded. In the case of the sandy-surfaced soils that have a rapid permeability but can be used for rice in the wet season because of a regionally high water table, three ratings have been given. One rating is for wet season rice, one is for dry season irrigated rice, and the other is for the dry season irrigation of horticultural and field crops.

A high soil moisture holding capacity is necessary for dry season horticultural and field crops to maximize periods between irrigations, and to minimize fluctuation in optimal plant growth conditions.

Soil drainage is often related to soil permeability. In soils formed on alluvial plains the low soil permeability requirement of rice crops is almost always accompanied by a poor or very poor soil drainage rating. However for horticultural or field crops well drained or moderately well drained soils are necessary for optimal crop performance.

A fine topsoil tilth after cultivation is desirable for most crops but it is very important for nursery seedlings and groundnut crops. The groundnuts grown in the Study area are not likely to be harvested mechanically and so the topsoil tilth requirement is of reduced importance.

(3) Soil Chemical Condition:

In most cases an estimate of their effect has been made based on the apparent age of the soil, soil profile morphology, soil pH, and observed crop performance in the field. Most element toxicity and nutrient fixation problems are pH dependant, and because soil pH tends towards neutral under anaerobic paddy soil conditions but not under horticultural crops, the soil pH requirements of horticultural crops are different from those of rice.

Profile morphology and pH analysis allow some deduction of the probable weathering status and clay mineral assemblage of a soil, which can, with input from other factors, help in an assessment of the likely fertility, salinity, toxicity and nutrient fixation status of the soil. However it must be emphasized that these are very crude measures and need to be upgraded.

(4) Landscape Complexity:

In this Study the basic mapping unit used is the land unit, there may be soils variation within a land unit. Fields with a variety of soil conditions are more difficult to manage. Where small patches of permeable soils occur in a paddy field for example and it is impracticable to treat these areas differently irrigation water can be lost by increased infiltration. Similarly, patches of saline or toxic soils can depress overall yield; small areas of higher ground may not be commandable and may contribute complexity to the irrigation layout or may need to be terraced; and so on.

(5) Flooding:

Flooding is a natural occurrence in the Study area and can affect any wet season crop. Some flooding may be man-induced, for example in the area west of Highway No. 2 and north of Stung Toch, or in the old alluvial terrace areas south of Stung Toch. Floods can be very damaging to both crops and the soil, by physical removal of plants and soil, siltation, and inundation of the crops. Some areas have too much water, for example land unit Ls, which consists of swamps. Some parts of these swamps are used for dry season (non-irrigated) rice, but the inundation is still a limitation for other crops.

However, very little formal data are available and anecdotal evidence from farmers in the field has been used as a guide. The geomorphological evidence that some areas are no longer floodplains but terraces has also been taken into account.

(6) Commandability:

Commandability may be a constraint to the production of dry season irrigated crops in some areas, however this is discussed in other parts of the Interim Report and is not elaborated upon here. In the suitability ratings given below it is assumed that all areas are commandable; if some areas are not, the suitability rating given (for irrigated use) must be downgraded by one unit.

3.3.3 Determination of Suitability

As a first step in generating land suitability classes, categories were constructed for the degree of severity of the limitation imposed if any of the environmental requirements of the crops should be present at an other than optimal level. Three degrees of severity were considered - not significantly limiting, moderately limiting, and severely limiting.

Suitability for the crops concerned was determined by matching the environmental requirements of the crops with the characteristics of the soils to determine the degree to which they were compatible. If the land can supply all the needs of a particular crop it would be rated class S1 for that crop; but if there are limiting factors it may be class S2 or S3 or worse, depending upon the degree of severity of the limiting factor(s). Thus a soil with drainage category 2 (imperfectly drained) may pose no limitation for rice but a limitation of moderate severity for horticultural crops, and so on.

However very little field data are available and in many cases qualitative and even anecdotal data have had to be utilized. Consequently, class limits for the environmental requirements of the crops have not been tabulated in specific terms, and a 'best estimate' has been made in each case based upon whatever data were available. Some of the suitability classes allocated must therefore be considered tentative and subject to review.

Tables II-3, II-4 and II-5 show the degrees of severity of the limitations imposed on each of the crops by the characteristics of the soils within each land unit, for each of the important crop requirements. The tabulated degrees of severity of the limiting factors for each crop are then drawn together to provide a synthesis of the suitability of each soil type (grouped under land units) for each crop. In doing this it has been assumed that for a particular degree of severity the limitation imposed is comparable for each of the environmental requirements considered. No weighting of the factors has been undertaken.

The suitability classes of each soil or land unit for each crop were determined according to the following principles:

Class S1: No significant limitation for that crop. One limiting factor at a moderate degree of severity allowable.
Class S2: Two types of limitation present at a moderate degree of severity.
Class S3: Three or more types of limitation present at a moderate degree of severity. The more limitations the worse the soil.
Class N1: One type of limitation present at a high degree of severity. The more limitations of moderate severity, the worse the soil.
Class N2: Two or more limitations present at a high degree of severity. The more limitations, the worse the soil.

The suitability classes so determined are shown in the final columns of Tables II-3, II-4 and II-5. The limiting factors that contribute to the classification can be seen in the preceding columns.

Table II-6 summarizes these results on a per land unit basis.

For easy reference, land units with suitability classes S1, S2 and S3 for the three crop types are shown in the following table. Note that the total area of some land units is not available for agricultural use, for example land units Al, Hy, Hc and Hs have a large part of their area occupied by villages (15 % of Al, 80 % of Hy, 60 % of Hc and 20 % of Hs are used for villages, roads, and other infrastructure).

Also, the inclusion of land units O1 and O2 in the class S3 column is tentative. In the following table these land units have been classed as S3-N1 for upland crops and they may need to be downgraded to N1. Because the suitability classification of these land units is not certain it needs to be confirmed by soil analyses and agronomic trials.

Crop	Suitability Class and Area (ha)								
	Class S1			Class S2			Class S3		
		Kandal Stung	Tonle Bati		Kandal Stung	Tonle Bati		Kandal Stung	Tonle Bati
Wet Season Rice	Hy:	167	-	A1:	1430	-	O1:	760	2,895
	Y1:	1,435	-	Hc:	375	360	O2:	1,511	-
	Y2:	2,451	792	Lw:	428	185			
				O3:	-	1,738			
Total:		4,053	792		2,233	2,283		2,271	2,895
Dry Season Rice	Hy:	167	-	A1:	1430	-	Hc:	375	360
	Y1:	1,435	-	Lw:	428	185	Ls:	275	450
				O3:	-	1,738	O1:	760	2,895
				Y2:	2,451	792	O2:	1,511	-
Total:		1,602	-		4,309	2,715		2,921	3,705
Horticulture & Field Crops	Hy:	167	-	A1:	1,430	-	Hs:	755	-
	Y1:	1,435	-	Hc:	375	360	O1:	760	2,895
				Lw:	428	185	O2:	1,511	-
				O3:	-	1,738	(NB: O1 & O2 are		
				Y2:	2,451	792		Class S3-N1)	
Total:		1,602	-		4,684	3,075		3,026	2,895

3.4 Development Opportunities

Table II-7 compares existing land use with land suitability, as a means of identifying development opportunities. This table is derived from the land unit descriptions and the land suitability determinations. The soils information in Tables II-3, II-4 and II-5 and other data were also consulted for this review.

From Table II-7, it can be seen firstly that rice is the preferred crop across the area. Secondly, existing land use does not always correlate with land suitability, for example, wet season rice is grown in some areas that are not well suited to rice. Other conclusions that can be drawn from Table II-7 are summarized below.

(1) Land Unit Al:

This land unit is already used to its capacity in the wet season, although agronomic inputs could probably improve crop yields. The Vertic Cambisols and Eutric Fluvisols, which constitute 80 % of the area, have suitability class S1 for dry season irrigated rice and S1, S2 for upland crops but are not used for these purposes. This is a development opportunity.

(2) Land Unit Hc:

This is relatively high ground, flood free, and less suitable for rice than the surrounding land, so it has been used for villages, roads, and other infrastructure. It has some suitability for rice but there is not sufficient spare land for paddy fields. More permanent tree crops (fruit trees) could be grown in these areas, and the roads and other infrastructure could be improved.

(3) Land Unit Hs:

These sandy, elevated areas are used for villages, roads and other infrastructure as for land unit Hc, but some land is unused or used only for grazing cattle. Some improvement of the upland crops grown is possible but these areas have only suitability class S3 for upland crops. Deep rooted tree crops including tree and shrub legumes for organic matter production and cattle feed could be introduced. Roads could also be improved.

(4) Land Unit Ht:

This land unit is unsuitable for most forms of use due to its poor soils. The soils have a low load-bearing capacity in the wet season and are not very suitable for villages or roads. Improved pastures including deep rooted tree and shrub legumes could be grown for organic matter production and cattle feed.

(5) Land Unit Hy:

Most of this land unit is already used to capacity. As it is slightly elevated (but still flooded) it is used for villages, roads and other infrastructure as for land units Hc and Hs. Some small wet season paddy fields already exist. More permanent tree crops (fruit trees) could be introduced, and the roads could be improved.

(6) Land Unit Le:

This land unit consists of sloping stream and lake banks and soil erosion is a hazard. Cultivation should therefore be discouraged in these areas and soil conservation measures should be introduced. No further intensification of land use is envisaged in this land.

(7) Land Unit Ls:

Parts of this land unit are used for wet season rice, sown as wet season floodwaters recede. The rest is not used. No improvement is envisaged in this pattern of use.

(8) Land Unit Lw:

Land unit Lw has good rice soils but is subject to floods with flowing water during the wet season. Dry season upland crops could utilize the abundant residual moisture left in these soils at the end of the dry season, but if this required significant reworking of the paddy fields to produce beds for upland crops and then re-flattening of the beds for the next rice crop there would be a soil erosion hazard. Minimal tillage, or a second crop of rice would be preferable.

(9) Land Units O1 and O2:

These land units are classified as only marginally suitable for crops but most of their area is used for wet season rice crops. To cater for the desires and needs of the people to grow rice in these areas soil and agronomic improvement activities should take place. Other agricultural intensification activities such as dry season cropping should be preceded by soil analyses and crop trials to confirm their suitability.

(10) Land Unit O3:

This is a variable land unit, mostly used for wet season rice. The Vertic Cambisols which constitute 60 % of the area have suitability class S1 for rice. The wet season rice crops in these areas could be improved with soil and agronomic inputs, and dry season irrigated rice or upland crops could be introduced. This is a development opportunity. However, because land unit O3 has landscape complexity a thorough soil survey would be required to delineate the areas of Vertic Cambisols.

(11) Land Unit Y1 and Y2:

These land units have good soils and no significant limiting factors for the production of rice or upland crops. At present they are only used for wet season rice, but they could be used for dry season irrigated rice or upland crops. This is a development opportunity. However, land unit Y2 has landscape complexity and a thorough soil survey would be required to delineate the areas of Vertic Cambisols, which are the best soils.

In summary, the major parts of land units A1, Lw, O3, Y1 and Y2 could be further developed for dry season irrigated rice or upland crops (rice preferred for land unit Lw). Land units O1 and O2 are marginal for cropping and their suitability needs to be confirmed by soil analyses and agronomic trials. Pastures or agroforestry may prove to be more suitable in some areas. Land units Hc, Hs and Hy would be able to support an intensification of existing cropping patterns and an increase in permanent tree crops (fruit trees preferred). Land unit Ht and part of Hs could be further developed with improved pastures and agroforestry for organic matter, cattle feed, bamboo and fuelwood production (non-irrigated).

4. THE PRIORITY AREA

4.1 Selection of the Priority Area

Proposed land use in Master Plan Study area are formulated on the basis of the present land use condition (which resulted from not only soil and land use survey but also agronomic survey), result of land suitability assessment and future irrigation condition. In this land use plan no substantial change is taken into account between the present and future uses. These are summarized in the following table.

Land use categories*	Kandal Stung		Tonle Bati		Total	
	(ha)	(%)	(ha)	(%)	(ha)	(%)
1. Present						
Villages, roads, etc.	1,500	13	400	6	1,900	10
Rainfed wet season rice field	7,300	65	5,100	74	12,400	68
Wet season uplandcrop field	300	3	50	1	350	2
Cattle grazing, unused	2,200	19	1,350	20	3,550	20
Total	11,300	100.0	6,900	100	18,200	100
2. With Prek Thnot Reservoir						
Villages, roads, etc.	1,500	13	400	6	1,900	10
Irrigated rice field	4,200	37	4,200	61	8,400	46
Rainfed wet season rice field	3,100	27	900	13	4,000	22
Wet season uplandcrop field	300	3	50	1	350	2
Cattle grazing, unused	2,200	19	1,350	20	3,550	20
Total	11,300	100.0	6,900	100	18,200	100
3. Without Prek Thnot Reservoir						
Villages, roads, etc.	1,500	13	400	6	1,900	10
Irrigated rice field	1,950	17	1,600	23	3,550	19
Rainfed wet season rice field	5,350	47	3,500	51	8,850	49
Wet season uplandcrop field	300	3	50	1	350	2
Cattle grazing, unused	2,200	19	1,350	20	3,550	20
Total	11,300	100.0	6,900	100	18,200	100

As result of the master plan study, the priority area were selected 1,950 ha of paddy field in Kandal Stung and 1,600 ha in Tonle Bati as priority area respectively. Detailed studies area carried out in and around these priority areas present land use condition, soil and land suitability for each crops. The results are described in following section.

4.2. Existing Land Use

4.2.1 Kandal Stung Area

The land use types of the Kandal Stung area are classified into four types of paddy fields, two types of uplands, and a swampy area. The details are described below.

(1) Paddy field

Paddy (wet season rice) fields are broadly extended in the study area. However, only one crop can be grown per year in most areas because of a shortage of irrigation water in the dry season. Most of the paddy fields are located in the gently sloping and flat terrain. The paddy field of gently sloping terrain (Up) is medium to small in size and often irregular in shape, and may be aligned relative to the contour. The paddy field of flat terrain is divided into two land use types by the field size and shape, small to medium and irregular (Ps) and medium to large and square or rectangular (Pl).

Some areas of depressional terrain (Pd), mainly old river channels, are designated for paddy fields of small size. These areas have good wet season water supplies and occasionally a chance of double cropping in the dry season by using retained water, but seasonal inundations are a limiting factor.

(2) Upland and others

Uplands are slightly elevated flood free areas. These lands are generally less suitable for rice because of higher soil permeability, and most of these would not be commandable by gravity. In the Kandal Stung area, about half of these are used for villages and others, and the other half for grazing cattle and some wet season upland crops.

The village areas (V) may be densely packed with houses or have only scattered buildings. Sugar palm, coconuts, mangoes, cassava, sweet potatoes, mung bean and other crops are grown amongst the buildings. Some rice may be grown if sufficient wet season rainwater can be impounded for the crop. In the grazing and upland crops field (U), mung bean, maize, bananas and other crops are planted, or grasses and shrubs are growing.

The land use map of Kandal Stung priority area is presented in Fig. II-7 and the extent of each land use type is shown in Table II-8 and summarized in the following table.

Land Use Types	Mapping Unit	Area (ha)*	%
1. Paddy fields	(P)	(2,048)	(85)
1-1 Paddy fields in gently sloping terrain	Up	389	16
1-2 Paddy fields in almost flat terrain			
(1) small to medium (irregular) size	Ps	460	19
(2) medium to large (square or rectangular) size	Pl	1,005	42
1-3 Paddy fields in depression terrain	Pd	194	8
2. Upland and others		(356)	(15)
2-1 Upland and Grazing land	U	130	5
2-2 Villages and others (house gardens, orchards, roads, etc.)	V	214	9
2-3 Swamps	S	13	1
Total		2,404	100

Remark: *: Area of each land use type is the gross area, including canal, foot paths, field bund, etc. especially in the each paddy field, it is supposed that the area of canals, foot paths, roads etc. are equal to 5% of the net area

4.2.2 Tonle Bati Area

The land use of the Tonle Bati area is similar to that of the Kandal Stung one. The difference of land use between Kandal Stung and Tonle Bati are as follows : the elevated land in Tonle Bati is fully occupied by villages, and upland crops field is in flank of the elevated land (while such an elevated land in Kandal Stung is shared, as villages and upland crops fields or grazing land). A land use map of Tonle Bati is shown in Fig. II-8 and the distribution of each land type are given in Table II-9 and summarized below:

Land Use Types	Mapping Unit	Area (ha)*	%
1. Paddy fields	(P)	(1,680)	(92)
1-1 Paddy fields in gently sloping terrain	Up	449	25
1-2 Paddy fields in almost flat terrain			
(1) small to medium (irregular) size (very gently sloping)	Ps	767	42
(2) medium to large (square or rectangular) size	Pl	464	25
1-3 Paddy fields in depression terrain	Pd	0	0
2. Upland and others		(148)	(8)
2-1 Upland crops fields	U	36	2
2-2 Villages and others (house gardens, orchards, roads, etc.)	V	91	5
2-3 Grazing land on hillocks	H	20	1
2-4 Swamps	S	2	0
Total		1,828	100

Remark: *: Area of each land use type is the gross area, including canal, foot paths, field bund, etc. especially in the each paddy field, it is supposed that the area of canals, foot paths, roads etc. are equal to 5% of the net area

4.3 Soil and Land Unit

4.3.1 Soils

Soil classification and description are according to the FAO system (FAO-UNESCO, 1974). Chemical and physical analyses were conducted in the Department of Agriculture laboratories in Phnom Penh. Summary of soil description surveyed in phase II study are syown ib Table 10 and soil maps of each priority area are presented in Figs. II-9 and II-10.

A summary of the soil classification in the both priority areas is given in following table.

Soil Unit (FAO)	Summary Description	Appearing Area
Acrisols:		
Gleyic Acrisols	Old, strongly mottled, sticky sandy loams over heavy clays with rounded sand grains and very poor drainage.	Both
Cambisols:		
Dystric/Ferralic Cambisols	Slightly elevated, poorly drained, dense, mottled heavy clay on old river levees.	Tonle
Eutric Cambisols	Shallow, yellowish brown, silty clay on recent alluvium of low permeability.	Both
Vertic Cambisols	Deep, yellowish brown, weakly structured, mottled silty medium clay on recent alluvium.	Both
Fluvisols:		
Eutric Fluvisols	Brown, massive, hard-setting silty clay on recent layered alluvium.	Both

4.3.2 Kandal Stung Area

Eight mapping units, two of which are not soils units (S-swamps, and H-hillocks) have been identified within the Kandal Stung area. They are described in general terms below.

The soils in the Kandal Stung area are relatively young. Sand grains tend to be coarser in the west, which is closer to the point of divergence of Prek Thnot and Stung Toch, and progressively finer towards the east. This trend is especially evident in the old river levee remnants (L). The plains in the western part of this area are very gently undulating, but in the east they are almost flat; this topographic difference is clearly evident on aerial photographs under the stereoscope. As well, the proportion of levee remnants and the general complexity of the landscape are greater towards the west.

(1) Levee (L) - Eutric Fluvisols

The river levees and levee remnants of mapping unit L are currently active and only recently relict, respectively. They have weakly differentiated, generally silty soils with moderate consistence, which merge with the soils of the slightly elevated plains. A typical profile has dark yellowish brown silty sandy loam or clay loam over brown medium clay B horizons, and a pH of about 6. The active levees are flooded to shallow depth at irregular intervals but the levee remnants are flood free.

(2) Slightly elevated plain (P1) - Eutric Cabisols

On the slightly elevated plains (P1) soil texture varies, probably depending on the velocity of the floodwaters that deposited the alluvium. Those with more sandy B horizons have a high pH - often 8.5 or 9. It is not known why this is so but it may be caused by upwards movement of saline soil water by capillarity during the dry season, evaporation of the water, and precipitation of soluble salts. Chemical analysis shows an exchangeable sodium percentage of 16 at about 1m depth, which tends to support this theory. Typically, these soils have brown, fine sandy loam to sandy clay loam A horizons overlying mottled sandy clay loam to clay loam high pH B horizons.

(3) Almost flat plain (P2) - Eutric Cambisols, Vertic Cambisols

Of the almost flat plains soils, one has a distinctly paler- coloured topsoil, visible both on aerial photographs and in the field (P21). This soil appears to have a recent silty overlay of 20 to 30 cm depth overlying older, more mature clay. The A horizons have pale grey silty clay, overlying dark yellowish brown, mottled medium to heavy clay B horizons; soil pH is 6-7. Drainage is poor.

The most extensive soil in the Kandal Stung area is a Vertic Cambisols. It occurs on almost flat plains and is mapped as P22. This is the best irrigation soil in the area. Typically, it has greyish silty clay A horizons overlying dark yellowish brown, silty medium to heavy clay B horizons; soil pH is 6-7.5. The grey topsoil colour is due to the reducing effects of inundation for rice production; when dry, the topsoils are brownish. Drainage is imperfect to poor and soil permeability is low, which is good for rice. Soil analysis results indicate that these soils are of high short term fertility (available phosphorus) and moderate long term fertility (cation exchange capacity).

(4) Old plain (P3) - Gleyic Acrisols

Only one area of old, very flat clay plains occurs in the Kandal Stung area, in the mid-north along the link road between Highways 2 and 3, near Rolous Village (P3). This soil is strongly differentiated and probably quite old. It has brown, mottled, sticky sandy loam to sandy clay loam A horizons abruptly overlying light yellowish brown, strongly mottled heavy clay B horizons with ferromanganiferous nodules and a pH of 5-5.5. Drainage is very poor. Soil analysis results indicate saline topsoils, and very low fertility in terms of available phosphorus.

(5) Depressional terrain (D) - Eutric Fluvisols, Gleysols

Land unit D in the Kandal Stung area is located in depressed, partially infilled, seasonally inundated, prior river channels and oxbows. These soils have very silty and fine sandy, layered, very poorly drained profiles with hydromorphic features. A typical profile has brownish silty clay A horizons overlying yellowish brown, strongly mottled silty sandy clay to medium clay B horizons; soil pH is 5.5-6.5. Fine sand dominates the profile. These areas are flooded seasonally to 50-100 cm several times a year.

Soil map of Kandal Stung area is shown in Fig. II-9. The area of each land unit of the Kandal Stung is shown in Table II-11, and summarized as follow:

Land Unit Types	Mapping Unit	Area (ha)*1	%
Levee (L)			
Old levee remnant	L	339	14
Plain (P)			
Slightly elevated plain	P1	389	16
Almost flat plain (younger)	(P2)		
pale surface	P21	218	9
the others	P22	1,229	51
Old flat plain	P3	18	1
Depressional terrain (D)	D	194	8
Low-lying land (S)	S	12	1
Hillock (H)	H	5	0
Total		2,404	100

4.3.3 Tonle Bati Area

Ten mapping units, three of which are not soils units (S-swamps, H-hillocks and M-man made rises) have been identified within the Kandal Stung area. They are described in general terms below.

The soils of the Tonle Bati area are formed on a complex alluvial terrace. Some of them are relatively old, for example the soils in map unit P3 (Gleyic Acrisols). The soils in map unit P2 are intermediate in degree of profile development and so presumably intermediate in age also. Other soils are quite young and have probably formed on the most recent increments of alluvium to be deposited in the area (see Interim Report for details of geomorphological history).

(1) Old levee remnants (L) - Gleyic Acrisols

The old levee remnants (L) have strongly differentiated soils with dark yellowish brown sticky sandy loams including an eluvial horizon abruptly overlying very hard, strongly mottled medium to heavy heavy clays. Soil pH varies depending on history of use but is often about 6 at the surface rising to 8 by 1m depth.

(2) Lower flanks (Lf) - Ferralic Cambisols

The lower flanks of the old levees (Lf) have younger soils due to continued slow erosion on these very gentle slopes. These soils have fine sandy loam to sandy clay loam A horizons over firm, medium textured, mottled B horizons, and a pH in the slightly acid range.

(3) Gently to Very gently sloping terrain (T1, T2) - Vertic Cambisols, Ferralic Cambisols

The soils of the plains fall into three distinct groups, the first two of which form a continuum. The highest of them (T1) forms on gently sloping terrain, with common low terracing and contour alignment of the fields in the more sloping areas. These have brownish fine sandy clay loam or silty clay loam A horizons over mottled medium to heavy clay B horizons and a pH of about 5.5-6. Drainage is imperfect to poor. This soil also occurs in mapping unit T2.

(4) Almost flat plain (P2) - Ferralic Cambisols

The second plains soil (P2) forms on very gently sloping to almost flat terrain. Only very minor terracing has been undertaken in these areas. The soils have brownish, mainly sandy clay A horizons over mottled heavy sandy clay to heavy clay B horizons and a pH of 6.5-7.5. Drainage is poor to very poor. This soil is most common in the east of the Tonle Bati area. It also occurs in mapping unit T2.

(5) Old plain (P3) - Gleyic Acrisols

The third plains soil is old. It forms almost exclusively in the west of the area along highway number 2, on apparently flat terrain. This soil is strongly differentiated and probably quite old. It has brown, mottled, sticky sandy loam to sandy clay loam A horizons abruptly overlying light yellowish brown, strongly mottled heavy clay B horizons with ferromanganiferous nodules and a pH of 5-5.5. Drainage is very poor.

(6) Depressional terrain (D) - Eutric Fluvisols, Gleysols

Land unit D in the Tonle Bati area is located in depressed, partially infilled, seasonally inundated, low lying areas. These soils have very silty and fine sandy, layered, very poorly drained profiles with hydromorphic features. A typical profile has brownish silty clay A horizons overlying yellowish brown, strongly mottled silty sandy clay to medium clay B horizons; soil pH is 5.5-6.5. Fine sand dominates the profile. These areas are flooded seasonally to 50-100 cm several times a year.

Soil map of Tonle Bati areas is shown in Fig. II-10. The area of each land unit of the Tonle Bati is shown in Table II-12, and summarized as follow:

Land Unit Types	Mapping Unit	Area (ha)*1	%
Levee (L)			
Old levee remnant	L	55	3
Levee flank	Lf	36	2
Terrace & Plain (T & P)			
Gently sloping plain with terrace (common)	T1	449	25
Very gently sloping plain with terrace (some)	T2	767	42
Almost flat plain	P2	344	19
Old flat plain	P3	120	7
Depressional terrain (D)	D	2	0
Hillock (H)	H	20	1
Low, man-made rise (M)	M	36	2
Total		1,828	100

4.3.4 Soil Analysis

Fifty five samples taken from typical soils in the both priority areas were analyzed by the Department of Agronomy Soil Laboratory. The results are shown in Table II-13 and general consideration of these result are described below.

(1) Soil Textures

Soil texture classes are defined on the basis of particle size distribution. The texture is the most permanent characteristic of the soil. It influences a number of the other soil properties, e.g. structure, consistency, water holding capacity, permeability, infiltration rate, run-off rate, erodibility, workability, root penetration and fertility. As shown in Table II-7, the soils of the priority areas range from sandy loam to silty clay. While higher level land (L, Lf, TI) has coarse texture soil, soils of the plain (P2, T2) are finer. It is found that clay contents of the all soil description trend to increase toward lower layer, which indicates clay leaching and illuviation. These soils are relatively old and plant nutrition also have been leached with clay.

(2) Soil Reaction (pH) and Salinity (EC)

The pH (H2O) values in root zone (up to 40 cm) of the priority areas range from 5.2 to 7.7. EC values in root zone (up to 40 cm) are also in very low levels of salts, ranging from an EC (1: 5) value of 0.03 to 0.19 mS/cm. But alkalinity and/or salinity trend at below layer soils in levee remnant (L) and plain (P21) are found. These results may reflect the high amount of fine sand and silt in the recent topsoil layer and the likelihood of upwards capillary movement and evaporation of soil water solutions in the dry season.

(3) Cation Exchange Capacity (CEC)

CEC and base saturation values represent the nutrient condition of soils. CEC is essentially a property of the colloidal fraction of soil, derived mainly from the clay and organic matter fractions, although silt-sized particles sometimes contribute significantly.

CEC in root zone of the priority areas ranges from 3.2 to 20.6 me/100 g, indicating a low to medium cation exchange capacity. This corresponds with organic matter contents, clay contents and clay types. Soil texture and clay type cannot be easily changed, the main strategy to maintain higher CEC involves the maintenance of soil organic matter.

(4) Sodicity

Most of all soils in the priority areas may have sodic B-C horizon. High ESP (Exchangeable Sodium Percentage) level are found at 1m depth of most sampled soils. Especially ESP is high at the surface soil in P3 and L, these are likely to affect some sensitive crops (but not rice).

(5) Carbon, nitrogen and available phosphate

Carbon and nitrogen contents and available phosphate level are very low. To get the satisfied yield of crops, fertilizers including manures, urea, 15-15-15, etc. should be applied.

4.4 Land Suitability

4.4.1 Nomenclature and Methodology

In this feasibility report land suitability is assessed in relation to the requirements of specific forms of land use; i.e.. it is based on the degree to which the characteristics of the land satisfy the environmental requirements of specific crops. The land is assessed in terms of its ability to support four particular forms of land use - wet season paddy rice (with supplementary irrigation), dry season (irrigated) paddy rice, dry season (irrigated) upland 'cash' crops, and variously irrigated pastures for cattle, to be harvested either by direct feeding or involving cut and carry or sale of fodder.

Prior to the land suitability classification, the following assumptions were made.

a. An optimum amount of water can be supplied to all the priority area on time, especially in the wet season.

b. After completion of the construction of river dike, the priority areas will be hardly subjected to flood damage.

c. Distance to the market, accessibility, regional location, skill or resources of farmers are not considered in the criteria for classification ratings.

4.4.2 Criteria for Suitability

The environmental factors of four type crops, i.e.. wet season paddy, dry season paddy, upland crops, pastures are summarized as follow:

Crop Type	Environmental Factor
Wet season paddy	- suitable soil physical conditions (soil depth and permeability) - suitable soil chemical condition (fertility, salinity, toxicity, nutrient fixation) - minimum landscape complexity - no serious flooding
Dry season paddy	same condition of wet season paddy
Upland crops	- suitable soil physical conditions (soil depth, moisture holding capacity, topsoil tilth and drainage) - suitable soil chemical condition (fertility, salinity, toxicity,nutrient fixation) - minimum landscape complexity - commandability (water may be pumped)
Pastures	- suitable soil physical conditions (drainage) - suitable soil chemical condition (salinity, toxicity) - minimum landscape complexity

4.4.3 Result of the Land Suitability Assessment

Tables II-14 and II-15 show the degrees of severity of the limitations imposed on each of the crops by the characteristics of the land (soils) within each mapping unit, for each of the important crop requirement. The suitability classes of each land for each crop were then determined according to the principals applied in Master plan study.

Table II-16 gives the distribution of suitability classes with sub-classes. A land suitability maps are presented in Figs. II-11 and 12. The following tables summarize them.

(1) Kandal Stung

Land unit	Wet season paddy	Dry season paddy	Upland crops	Pastures	Area (ha)
L	S2st	S2st	S1	S1	339
P1	S3sft	S3sft	S2ft	S1f	389
P21	S1f	S1f	S3sfd	S3sfd	218
P22	S1	S1	S2sd	S2sd	1,229
P3	S2sf	S2sf	S3sfd	S3sfd	18
D	S3dt	S1t	N1	S1d	194

(2) Tonle Bati

Land unit	Wet season paddy	Dry season paddy	Upland crops	Pastures	Area (ha)
L	S2ft	S2ft	S1f	S1f	55
Lf	S2ft	S2ft	S1f	S1f	36
T1	S1	S1	S2sd	S1s	449
T2 (70%)	S1	S1	S2sd	S1s	537
T2 (30%)	S1f	S2ft	S3sfd	S2sf	230
P2	S1f	S2ft	S3sfd	S2sf	334
P3	S2sf	S3sft	N1	S2sf	120
D	S3dt	S2dt	N2	N1	2

4.5 Development Opportunities

Development opportunities of each priority area are estimated from existing land use and land suitability for each crop. This result are summarized in the following table.

Kandal Stung Priority Area

Present land use	Map unit	Suitability Classes (W. paddy / D. paddy / Upland / Pastures)	Area (ha)
1. Paddy field			
Gently sloping	Up	**S3sft** / S3sft / **S2ft** / S1f	389
Almost flat	P! & Pd	**S1** / **S1** / S2sd / S2sd (S1f / S1f / S3sfd / S3sfd)	1,465
Deppressional	D	**S3sft** / Sit / N1 / Sid	194
Sub-total			2,048*
2. Upland field'	U & V	S2st / S2st / **S1** / **S1**	344

Remark: * Net area is 1,950 ha.

Most of paddy field in the both areas have a good chance to introduce two times paddy cropping. Only gently sloping paddy fields in Kandal Stung priority area are more suitable for upland cropping than paddy in dry season. It is considered that Upland and Village areas should be used for upland crops, pastures for cattle, forest for fuel wood, etc. than paddy cropping, especially in the abandoned areas.

As a result, no substantial change between future land use and present condition is taken account.

5. SOIL IMPROVEMENT PLAN

5.1 Basic Concept

They all have a conspicuous lack of organic matter (as measured by total carbon) and most of them have a low fertility (about nitrogen, potassium and available phosphorus levels). Marked responses to applied fertilizers are observable in the field. Cation exchange capacities are moderate, but low to moderate for irrigation. Some soils in both areas have elevated exchangeable sodium percentages within the plant root zone.

In the soil improvement strategy proposed the production and use of organic matter is stressed, as well as the use of mineral fertilizers.

The problems of low fertility and low cation exchange capacity could be ameliorated by increasing the soil organic matter content, which can increase the cation exchange capacity of a soil fairly quickly. Green manuring has been advocated for this before (SMEC,1992). The suggested technique has been to grow an early crop of a leguminous plant, e.g.. Sesbania rostrata, then to incorporate it into the topsoil as a fertilizer for the rice crop, which follows immediately. However, although many of the technical difficulties have been overcome on research stations there is a reluctance of many farmers to adopt this technology.

Organic matter decomposition has three main effects in a paddy soil: it raises the cation exchange capacity, helps reduce soil permeability as decomposition products block soil pores, and after the decomposing organisms have died and decomposed, the nutrients from the original organic materials are mineralized and become available for plant uptake, increasing soil fertility.

In the case of incorporated Sesbania rostrata for example, the effects would include an almost immediate contribution of soil nitrogen, a physical amelioration of adverse soil structure and a longer term contribution to both soil fertility and the capacity of the soils to be successfully puddled for rice production.

The incorporation of rice straw into the soil and its decomposition by soil micro-organisms would also be beneficial, but in this area much of the rice straw is presently burnt, or cut and fed to cattle or used as fuel in homes or brick kilns. However, decomposing rice straw does not add much soil nitrogen - in fact it may deplete it, at least temporarily, by tying it up in the soil micro-organism biomass. The longer term effects however are favourable, and this could be done on-site in every paddy field.

The advantage of leguminous green manure is that it provides not only organic matter, which has a medium to long term effect, but also nitrogenous material for short term fertility. The advantage of rice straw is that it is produced anyway and does not involve double cropping.

However, the incorporation of organic matter alone will not completely solve the soil productivity problems under irrigation conditions - the effects will be more physical than chemical. Mineral fertilizer applications will also be necessary to provide an adequate and balanced plant nutrient supply, to replace nutrient loss in harvested crops, and to cope with mineral nutrient immobilization (e.g.. phosphorus) caused by adverse soil pH or calciummagnesium ratios.

The high ESP found in some soils will not be easy to overcome; however it is only a minor problem. Application of agricultural lime would ameliorate it by both altering the calcium-sodium ratio and also by alleviating any likely calcium deficiency.

No significant plough pans were encountered during either the Phase I or the Phase II field survey work, probably because historically these areas have been subjected to mainly wet season cropping, and given that the wet season water table has been high at those times there has been little need for the farmers to thoroughly puddle the soil for improved water retention. Consequently there appears to be no need for deep ripping or other tractor-based remedial activities. It is emphasized that economics, land tenure and sociological aspects are not taken into account in these notes.

5.2 Soil Improvement Plan of Each Land Unit

The soils and land units have been grouped into four categories for discussion purposes. It is emphasized that economics, land tenure and sociological aspects are not taken into account in these notes.

(1) Land Units Hs, Ht: (Maser Plan Area)

These areas are not presently used for rice or upland crops and are not suitable for them. They have sandy or sandy-surfaced soils of low fertility and are probably not commandable for irrigation. They could however produce leguminous improved pastures and fodder crops or perennial tree and shrub legumes, with an input of phosphorus, potassium, and possibly trace elements. The forage could be grazed in situ or cut and sold as cattle feed or green manure. At intervals of a few years when pasture renovation became necessary one or two crops of wet season rice or maize could then possibly be produced in the better areas. Cattle could be sold, and alley cropping might also become possible. Bamboo, (a variety of which grows in these areas now) could also be produced for building materials, with a cattle feed by-product. Fuelwood production is also a possibility. Land tenure in these unused areas is not known but would need to be ascertained.

(2) Land Units Hy, Hc (Maser Plan Area), L, Lf (Priority Area)

These area have silty to sandy soil with moderately well drainability. These are presently used for villages with house gardens, grazing land for cattale feeding, upland cropping area. Due to topographic condition and permeability feature, these are marginal suitable for paddy, but suitable for upland crops and pastures. The surface soils is low fertility, therefore organic matter such as rice straw, compost, green manure, etc. should be incorporated into them and also chemical fertilizer should be applied to get good yields.

As well, machinery tillage shall be done up to 30 cm below for improvement to retain the soil nutrition and expand the root zone of upland crops.

(3) Land Units O1, O2, O3 (Maser Plan Area), P3 (Priority Area)

(Gleyic Acrisols and Orthic/Albic Luvisols):

These are sandy-surfaced plains soils, presently used for wet season rice. Because of the low clay content, low organic matter content and low fertility of their topsoils, these soils need additional organic matter. The most urgent need is to incorporate the residual rice straw into the soil after harvest. Farmers willing to grow an early leguminous cover-crop should be encouraged. Leguminous shrubs could be grown on paddy field bunds and other patches of high ground for both additional green manure, cattle fodder and fuelwood. Green manure could also be purchased, possibly from farmers in land units Hs and Ht (see above). Application of mineral fertilizers probably including trace elements would also help.

As well, depending upon economics, farmers in the worst areas could be encouraged to stop growing rice (except for an occasional opportunistic crop) and begin producing forage, fuelwood, green manure crops and cattle for sale. To improve the profitability of these farms, limited dry season irrigation could be introduced. These farmers would then have to purchase the bulk of their rice supplies.

(4) Land Units Al, O3, Y1, Y2 (Maser Plan Area), P1, P21, P22, T1, T2, P2 (Priority Area):

These areas have good silty clay soils and are used extensively for wet season rice. The soils are suitable for dry season irrigation of both rice and upland crops. Soil improvement in these areas would include the incorporation of post harvest rice straw and whatever other organic materials can be made available, leguminous or otherwise, plus mineral fertilizers. High yields can be expected on these soils and the farmers would be able to afford to buy fertilizers. Because of the high yield potential of these soils the fertilizer balance should include basic phosphorus and potassium, but have an emphasis on nitrogenous fertilizers. Rice varieties with a high yield response to fertilizer would be required. In this double cropping situation blue-green nitrogen fixing algae could also be better maintained.

As well as the above measures there are other considerations, which are touched on only briefly here. For dry season rice, the farmers would need better proficiency in soil puddling. Herds of cattle could be used for puddling on a community basis, or suitable ox-drawn implements could be introduced. A fertilizer subsidy or marketing cooperative could be considered. Markets for upland crops, cut and carry cattle fodder, green manure, bamboo, firewood, cattle, and other commodities may need improvement. Transport of primary products could be improved by attention to the secondary road network. Farmer education, including in the fields of soil puddling, soil organic matter improvement, upland crop production, pasture and forage production, and agroforestry would be beneficial.

6. LAND RESOURCES DEVELOPMENT PLAN

The land resources development plan for this Feasibility Study is based on the soils map, and the suitability of each soil type for both wet and dry season rice, upland crops and pastures. The following procedures are advocated:

a. Soils should allocated to use initially with respect to their agricultural suitability class (taking existing land tenure into account).

b. If soils need to be used that have suitability class S2 or worse for that form of use, plans should be made to ameliorate the limiting factors that have downgraded them.

c. Where good soils for a desired form of use are scarce, all soils that are class S1 for that use should be allocated to it, even if the same soils are also class S1 for other forms of use. The same should be done with class S2 (or possibly class S3 soils) for the indicated forms of use.

d. 'Non-land' planning constraints such as insufficient water supply or existing forms of land use or tenure should be recognized.

e. Where water supply is limiting, crops that use less water should be preferred. If rice is still the preferred crop, proper puddling of the soil especially in the dry season to conserve applied irrigation water is also stressed. Planting of the paddy bunds with vegetation that can reduce wind-run over the field can help to reduce both water losses and crop nitrogen loss.

f. Physical infrastructure such as roads, processing facilities, etc. should be planned to be on soils with a lower suitability for crops (Classes N1 and N2, possibly also class S3); hence roads and villages would be best located on land such as the slightly elevated river levees and relict levees having better drainage and which are less commandable; or on the older plains soils having fertility problems or possible toxicity problems but no flooding limitations.

g. The requirements of inter-related forms of land use such as the location of villages and the need for fuelwood, grazing land or fodder for draught animals should be considered. As most cattle are tethered during the wet season to keep them out of the rice fields, strengthening of the 'cut-and-carry' system of fodder production and the growth of fodder for resale are advocated.

h. Present land use should also be taken into account. The objective should be to recognize present land ownership and to avoid re-location of farmers simply to achieve land use change; indeed, it is important to recognized that such an approach would most likely fail.

i. Presently unused or under-used land could be used for the growth of leguminous (or other) forage and green manure crops and their utilization on site by cattle; alternatively their harvest and sale for stock feed or green manure. More cattle also mean more manure for use as organic fertilizer. Fuelwood could also be produced on this land.

Tables

Table II-1. Area of the Soil Units

Soil Unit (FAO)	Land Units Having Each Soil	Area of the Soil Units (ha)
Acrisols:		
Gleyic Acrisols	O1, O2 (80%), O3 (30%)	5385
Arenosols:		
Albic/Luvic Arenosols	Hs (80%)	604
Cambisols:		
Dystric/Ferralic Cambisols	Hc, O3 (10%), Y2 (5%)	1071
Eutric Cambisols	Y2 (5%)	162
Vertic Cambisols	A1 (60%), Y1, Y2 (85%), O3 (60%)	
Fluvisols:		
Eutric Fluvisols	Hy, A1 (20%)	453
Luvisols:		
Orthic/Albic Luvisols	Ht, Hs (20%), O2 (20%)	783
Other Soils:		
Gleysols	Lw, Ls, A1 (20%)	1624
Regosols	Y2 (5%)	162
(Eroded/Truncated Soils)	Le	1428
(Lakes)	La	435
	TOTAL	18,200

Additional information on the soils is included in Section 6.

Table II-2. Area of the Land Units and Geomorphic Provinces

Geomorphic Province and Land Units	Area (ha) Kandal Stung	Tonle Bati
Younger Floodplains		
Hy	167	-
Hc	312	135
A1	1430	-
Y1	1435	-
Y2	2451	792
Lw	38	25
Ls	-	235
Le	442	-
Total	6275	1187
Older Terrace		
Hs	755	-
Ht	330	-
Hc	63	-
O1	760	2895
O2	1511	-
O3	-	120
Lw	390	60
Ls	275	-
Le	706	250
La	235	-
Total	5025	3325
Younger Terrace		
La	-	200
Hc	-	225
O3	-	1618
Lw	-	100
Ls	-	215
Le	-	30
Total	0	2388
Grand Total	11300	6900

Table II-3. Soil Suitability Classes for Wet Season Rice

Land Unitsand Soils	Degree of Severity of Limiting Factors (+ = low ++ = moderate +++ = severe)				Soil Suitability Class
	Soil Phys. Condition	Soil Chem. Condition	Landscape Complexity	Flooding	
A1:					
Vertic Cambisols (60%)	+	+	++	++	S2
Eutric Fluvisols (20%)	+	+	++	++	S2
Gleysols (20%)	++	+	++	+++	N1
Hc:					
Dystric/Ferralic Cambisols (100%)	++	++	+	+	S2
Hs:					
Albic/Luvic Arenosols (80%)	+++	++	++	+	N1
Orthic/Albic Luvisols (20%)	++	++	++	+	S3
Ht:					
Orthic/Albic Luvisols (100%)	++	+++	+	+	N1
Hy:					
Eutric Fluvisols (100%)	+	+	+	++	S1
Le:					
Eroded/truncated Soils (100%)	+++	++	+	+	N1
Ls:					
Gleysols (100%)	++	+	+	+++	N1
Lw:					
Gleysols (100%)	++	+	+	++	S2
O1:					
Gleyic Acrisols (100%)	++	++	++	+	S3
O2:					
Gleyic Acrisols (80%)	++	++	++	+	S3
Orthic/Albic Luvisols (20%)	++	++	++	+	S3
O3:					
Vertic Cambisols (60%)	+	+	++	+	S1
Gleyic Acrisols (30%)	++	+++	++	+	N1
Dystric/Ferralic Cambisols (10%)	+	++	++	+	S2
Y1:					
Vertic Cambisols (100%)	+	+	+	++	S1
Y2:					
Vertic Cambisols (85%)	+	+	+	++	S1
Eutric Cambisols (5%)	+	+	++	++	S2
Dystric/Ferralic Cambisols (5%)	+	++	++	+	S2
Regosols (5%)	++	++	++	+++	N1

Table II-4. Soil Suitability Classes for Dry Season Rice

Land Unitsand Soils	Degree of Severity of Limiting Factors (+ = low ++ = moderate +++ = severe)				Soil Suitability Class
	Soil Phys. Condition	Soil Chem. Condition	Landscape Complexity	Flooding	
A1:					
Vertic Cambisols (60%)	+	+	++	+	S1
Eutric Fluvisols (20%)	+	+	++	+	S1
Gleysols (20%)	+++	+	++	+	N1
Hc:					
Dystric/Ferralic Cambisols (100%)	++	++	++	+	S3
Hs:					
Albic/Luvic Arenosols (80%)	+++	+++	++	+	N2
Orthic/Albic Luvisols (20%)	+++	++	++	+	N1
Ht:					
Orthic/Albic Luvisols (100%)	+++	++	+	+	N1
Hy:					
Eutric Fluvisols (100%)	+	+	+	+	S1
Le:					
Eroded/truncated Soils (100%)	+++	+++	+	+	N2
Ls:					
Gleysols (100%)	++	+	++	++	S3
Lw:					
Gleysols (100%)	++	+	++	+	S2
O1:					
Gleyic Acrisols (100%)	++	++	++	+	S3
O2:					
Gleyic Acrisols (80%)	++	++	++	+	S3
Orthic/Albic Luvisols (20%)	+++	++	++	+	N1
O3:					
Vertic Cambisols (60%)	+	+	++	+	S1
Gleyic Acrisols (30%)	++	+++	++	+	N1
Dystric/Ferralic Cambisols (10%)	+	++	++	+	S2
Y1:					
Vertic Cambisols (100%)	+	+	+	+	S1
Y2:					
Vertic Cambisols (85%)	+	+	+	+	S1
Eutric Cambisols (5%)	+	+	++	+	S1
Dystric/Ferralic Cambisols (5%)	+	++	++	+	S2
Regosols (5%)	+++	++	++	+	N1

Table II-5. Soil Suitability Classes for Upland Crops

Land Unitsand Soils	Degree of Severity of Limiting Factors (+ = low ++ = moderate +++ = severe)				Soil Suitability Class
	Soil Phys. Condition	Soil Chem. Condition	Landscape Complexity	Flooding	
A1:					
Vertic Cambisols (60%)	+	+	++	+	S1
Eutric Fluvisols (20%)	++	+	++	+	S2
Gleysols (20%)	++	+	++	+++	N1
Hc:					
Dystric/Ferralic Cambisols (100%)	++	++	+	+	S2
Hs:					
Albic/Luvic Arenosols (80%)	++	++	++	+	S3
Orthic/Albic Luvisols (20%)	++	++	++	+	S3
Ht:					
Orthic/Albic Luvisols (100%)	++	+++	+	+	N1
Hy:					
Eutric Fluvisols (100%)	++	+	+	+	S1
Le:					
Eroded/truncated Soils (100%)	++	+++	+	+	N1
Ls:					
Gleysols (100%)	+++	+	+	+++	N2
Lw:					
Gleysols (100%)	++	+	+	++	S2
O1:					
Gleyic Acrisols (100%)	++	++	++	+	S3-N1
O2:					
Gleyic Acrisols (80%)	++	++	++	+	S3-N1
Orthic/Albic Luvisols (20%)	++	++	++	+	S3
O3:					
Vertic Cambisols (60%)	+	+	++	+	S1
Gleyic Acrisols (30%)	+++	+++	++	+	N2
Dystric/Ferralic Cambisols (10%)	+	++	++	+	S2
Y1:					
Vertic Cambisols (100%)	+	+	+	+	S1
Y2:					
Vertic Cambisols (85%)	+	+	+	+	S1
Eutric Cambisols (5%)	+	+	++	+	S1
Dystric/Ferralic Cambisols (5%)	+	++	++	+	S2
Regosols (5%)	+++	++	++	+	N1

Table II-6. Suitability of the Land Units for Three Crops

Land Units	Overall Land Suitability Class		
	Wet Season Rice	Dry Season Rice	Dry Season Horticulture or Field Crops
A1	S2	S1	S2
Hc	S2	S3	S2
Hs	N1	N2	S3
Ht	N1	N1	N1
Hy	S1	S1	S1
Le	N1	N2	N1
Ls	N1	S3	N2
Lw	S2	S2	S2
O1	S3	S3	S3-N1
O2	S3	S3	S3-N1
O3	S2	S2	S2
Y1	S1	S1	S1
Y2	S1	S2	S2

Table II-7. Existing Land Use Compared With Land Suitability (Before Project)

Form of Land Use and Land Units	Area Used Now (ha)		Specific Suitability of the Land Units for:		
	Kandal Stung	Tonle Bati	Wet Season Rice	Dry Season Rice	Dry Season Upland Crops
Villages, upland crops (Vr):					
Hc	375	360	S2	S3	S2
Hs	755	-	N1	N2	S3
Villages, upland crops, small rice fields (Vp):					
A1	1430	-	S2	S2	S2
Hy	167	-	S1	S1	S1
Villages, upland crops, cattle grazing (Vc):					
Le (30%)	344	84	N1	N2	N1
Cattle grazing, bamboo, unused areas (Cb):					
Ht	330	-	N1	N1	N1
Le (40%)	459	112	N1	N2	N1
Large paddy fields, sugar palm (Pl):					
O1	760	2895	S3	S3	S3-N1
Y1	1435	-	S1	S1	S1
Medium to small paddy fields, sugar palm (Ps):					
O2	1511	-	S3	S3	S3-N1
O3	-	1738	S2	S2	S2
Y2	2451	792	S1	S2	S2
Medium to small paddy fields, inundated (Pw):					
Lw	428	185	S2	S2	S2
Swamps with dry season rice (Sp):					
Ls (50%)	138	225	N1	S3	N2
Fishing, bathing, waste disposal (Fb):					
Le (30%)	344	84	N1	N2	N1
Unused for agricultural purposes (O):					
Ls (50%)	138	225	N1	S3	N2
La	235	200	-	-	-

* See full descriptions in Section 4, also Land Use Map Legend.

Table II-8 Present Land Use of Kandal Stung Priority Area

Land Use Type		Mapping Unit	Area (ha) *1	%
1. Paddy fields			(2,047.7)	(85.2%)
1-1	Paddy fields in sloping terrain	Up	388.8	16.2%
1-2	Paddy fields in almost flat terrain			
	(1) Small to medium (irregular)	Ps	460.0	19.1%
	(2) Medium to large (square or rectangular)	Pl	1,004.7	41.8%
1-3	Depressional terrain (seasonaly or partly unused)	Pd	194.2	8.1%
2. Upland crops field and others			(356.3)	(14.8%)
2-1	Grazing or Upland crops fields	U	129.8	5.4%
2-2	vellages and others (House gardens, orchards, roads, paths etc.)	V	214.0	8.9%
2-3	Swamps	S	12.5	0.5%
Total			2,404.0	100.0%

Remarks: *1 : Area of each land use type is the gross area, including canals, foot paths, field bund, etc. espscially in the each paddy field, it is supposed that the area of canals, foot paths, roads etc. are equal to 5% of the net area

Table II-9 Present Land Use of Tonle Bati Priority Area

Land Use Type		Land Unit	Area (ha)*1	%
1. Paddy fields			(1,680.0)	(91.9%)
1-1	Paddy fields in sloping terrain	Up	449.1	24.6%
1-2	Paddy fields in almost flat terrain			
	(1) Small to medium (irregular)	Ps	767.1	42.0%
	(2) Medium to large (square or rectangular)	Pl	463.8	25.4%
1-3	Depressional terrain (seasonaly or partly unused)	Pd		
2. Upland crops field and others			(148.0)	(8.1%)
2-1	Upland crops fields	U	35.6	1.9%
2-2	vellages and others (House gardens, orchards, roads, paths etc.)	V	90.5	4.9%
2-3	Grazing land on hillocks	H	19.6	1.1%
2-4	Depression terrain (no used)	D	2.4	0.1%
Total			1,828.0	100.0%

Remarks: *1 : Area of each land use type is the gross area, including canals, foot paths, field bund, etc. espscially in the each paddy field, it is supposed that the area of canals, foot paths, roads etc. are equal to 5% of the net area

Table II-10 Sammary of Soil Description in the Study Area (1/4)

Sample No.	General Information	Depth	Colour	Mottling	Texture	Consistence	Structure	PH	Remarks
100	Land form : plain	0-10	10YR5/4	F1D.BR	M.C	M.Fi	M	5.8	
	Microrelief : smooth	10-25	10YR5/4	F1D.BR	H.C	M.VFi	M.SAB	5.9	
	Permeability : slow	25-55	10YR5/4	F1D.BR	H.C	M.VFi	AB	5.9	
	Dranage : imperfect	55-80	10YR6/4	F2D.BR	SiC	D.H	M	6.5	
	Slope : 0%	80-120	10YR6/3		SiC	D.H	M	7.0	
	Flood & Inunded : -								
101	Land form : old levee	0-15	10YR3/2	-	SCL	D.H	M	7.2	
	Microrelief : smooth	15-50	10YR5/6	M1D.BR	SiCL	D.H	M	7.5	
	Permeability : moderate	50-100	10YR5/4		SiL	D.H	M	5.5	
	Dranage : well drained	100-120	10YR4/4	C1D.Dark	CL	D.VH	M	6.0	
	Slope : 2%								
	Flood & Inunded : -								
102	Land form : plain	0-10	10YR4/4		SiCL	M.Fi	M	5.8	
	Microrelief : smooth	10-25	10YR4/3	C2D.BL	SC	M.Fi	M	6.0	
	Permeability : v. slow	25-65	10YR4/3	C2D.BL	H.C	D.VH	M.AB	7.4	
	Dranage : poorly			C1D.BL					
	Slope : 0%	65-95	10YR3/3	M1P.BR	H.C	D.VH	SAB	7.5	
	Flood & Inunded : -			F2D.BL					
		95-120	10YR3/4	F2D.BR	H.C	M.Fi	SAB	8.0	
103	Land form : plain	0-10	10YR5/4	M1D.BR	SiC	M.Fi	M	5.8	
	Microrelief : smooth	10-50	10YR5/3	C2D.BL	M.C	M.VFi	AB	7.0	
	Permeability : v. slow	50-80	10YR5/3	M2D.BR	H.C	M.VH	AB	6.3	
	Dranage : poorly	80-120	10YR5/3	C2D.BR	H.SC	MD.H	W.AB	6.5	
	Slope : 0%								
	Flood & Inunded -								
104	Land form : plain	0-10	10YR5/4		F.SL	M.S	M	6.0	
	Microrelief : smooth	10-50	10YR5/5	M1D.BL	F.SCL	M.S.H	M	7.0	
	Permeability : moderate	50-100	10YR5/3	C2D.BR	F.SCL	M.H	M	6.5	
	Dranage : imperfectly			C1D.BL				9.0	
	Slope : 0%	100-120	10YR4.5/4	C2D.BR	SCL	M.S.H	M	7.5	
	Flood & Inunded : -			C1P.BL					
105	Land form : old levee	0-10	10YR4/3		SL	M.Fi	M	7.8	
	Microrelief : smooth	10-40	10YR4/3	F1D.BL	SCL	D.VH	M	8.0	
	Permeability : moderate			C1D.BR					
	Dranage : well drained	40-70	10YR4.5/3		F.SCL	D.VH	M	9.0	
	Slope : 1%	70-120	10YR4.5/4		CL	M.Fi	M	9.0+	
	Flood & Inunded : -								
106	Land form : plain	0-15	10YR5/4	M1D.BR	L.C	D.H	M	5.6	
	Microrelief : smooth	15-35	10YR5/4	C1D.DK	M.C	D.VH	M	7.0	
	Permeability : v. slow	35-70	10YR4/4	C2D.BR	M.C	D.VH	W.AB	6.0	
	Dranage : poorly			F1D.BL					
	Slope : 0%	70-85	10YR5/6	M2D.BR	H.C	D.IH	AB	6.4	
	Flood & Inunded : 0.6 m			C1D.BL					
		85-120	10YR5/6	M2D.GR	H.C	D.IH	AB	6.7	
				C2D.RE					
107	Land form : plain	0-10	10YR6/2	C1D.BR	SiC	D.H	M	5.6	
	Microrelief : smooth	10-25	10YR6/3	F1F.BR	SiC	D.H	M	6.0	
	Permeability : v. slow	25-30	10YR5/3		H.C	D.VH	AB	6.8	
	Dranage : poorly	30-100	10YR5/4	M2D.BR	SC	M.VFi	AB	7.0	
	Slope : 0%			C2D.GR					
	Flood & Inunded : -			F1D.BL					
		100-120	10YR5/3	C3D.BR	SL	M.S	M	7.5	
108	Land form : plain	0-10	10YR6/3	F1F.BR	SiCL	D.H	M	5.6	
	Microrelief : smooth	10-20	10YR6/2	C1D.BR	SiCL	D.H	M	5.8	
	Permeability : v. slow	20-40	10YR5/2	C2D.BR	H.C	M.VFi	AB	7.0	
	Dranage : poorly	40-90	10YR5/3	C2D.BR	H.C	M.VFi	AB	7.5	
	Slope : 0%			F2D.BL					
	Flood & Inunded : -	90-120	10YR5/4	M3D.BR	M.HC	M.VFi	W.AB	7.8	
				C3D.GR					
109	Land form : plain	0-15	10YR5/3	F1F.BR	SiC	D.H	M	5.7	
	Microrelief : smooth	15-40	10YR5/2	F1D.BR	M.C	D.VH	AB	7.0	
	Permeability : v. slow	40-65	10YR5/3	C2D.BR	H.C	M.BFi	AB	7.0	
	Dranage : poorly			F2D.GR					
	Slope : 0%	65-120	10YR4/3	M2D.BR	H.C	M.VFi	W.AB	7.5	
	Flood & Inunded : -			C2D.GR					
110	Land form : plain	0-15	10YR5/3	M1D.BR	CL	D.H	M	6.0	
	Microrelief : smooth	15-30	10YR4/3	C1D.BR	L.C	D.H	W.AB	6.0	
	Permeability : slow	30-70	10YR4/4	C1D.BR	M.C	D.VH	W.AB	6.6	
	Dranage : imperfect			C1D.Pale					
	Slope : 1%	70-80	10YR4/4	M2D.BR	M.C	D.EH	W.AB	7.5	
	Flood & Inunded : 1 m			M2D.DK					
		80-120	10YR4/4	M1D.BR	M.C	D.EH	AB	7.8	
112	Land form : plain	0-10	2.5Y4/4	E1D.BR	SiC	W.VFi	M	5.5	
	Microrelief : smooth	10-55	10YR5/3	M1D.BR	H.C	W.VFi	W.AB	6.0	
	Permeability : v. slow			F1F.DK					
	Dranage : poorly	55-70	10YR4/3	M2D.BR	M.C	M.Fi	W.AB	5.8	
	Slope : 0%			M2F.GR					
	Flood & Inunded : -	70-120	10YR5/4	M2D.BR	Li.C	M.Fi	M	6.8	
				M3F.GR					
113	Land form : plain	0-15	10YR4.5/3		F.SL	D.S	M	6.0	
	Microrelief : smooth	15-45	10YR4/3	F1F.BR	F.SL	D.H	M	8.5	
	Permeability : rapid	45-95	10YR4/4	C1D.BR	F.LS	D.H	M	9.0	
	Dranage : well drained	95-120	10YR4/5		SL	D.S	M	6.5	
	Slope : 2%								
	Flood & Inunded : -	95-120	10YR4/5		SL	D.S	M	6.5	

Table II-10 Sammary of Soil Description in the Study Area (2/4)

Sample No.	General Information	Depth	Colour	Mottling	Texture	Consistence	Structure	PH	Remarks
114	Land form : plain	0-10	10YR5/4	F1F.BR	SiC	M.Fr	M	5.7	
	Microrelief : smooth	10-45	10YR4.5/3	C1D.BR	SiC	D.H	W.AB	6.5	
	Permeability : v. slow			F1D.BL					
	Dranage : poorly	45-80	10YR4/4	F1D.BL	Si.M.C	D.VH	W.AB	5.8	
	Slope : 0%	80-120	10YR4/5		M.C	D.EH	W.AB	7.0	
	Flood & Inunded : 2 m								
115	Land form : plain	0-10	10YR4/3	M1D.BR	SiC	W.S	M	5.5	
	Microrelief : smooth	10-30	10YR4.5/3	C2D.BR	Si.L.C	W.Fi	M	6.2	
	Permeability : v. slow			F1D.DK					
	Dranage : v. poor	30-50	10YR5/4	C2D.BR	H.C	W.VFi	W.AB	6.5	
	Slope : 0%			C3D.GR					
	Flood & Inunded : 2 m	50-120	10YR6/2	M2D.BR	H.C	W.Fi	M	5.5	
116	Land form : old levee	0-10	10YR3/2		SCL	D.H	M	6.5	
	Microrelief : smooth	10-65	10YR3/2		SCL	D.EH	M	7.2	
	Permeability :		10YR5/2(DRY)					7.8	
	Dranage :	65-120	10YR4/3		CL	D.EH	M	8.2	
	Slope : 2%								
	Flood & Inunded : -	65-120	10YR4/3		CL	D.EH	M	8.2	
117	Land form : plain	0-10	10YR4/3	C1F.BR	F.SL				
	Microrelief : smooth	10-25	10YR4/4	M1D.DK	F.SL				
	Permeability : slow	25-60	2.5Y5/4	C2D.BR	Li.C with S				
	Dranage : imperfectly	60-120	10YR5/6	M2D.BR	Li.C with S				
	Slope : 0%								
	Flood & Inunded : -								
118	Land form : plain	0-10	10YR5/4	C1D.BR	Li.C	M	M	5.6	
	Microrelief : smooth	10-45	7.5YR4/6	M2D.Red	M.C	M.VFi	AB	7.0	1% 3mm Mn nod.
	Permeability : v. slow			C1D.GR					
	Dranage : v. poor			F1P.BL					
	Slope : 0%	45-70	7.5YR5/4	M2D.Yel	H.C	M.VFi	AB	5.8	5% 15mm Fe, Mn nod.
	Flood & Inunded : -			C2D.Red					
				C2F.GR					
		70-120	7.5YR4/4	M3D.Red	H.C	M.Fi	W.AB	5.8	
				C2D.GR					
120	Land form : old levee	0-10	10YR3/2		SCL	M.Fi	M	7.4	
	Microrelief : smooth	10-40	10YR5/3	F2D.BR	SCL	M.Fi	M	8.5	
	Permeability : moderate	40-80	10YR5/3	F2F.BR	CL	D.VH	M	8.5	
	Dranage : imperfectly	80-120	10YR4/3	C2D.BR	CL	D.H	M	9.0	
	Slope : 1%			M1F.GR	(sticky)				
	Flood & Inunded : -								
122	Land form : plain	0-10	10YR5/6	F1F/BR	F.SL	M.Fi	M	5.7	
	Microrelief : smooth	10-50	10YR5/4	C1D.BR	Li.C	D.VH	M	7.0	
	Permeability : slow			F2D.GR					
	Dranage : imperfectly			F1P.BL					
	Slope : 0%	50-80	10YR5/4	C1D.BR	CL	D.H	W.AB	7.0	
	Flood & Inunded : -	80-120	10YR4/3	F1F.BR	Li.C	D.H	W.AB	8.0	
123	Land form : plain	0-10	10YR5/4		SiL	M.Fi	M	5.8	
	Microrelief : smooth	10-25	10YR5/4		Li.C	M.VFi	W.AB	7.0	
	Permeability : slow	25-50	10YR5/6		M.C	M.Fi	W.AB	7.0	
	Drainage : poorly	50-70			Old sugar parm root				
	Slope : 0%	70-120	10YR5/3		SC	W.Fi	W.AB	7.5	
	Flood & Inunded : -	70-120	10YR5/3		SC	W.Fi	W.AB	7.5	
124	Land form : plain	0-10	10YR6/4	F1F.BR	SC	D.H	M	5.9	
	Microrelief : smooth	10-40	10YR5/2		M.C	D.VH	AB	6.6	
	Permeability : slow	40-60	10YR5/6	M2D.BR	SC	M.H	W.AB	7.7	
	Dranage : poorly	60-120	10YR5/3	M2D.BR	S.Li.C	W.Fi	W.AB	7.5	
	Slope : 0%			C2P.DK					
	Flood & Inunded : -			C2P.DK					
125	Land form : plain	0-10	10YR4.5/4	C1D.BR	SiC	M.Fi	M	5.7	
	Microrelief : smooth	10-35	10YR4/4	C2D.BL	SiC	M.Fi	W.AB	6.7	
	Permeability : slow	35-80	10YR4/3	C2D.BR	M.C	M.VFi	W.AB	7.0	
	Dranage : imperfectly			M3F.GR					
	Slope : 0%	80-120	10YR4/3	C2D.BK	Li.C	M.Fi	W.AB	8.0	1% 5mm Fe, Mn nod.
	Flood & Inunded : -			F1P.BK					
126	Land form : plain	0-10	10YR5/4	C1D.BR	SiCL	M.Fi	M	5.8	
	Microrelief : smooth	10-55	10YR5/4	C2D.BL	SiC	M.Fi	W.AB	7.0	
	Permeability : slow	55-85	10YR4/3	F1D.BR	F.SC	M.VFi	W.AB	6.9	
	Dranage : imperfectly			F1P.BL					
	Slope : 0%	85-120	10YR4/3	C2D.BR	F.SC	M.Fi	W.AB	6.9	1% 10mm Fe, Mn nod.
	Flood & Inunded : -								
127	Land form : plain	0-10	10YR4/6	F1F.BR	F.SL	M.Fi	M	5.9	
	Microrelief : smooth	10-25	10YR4/4	C1D.BR	CL	M.VFi	M	6.0	
	Permeability : slow	25-55	10YR4/4	C1D.BL	SiL	D.VH	M	6.3	
	Dranage : imperfectly	55-120	10YR4/4	C1D.BR	Li.C	D.VH	W.AB	7.5	
	Slope : 2%			F1F.BL					
	Flood & Inunded : -								
150	Land form : plain	0-10	7.5YR5/4	C2D.BR	CL	W.So	M	5.5	
	Microrelief : smooth	10-20	7.5YR5/6	M2D.BR	Li.C	M.Fi	W.AB	6.0	
	Permeability : v. slow			F2D.Red					
	Dranage : v. poor	20-45	7.5YR6/4	M2P.Red	M.C	M.VFi	W.AB	5.4	
	Slope : 0%			M3D.GR				5.5	
	Flood & Inunded : -	45-120	7.5YR4/4	C2P.Red	HC	M.EFi	W.AB	8.0	
				M3D.GR					

Table II-10 Sammary of Soil Description in the Study Area (3/4)

Sample No.	General Information	Depth	Colour	Mottling	Texture	Consistence	Structure	PH	Remarks
151	Land form : plain	0-15	7.5YR5/4		S	M.So	M	5.4	
	Microrelief : smooth	15-40	7.5YR4/4	C1D.BR	L.SC	M.Fi	M	6.7	
	Permeability : slow			M2D.BK					
	Dranage : imperfectly	40-75	10YR4/3	C1D.BR	S.LiC	M.VFi	W.AB	9.0	
	Slope : 0%								
	Flood & Inunded : -	75-120	7.5YR4/4	M3D.BR	H.SC	M.VFi	W.AB	8.8	
				C2D.GR					
152	Land form : plain	0-10	10YR5/4		S	M.So	M	6.0	
	Microrelief : smooth	10-25	10YR5/4		SC	M.So	M	6.5	
	Permeability : slow	25-55	10YR5/4	C2D.BR	H.SC	M.VFi	W.AB	7.5	
	Dranage : imperfectly	55-80	10YR4/4	F2D.BR	H.C(with S)	M.VFi	W.AB	7.5	
	Slope : 0%	80-120	10YR4/4	C2D.Red	H.C(with S)	M.VFi	W.AB	8.5	1% 10mm Fe, Mn nod.
	Flood & Inunded : -			C2D.GR					
153	Land form : plain	0-10	7.5YR5/4	F1D.BR	SCL	W.So	M	6.0	
	Microrelief : smooth	10-30	10YR4/3	C2D.BR	SC	M.VFi	M	7.0	Charcoal
	Permeability : slow	30-50	10YR4/4	M2D.BR	M.C	M.Fi	M	6.4	Water table at 50cm
	Dranage : imperfectly	50-120	10YR4/6	M2P.BR	M.C	M.VFi		5.5	
	Slope : 1%			C2D.BR	(with S)				
	Flood & Inunded : -								
154	Land form : old levee	0-15	7.5YR4/4		LS	W.So	M	6.8	
	Microrelief : smooth	15-50	10YR4/6	C2D.BR	LS-CL	M.Fi	M	7.0	
	Permeability : v. slow	50-120	7.5YR4/6	M2D.Red	M.C	M.VFi	W.AB	5.5	
	Dranage : v. poor			C1D.RB					
	Slope : 2%			M2D.BR					
	Flood & Inunded : -								
155	Land form : plain	0-10	7.5YR4/6		LS	W.So	M	5.7	
	Microrelief : smooth	10-30	7.5YR4/6	C1D.BR	LS	W.So	M	5.7	
	Permeability : v. slow	30-50	7.5YR5/4	M2D.BR	SC	M.Fi	M	5.7	
	Dranage : v. poor	50-100	7.5YR6/4	M3D.BR	SC	M.VFi		5.5	Water table at 60cm
	Slope : 1%			C2D.GR					
	Flood & Inunded : -	100-120	7.5YR6/4	C2P.Red	H.C	M.EFi		5.5	
				M2D.GR	(with S)				
156	Land form : plain	0-10	10YR5/4		SL	M.So	M	5.8	
	Microrelief : smooth	10-35	10YR5/5	F1F.BR	SCL	M.Fi	M	5.8	
	Permeability : v. slow	35-45	7.5YR5/6	C2D.BR	M.C	M.VFi	M	7.0	10% 25mm Fe, Mn nod.
	Dranage : v. poor			F1P.Red					
	Slope : 0%	45-120	7.5YR5/4	M2P.Red	HC	M.EFi		5.5	
	Flood & Inunded : -			M3D.GR					
157	Land form : plain	0-10	7.5YR5/4	C1D.BR	SCL	M.Fi	M	6.0	
	Microrelief : smooth	10-40	7.5YR5/4	C1D.BR	SCL	M.Fi	M	6.0	
	Permeability : slow	40-80	7.5YR5/4	F1F.BR	CL	D.VH	M	6.8	
	Dranage : imperfectly	80-120	10YR4/4	F1F.BR	M.C	M.VFi	AB	8.5	
	Slope : 1%			F1D.BK					
	Flood & Inunded : -			F1D.BK					
161	Land form : plain	0-10	10YR4/3		F.SCL	M.Fi	M	5.9	
	Microrelief : smooth	10-30	10YR4/3	C1D.BR	CL	M.Fi	M	5.8	
	Permeability : slow			F1D.BK					
	Dranage : imperfectly	30-55	7.5YR5/4	C2D.BR	Li.C	M.Fi	M	5.5	
	Slope : 2%	55-120	7.5YR5/4	M2D.BR	Li.C	M.Fi	W.AB	5.4	
	Flood & Inunded : -			C2D.GR					
162	Land form : plain	0-10	7.5YR5/4	F1F.BR	SCL	M.Fi	M	5.5	
	Microrelief : smooth	10-25	7.5YR5/6	C2F.BR	CL	M.Fi	W.AB	6.8	
	Permeability : slow	25-80	7.5YR5/5	C2F.BR	M.C	M.Fi		5.5	
	Dranage : imperfectly			C2D.BR					
	Slope : 0%								
	Flood & Inunded : -	80-120	10YR4/4	C2D.BR	M.C	M.Fi		7.4	
164	Land form : plain	0-10	10YR5/4	F1D.BR	SiCL	M.Fi	M	6.0	
	Microrelief : smooth	10-35	10YR5/4	C2D.BR	Li.C	M.Fi	W.AB	5.8	
	Permeability : slow	35-90	5YR4/6	M2P.Red	H.C	M.VFi		5.5	
	Dranage : v. poor			C2D.GR					
	Slope : 1%	90-120	5YR5/4	C2D.Red	H.C	M.VFi		5.5	
	Flood & Inunded : -			M3D.GR					
165	Land form : old levee	0-10	10YR3/3		SCL	M.Fi	M	8.0	
	Microrelief : smooth	10-35	10YR3/3		CL	M.Fi	M	8.0	
	Permeability : v. slow	35-45	10YR4/3	C1F.DR	SiL	D.H	M	8.5	5% 10mm Fe, Mn nod.
	Dranage : poor		10YR6/3(dry)		(sticky)				
	Slope : 2%	45-100	10YR4/4	M2D.BR	M.C	D.EH		8.5	5% 10mm Fe, Mn nod.
	Flood & Inunded : -			C1D.BK					
		100-120	10YR4/6	F1F.BK	M.C	D.VH	AB	9.0	
166	Land form : plain	0-10	10YR4/4	F1D.BR	F.SCL	M.Fi	M	5.5	
	Microrelief : smooth	10-30	10YR4/6	C2D.BR	SC-SiC	M.Fi	M	6.0	
	Permeability : slow	30-75	5YR4/6	M2D.Red	H.C	M.VFi	W.AB	5.8	
	Dranage : v. poor	75-120	7.5YR4/6		H.C	M.VFi	W.AB	7.0	
	Slope : 1%								
	Flood & Inunded : -								
167	Land form : plain	0-10	7.5YR5/4	F1D.BK	F.SL	M.Fi	M	5.5	
	Microrelief : smooth	10-40	10YR4/6	C2D.BR	SiCL	M.Fi	M	6.0	
	Permeability : slow	40-70	10YR4/4	C2D.BR	SiC	D.VH	M	7.4	
	Dranage : imperfectly	70-90	10YR4/4	C2D.BR	SiC	D.VH	AB	7.8	
	Slope : 0%	90-120	10YR4/4	C1P.BR	SiC	D.VH	W.AB	8.0	
	Flood & Inunded : -								
168	Land form : plain	0-10	10YR5/2	F1D.BR	SC	W.So	M	7.4	Grey colour
	Microrelief : smooth	10-40	10YR4/3	F1D.BR	M.C	M.Fi	M	8.5	
	Permeability : slow	40-65	10YR4/2		Li.C	M.VFi	AB	8.7	
	Dranage : poor	65-80	10YR4/3		Li.C	M.VFi	AB	9.0	2% 5mm Fe, Mn nod.
	Slope : 0%	80-120	10YR5/3		Li.C-H.C	M.VFi	W.AB	8.8	
	Flood & Inunded : -								

Table II-10 Sammary of Soil Description in the Study Area (4/4)

Sample No.	General Information	Depth	Colour	Motting	Texture	Consistence	Structure	PH	Remarks
169	Land form : plain	0-10	10YR4/4		LS	M.So	M	6.0	
	Microrelief : smooth	10-30	10YR4/4	C2D.BR	SCL	M.Fi	M	5.4	
	Permeability : slow	30-50	10YR5/6	M2D.BR	Li.C(with S)	W.Fi	M	5.0	
	Dranage : v. poor	50-60	7.5YR5/6	M2P.Red	Li.C	M.Fi		5.0	
	Slope : 1%			C2D.BR					
	Flood & Inunded : -			C2F.GR					
		60-120	7.5YR5/4	C2D.Red	M.C	M.Fi		5.5	
				M3D.GR					
170	Land form : plain	0-10	10YR4/4	F1F.BR	SCL	M.Fi	M	5.4	
	Microrelief : smooth	10-55	40YR5/6	C2D.BR	Li.C(with S)	M.Fi	M	5.8	
	Permeability : slow	55-105	7.5YR5/6	M2D.Red	H.C	M.VFi	AB	5.7	
	Dranage : poor			C3D.GR					
	Slope : 0%	105-120	5YR4/6	M3D.BR	H.C	M.VFi	W.AB	6.0	
	Flood & Inunded : -			C2D.BR					
171	Land form : plain	0-10	10YR5/4	F1D.BR	SiL	M.Fi	M	5.6	
	Microrelief : smooth	10-25	10YR5/6	C2D.BR	SiC	M.VFi	M	6.0	
	Permeability : slow	25-50	7.5YR4/6	C2D.Red	H.C	M.VFi	AB	5.5	
	Dranage : poor	50-80	5YR4/6	M2D.Red	H.C	M.VFi	AB	6.0	
	Slope : 0%			C3D.GR					
	Flood & Inunded : -	80-120	5YR5/6	C1F.GR	H.C	M.VFi	W.AB	6.5	
172	Land form : plain	0-10	10YR4/4	F1D.BR	SiL	M.Fi	M	5.8	
	Microrelief : smooth	10-40	10YR4/5	C1D.BR	SiC	M.Fi	M	7.0	
	Permeability : slow	40-100	7.5YR4/6	M2D.BR	Si.M.C	M.Fi	W.AB	5.8	
	Dranage : imperfectly			C2D.GR					
	Slope : 0%	100-120	10YR5/2	C2D.Red	Si.M.C	M.VFi	W.AB	5.8	
	Flood & Inunded : -			F2D.BR					
				M3F.GR					
173	Land form : plain	0-10	10YR4/4	F1D.BR	SiL	M.Fi	Massive	5.6	
	Microrelief : smooth	10-25	10YR5/6	C1D.BR	SiL	M.Fi	Massive	6.0	
	Permeability : slow	25-40	7.5YR5/4	M2D.BR	SiC	M.Fi	W.AB	6.2	
	Dranage : poor	40-80	5YR4/6	M2D.Red	SiMC	M.VFi	AB	5.8	
	Slope : 0%			M2D.GR					
	Flood & Inunded : -	80-120	7.5YR5/6	C2D.GR	H.C	M.VFi	W.AB	6.0	

Table II-11 The Extent of Soils in Kandal Stung Area

Land units	Map unit	Area (ha)	%
Levee (L)			
Old levee remnant	L	339.1	14.1%
Plain (P)			
High plain	P1	388.8	16.2%
Almost Flat plain	(P2)		
	P21	217.7	9.1%
	P22	1,229.5	51.1%
Old plain	P3	17.6	0.7%
Depressional terrain (D) (Old river course,oxbows)	D	194.2	8.1%
Swamps (S)	S	12.5	0.5%
Hillocks (H)	H	4.7	0.2%
Total		2,404.0	100.0%

Table II-12 The Extent of Soils in Tonle Bati Area

Land units	Map unit	Area (ha)	%
Levee (L)			
Old levee remnant	L	54.9	3.0%
Levee flank	Lf	35.6	1.9%
Terrace & Plain (T&P)			
Gently sloping plain with terrace (common)	T1	449.1	24.6%
Very gently sloping plain with terrace (some)	T2	767.1	42.0%
Almost flat plain	P2	344.0	18.8%
Old flat plain	P3	119.8	6.6%
Depressional terrain (D)	D	2.4	0.1%
Hillocks (H)	H	19.6	1.1%
Man-made rises (M)	M	35.5	1.9%
Total		1,828.0	100.0%

Table II-13 Result of Soil Analysis in the Study Area

Kandal Stung Area

Sample No.	Land unit	Layer	Texture (%) Clay	F. Silt	C. Silt	F. Sand	C. Sand		PH (1:5) (H2O)	(KCl)	EC (1:5) (mS/cm)	Total-C (%)	Total-N (%)	C/N	CEC (me/100g.d.s)	Exchangeable Cation (me/100g.d.s) Ca	Mg	K	Na	Total	BSP (%)	ESP (%)	Available P (ppm)	Total-P (ppm)
114	P22	0-15	27.8	49.9	13.0	7.7	1.5	SiCL	5.7	4.0	0.030	0.72	0.06	12.8	9.70	4.00	1.31	0.12	0.57	6.00	62	5.9	7.0	80
		30-40	35.8	39.8	10.0	9.2	5.2	SiCL	6.2	3.7	0.055	0.26	0.03	9.0	12.20	4.75	2.37	0.12	1.37	8.61	71	11.2	8.0	79
		60-70	46.2	34.3	9.2	7.9	2.4	SiC	6.2	3.6	0.081	0.30	0.03	10.4	17.30	5.50	3.15	0.20	2.71	11.56	67	15.7	15.0	110
		90-100	57.1	25.4	8.7	7.5	1.3	C	6.9	4.6	0.091	-	-	-	20.07	6.00	3.75	0.15	3.73	13.63	68	18.6	-	-
115	D	0-15	23.3	24.5	23.6	26.3	2.3	L	5.2	3.7	0.067	0.56	0.05	11.4	8.67	3.00	1.50	0.21	0.33	5.04	58	3.8	8.0	99
		30-40	43.0	26.9	15.5	12.7	1.9	SiC	6.7	4.8	0.052	0.43	0.04	11.8	17.16	8.00	3.87	0.15	1.04	13.06	76	6.1	14.0	98
		60-70	50.4	23.3	13.4	12.1	0.8	C	6.0	3.9	0.087	0.40	0.04	11.3	18.37	7.25	4.37	0.17	1.29	13.08	71	7.0	15.0	90
		90-100	53.3	21.3	9.9	14.5	1.0	C	5.8	3.6	0.110	-	-	-	19.06	6.50	4.68	0.16	1.51	12.85	67	7.9	-	-
118	P3	0-10	21.6	29.6	14.6	24.9	9.4	L	5.1	3.8	0.060	0.72	0.05	14.4	7.52	2.00	0.87	0.11	1.31	4.29	57	17.4	7.0	80
		30-40	39.1	22.8	14.3	15.2	8.5	CL	6.3	4.2	0.046	0.42	0.04	11.8	11.93	5.00	2.35	0.13	0.82	8.30	70	6.9	trace	49
		60-70	42.4	24.5	13.3	13.7	6.2	C	6.4	4.0	0.033	0.32	0.02	14.7	10.90	2.75	1.75	0.13	1.20	5.83	53	11.0	trace	32
		90-100	62.2	21.4	7.0	6.7	2.7	C	6.8	4.1	0.043	-	-	-	47.67	2.75	2.50	0.16	2.06	7.47	16	4.3	-	-
120	L	0-15	9.4	18.1	17.2	44.5	10.7	SL	6.8	5.8	0.153	1.83	0.12	14.9	12.14	6.75	2.12	1.88	0.42	11.17	92	3.5	435.0	835
		30-40	21.0	19.0	15.7	37.0	7.4	L	7.8	6.4	0.158	0.36	0.04	10.3	11.18	6.75	1.67	2.03	0.68	11.13	100	6.1	183.0	235
		60-70	24.3	19.1	14.3	36.3	6.0	L	8.3	6.8	0.192	0.36	0.02	14.9	12.11	8.00	2.50	0.96	1.47	12.93	107	12.1	39.0	75
122	P21	0-15	13.2	28.0	23.3	33.1	2.4	SiL	5.9	3.9	0.027	0.59	0.04	13.9	4.68	1.75	0.75	0.13	0.30	2.93	63	6.4	10.0	60
		30-40	27.9	20.4	18.7	31.0	2.1	CL	7.3	5.0	0.161	0.29	0.02	14.6	11.15	6.75	2.12	0.11	1.80	10.78	97	16.1	6.0	45
		60-70	22.7	23.1	26.0	26.2	2.0	L	6.7	4.9	0.341	0.20	0.01	14.8	12.80	5.75	2.12	0.10	2.75	10.72	84	21.5	7.0	28
		90-100	37.1	25.7	16.9	16.9	3.5	CL	7.4	5.5	0.687	-	-	-	15.71	10.00	3.50	0.17	2.31	15.98	102	14.7	-	-
123	P22	0-15	16.4	30.2	22.8	26.1	4.4	SiL	5.8	4.0	0.030	0.60	0.04	14.8	6.11	2.50	1.00	0.08	0.27	3.85	63	4.4	11.0	78
		30-40	20.8	13.3	12.3	43.6	10.0	SCL	7.1	5.2	0.034	0.17	0.01	16.2	7.52	4.50	2.12	0.10	0.49	7.21	96	6.5	8.0	36
		60-70	17.2	9.4	7.5	46.9	19.0	SL	8.4	6.8	0.047	0.18	0.01	12.8	6.57	4.25	2.12	0.08	0.79	7.24	110	12.0	4.0	40
		90-100	19.7	19.7	23.8	32.5	4.4	L	8.0	5.7	0.054	-	-	-	9.04	5.25	2.87	0.10	1.40	9.62	106	15.5	-	-
127	P22	0-10	8.6	23.7	27.4	36.8	3.4	SiL	5.3	3.8	0.022	0.64	0.05	12.4	4.38	1.25	0.50	0.23	0.22	2.20	50	5.0	12.0	112
		30-40	40.9	20.2	16.7	17.3	4.9	C	6.5	4.1	0.035	0.44	0.04	12.6	11.39	4.50	2.50	0.08	1.63	8.71	76	14.3	16.0	82
		60-70	25.5	24.7	29.2	19.1	1.4	SiL	6.7	4.5	0.050	0.23	0.02	10.8	16.81	6.25	3.25	0.10	2.30	11.90	71	13.7	5.0	79
		90-100	24.9	21.7	25.5	26.3	1.5	L	6.4	4.1	0.038	-	-	-	13.76	5.75	3.25	0.13	2.20	11.33	82	16.0	-	-

Tonle Btal Area

Sample No.	Land unit	Layer	Texture (%) Clay	F. Silt	C. Silt	F. Sand	C. Sand		PH (1:5) (H2O)	(KCl)	EC (1:5) (mS/cm)	Total-C (%)	Total-N (%)	C/N	CEC (me/100g.d.s)	Exchangeable Cation (me/100g.d.s) Ca	Mg	K	Na	Total	BSP (%)	ESP (%)	Available P (ppm)	Total-P (ppm)
156	P3	0-10	9.7	18.2	17.1	43.2	11.8	SL	5.8	4.0	0.034	0.34	0.03	12.0	3.28	1.00	0.11	0.09	0.12	1.32	40	3.7	14.0	50
		30-40	17.6	26.5	15.4	16.9	23.6	L	6.3	4.8	0.059	0.18	0.02	11.6	6.69	4.50	0.41	0.02	0.26	5.19	78	3.9	7.0	20
		60-70	53.2	21.6	7.0	8.7	9.4	C	6.0	3.7	0.073	0.43	0.04	12.0	18.77	4.50	0.87	0.07	1.11	6.55	35	5.9	3.0	35
		90-100	58.1	21.6	6.8	6.2	7.4	C	6.3	4.5	0.039	-	-	-	29.52	5.25	0.68	0.07	1.56	7.56	26	5.3	-	-
157	T2	0-10	7.3	18.2	19.4	28.5	26.5	SL	5.8	3.8	0.035	0.40	0.04	11.4	3.07	1.00	0.11	0.22	0.21	1.54	50	6.7	17.0	42
		30-40	19.9	24.5	15.2	19.2	21.3	L	6.0	3.7	0.077	0.35	0.03	11.5	6.53	1.75	0.34	0.02	1.13	3.24	50	17.3	7.0	30
		60-70	26.9	28.2	14.3	17.9	12.7	CL	6.0	4.0	0.112	0.27	0.02	12.8	10.75	4.00	0.71	0.03	3.44	8.18	76	32.0	5.0	22
		90-100	40.0	25.8	12.4	12.6	9.1	C	8.3	6.7	0.244	-	-	-	15.60	9.00	1.50	0.08	6.68	17.26	111	42.8	-	-
160	T1 - Lf	0-10	13.5	26.4	26.9	26.1	6.4	SiL	5.4	4.2	0.029	0.63	0.05	12.9	7.35	2.50	1.50	0.09	0.08	4.17	57	1.0	150.0	390
		30-40	20.2	24.4	21.7	26.0	8.4	L	5.3	4.2	0.024	0.39	0.03	13.1	9.97	2.50	1.50	0.09	0.11	4.20	42	1.1	102.0	334
		60-70	24.4	27.2	26.4	19.8	3.8	SiL	5.4	4.0	0.017	0.33	0.03	12.7	10.44	2.75	2.00	0.21	0.10	5.06	48	1.0	199.0	800
		90-100	30.0	21.6	19.5	22.7	6.8	CL	5.3	4.1	0.028	-		-	13.09	2.25	2.00	4.29	0.10	8.64	66	0.8	-	-
161	T1	0-10	9.9	25.5	25.7	21.3	12.8	SiL	5.9	4.4	0.030	0.45	0.05	9.2	5.27	2.00	0.35	0.03	0.18	2.56	49	3.4	11.0	70
		30-40	30.7	41.0	15.0	8.1	5.7	SiCL	6.1	4.0	0.055	0.23	0.03	8.3	10.93	2.75	1.37	0.03	0.98	5.13	47	9.0	6.0	30
		60-70	26.8	37.3	15.7	12.4	8.4	SiCL	7.2	4.8	0.068	0.21	0.02	9.2	14.49	6.50	2.50	1.04	1.65	11.69	81	11.4	4.0	35
		90-100	44.2	33.1	15.5	5.9	2.3	SiC	6.3	4.4	0.153	-	-	-	24.92	7.50	5.25	0.12	3.35	16.22	65	13.4	-	-
165	L	0-10	13.9	29.6	25.3	24.8	10.9	SiL	7.7	7.0	0.187	1.37	0.12	11.4	10.06	9.75	1.25	0.29	1.22	12.51	124	12.1	900.0	1,290
		30-40	18.7	31.6	22.0	19.6	7.8	SiL	8.1	7.1	0.181	0.66	0.05	13.6	11.70	8.00	1.75	0.37	2.14	12.26	105	18.3	525.0	990
		60-70	19.9	31.5	19.9	18.0	11.1	SiL	7.9	6.8	0.171	0.14	0.01	11.8	7.93	5.25	1.37	0.93	1.00	8.55	108	12.6	45.0	82
		90-100	29.5	31.4	19.1	18.1	5.4	CL	8.8	7.4	0.328	-	-	-	12.86	9.00	2.35	1.12	1.88	14.35	112	14.6	-	-
166	T2	0-10	8.9	28.2	30.0	22.9	11.5	SiL	6.0	4.3	0.024	0.51	0.04	12.3	4.48	1.00	1.00	0.13	0.11	2.24	50	2.5	29.0	102
		30-40	34.0	23.9	18.2	12.8	10.1	CL	7.3	4.5	0.025	0.36	0.04	10.3	11.97	2.50	2.75	0.05	0.78	6.08	51	6.5	17.0	83
		60-70	45.9	22.7	13.9	8.9	6.1	C	7.0	4.2	0.047	0.33	0.04	9.2	18.65	5.00	5.25	0.10	1.82	12.17	65	9.8	5.0	57
		90-100	43.3	27.7	13.5	7.0	3.6	SiC	6.7	4.5	0.124	-		-	17.32	7.00	7.50	0.08	3.48	18.06	104	20.1	-	-
172	T3	0-10	11.2	32.9	29.4	19.5	7.0	SL	4.7	3.7	0.153	0.72	0.05	14.8	4.46	1.50	1.00	0.04	0.56	3.10	70	12.6	39.0	1,250
		30-40	47.9	30.5	11.7	7.3	2.6	SiC	6.7	4.8	0.133	0.39	0.03	12.3	20.63	4.50	1.00	1.03	1.85	8.38	41	9.0	25.0	80
		60-70	54.3	26.9	10.8	6.2	1.8	C	5.4	3.7	0.219	0.58	0.05	12.0	17.60	4.50	2.50	0.07	2.83	9.90	56	16.1	34.0	85
		90-100	28.1	32.3	21.0	13.2	5.4	SiCL	5.1	3.5	0.267	-		-	14.76	3.75	2.00	0.07	2.83	8.65	59	19.2	-	-

Table II-14 Land Suitability Classes for Each Crop in Kandal Stung Priority Area

Crop type	Land unit categories		Dgree of severity of limiting factors: Phys. cond.	Chem. cond.	Landscape	Drain. cond.	Suitability class	Area (ha)
for wet season rice	L	Eutric Fluvisols	++	+	++	+	S2st	339
	P1	Eutric Cambisols	++	++	++	+	S3sft	389
	P21	Eutric Cambisols	+	++	+	+	S1f	218
	P22	Vertic Cambisols	+	+	+	+	S1	1,229
	P3	Gleyic Acrisols	++	++	+	+	S2sf	18
	D	Eutric Fluvisols	+	+	++	++ - +++	S3dt	194
for dry season rice	L	Eutric Fluvisols	++	+	++	+	S2st	339
	P1	Eutric Cambisols	++	++	++	+	S3sft	389
	P21	Eutric Cambisols	+	++	+	+	S1f	218
	P22	Vertic Cambisols	+	+	+	+	S1	1,229
	P3	Gleyic Acrisols	++	++	+	+	S2sf	18
	D	Eutric Fluvisols	+	+	++	+	S1t	194
for upland cropse	L	Eutric Fluvisols	+	+	+	+	S1	339
	P1	Eutric Cambisols	+	++	++	+	S2ft	389
	P21	Eutric Cambisols	++	++	+	++	S3sfd	218
	P22	Vertic Cambisols	++	+	+	++	S2sd	1,229
	P3	Gleyic Acrisols	++	++	+	++	S3sfd	18
	D	Eutric Fluvisols	++	+	++	+++	N1	194
for pastures	L	Eutric Fluvisols	+	+	+	+	S1	339
	P1	Eutric Cambisols	+	++	+	+	S1f	389
	P21	Eutric Cambisols	++	++	+	++	S3sfd	218
	P22	Vertic Cambisols	++	+	+	++	S2sd	1,229
	P3	Gleyic Acrisols	++	++	+	++	S3sfd	18
	D	Eutric Fluvisols	+	+	+	++	S1d	194

Remarks: + = low, ++ = moderate, +++ = severe
deficiency indicator : s = physical condition, f = chemical condition, t = landscape condition, d = drainage condition

Table II-15 Land Suitability Classes for Each Crop in Tonle Bati Priority Area

Crop type		Land unit categories	Dgree of severity of limiting factors				Suitability class	Area (ha)
			Phys. cond.	Chem. cond.	Landscape	Drain. cond.		
for wet season rice	L	Distric/Ferralic Cambisols	+	++	++	+	S2ft	55
	Lf	Ferralic Cambisols	+	++	++	+	S2ft	36
	T1	Vertic Cambisols	+	+	+	+	S1	449
	T2	Vertic Cambisols (70%)	+	+	+	+	S1	537
	T2	Ferralic Cambisols (30%)	+	++	+	+	S1f	230
	P2	Ferralic Cambisols	+	++	+	+	S1f	344
	P3	Gleyic Acrisols	++	++	+	+	S2sf	120
	D	Eutric Fluvisols	+	+	++	++ - +++	S3dt	2
for dry season rice	L	Distric/Ferralic Cambisols	+	++	++	+	S2ft	55
	Lf	Ferralic Cambisols	+	++	++	+	S2ft	36
	T1	Vertic Cambisols	+	+	+	+	S1	449
	T2	Vertic Cambisols (70%)	+	+	+	+	S1	537
	T2	Ferralic Cambisols (30%)	+	++	++	+	S2ft	230
	P2	Ferralic Cambisols	+	++	++	+	S2ft	344
	P3	Gleyic Acrisols	++	++	++	+	S3sft	120
	D	Eutric Fluvisols	+	+	++	++	S2td	2
for upland cropse	L	Distric/Ferralic Cambisols	+	++	++	+	S2ft	55
	Lf	Ferralic Cambisols	+	++	+	+	S1f	36
	T1	Vertic Cambisols	++	+	+	++	S2sd	449
	T2	Vertic Cambisols (70%)	++	+	+	++	S2sd	537
	T2	Ferralic Cambisols (30%)	++	++	+	++	S3sfd	230
	P2	Ferralic Cambisols	++	++	+	++	S3sfd	344
	P3	Gleyic Acrisols	++	+++	+	++	N1	120
	D	Eutric Fluvisols	+++	+	++	+++	N2	2
for pastures	L	Distric/Ferralic Cambisols	+	++	+	+	S1f	55
	Lf	Ferralic Cambisols	+	++	+	+	S1f	36
	T1	Vertic Cambisols	++	+	+	+	S1s	449
	T2	Vertic Cambisols (70%)	++	+	+	+	S1s	537
	T2	Ferralic Cambisols (30%)	++	++	+	+	S2sf	230
	P2	Ferralic Cambisols	++	++	+	+	S2sf	344
	P3	Gleyic Acrisols	++	++	+	+	S2sf	120
	D	Eutric Fluvisols	++	+	+	+++	N1	2

Remarks: + = low, ++ = moderate, +++ = severe
deficiency indicator : s = physical condition, f = chemical condition, t = landscape condition, d = drainage condition

Table II-16 The Extent Area of Land Suitability in Kandal Stung Priority Area (1/2)

(1) Wet season paddy

Suitability class	Sub-class	Land Unit	Area (ha)	%
S1	-	P22	1,229	51
	f	P21	218	9
S2	sf	P3	18	1
	st	L	339	14
S3	st	P1	389	16
	dt	D	194	8
Swamp etc.			17	1
Total			2,404	100

(2) Dry season paddy

Suitability class	Sub-class	Land Unit	Area (ha)	%
S1	-	P22	1,229	51
	f	P21	218	9
	t	D	194	8
S2	sf	P3	18	1
	st	L	339	14
S3	st	P1	389	16
Swamp etc.			17	1
Total			2,404	100

(3) Upland crops

Suitability class	Sub-class	Land Unit	Area (ha)	%
S1	-	L	339	14
S2	ft	P1	389	16
	sd	P22	1,229	51
S3	sfd	P21, P3	236	10
N1		D	194	8
Swamp etc.			17	1
Total			2,404	100

(4) Pastures

Suitability class	Sub-class	Land Unit	Area (ha)	%
S1	-	L	339	14
	d	D	194	
	f	P1	389	16
S2	sd	P22	1,229	51
S3	sfd	P21, P3	236	10
Swamp etc.			17	1
Total			2,404	100

Table II-16 The Extent Area of Land Suitability in Kandal Stung Priority Area (2/2)

(1) Wet season paddy

Suitability class	Sub-class	Land Unit	Area (ha)	%
S1	-	T1, T2 (70%)	986	54
	f	T2 (30%), P2	574	31
S2	ft	L, Lf	91	5
	sf	P3	120	7
S3	dt	D	2	0
Swamp etc.			56	3
Total			1,828	100

(2) Dry season paddy

Suitability class	Sub-class	Land Unit	Area (ha)	%
S1	-	T1, T2 (70%)	986	54
S2	ft	L, Lf, P2, T2	665	36
	td	D	2	0
S3	sft	P1	120	7
Swamp etc.			56	3
Total			1,828	100

(3) Upland crops

Suitability class	Sub-class	Land Unit	Area (ha)	%
S1	f	Lf	36	1
S2	ft	L	55	2
	sd	T1, T2 (70%)	986	41
S3	sfd	P2, T2 (30%)	574	24
N1		P3	120	5
N2		D	2	0
Swamp etc.			56	2
Total			1,828	76

(4) Pastures

Suitability class	Sub-class	Land Unit	Area (ha)	%
S1	f	L, Lf	91	4
	t	T1, T2 (70%)	986	41
S2	sf	P2, T2 (30%), P3	694	29
N1		D	2	0
Swamp etc.			56	2
Total			1,828	76

Figures

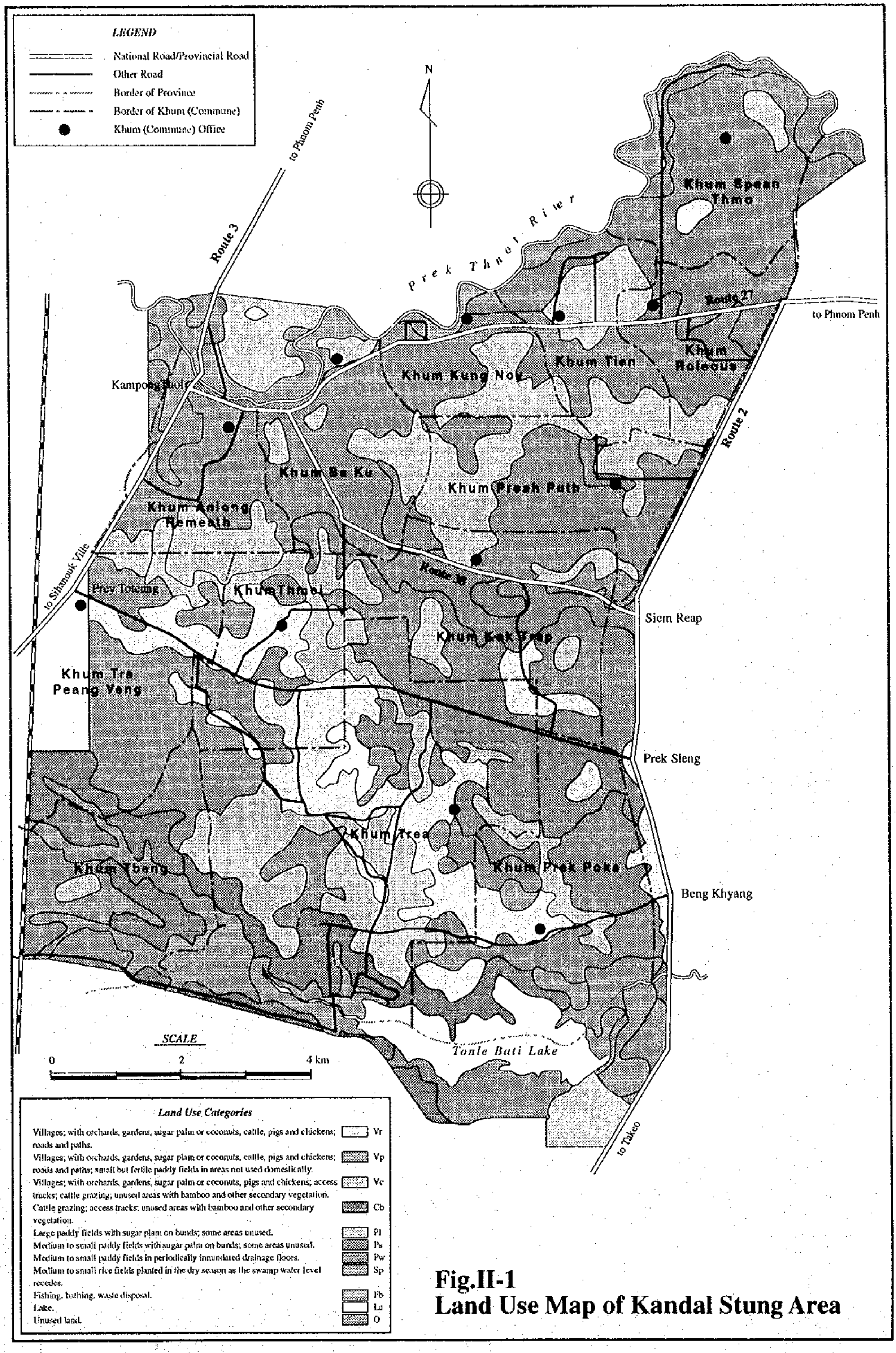

Fig.II-1
Land Use Map of Kandal Stung Area

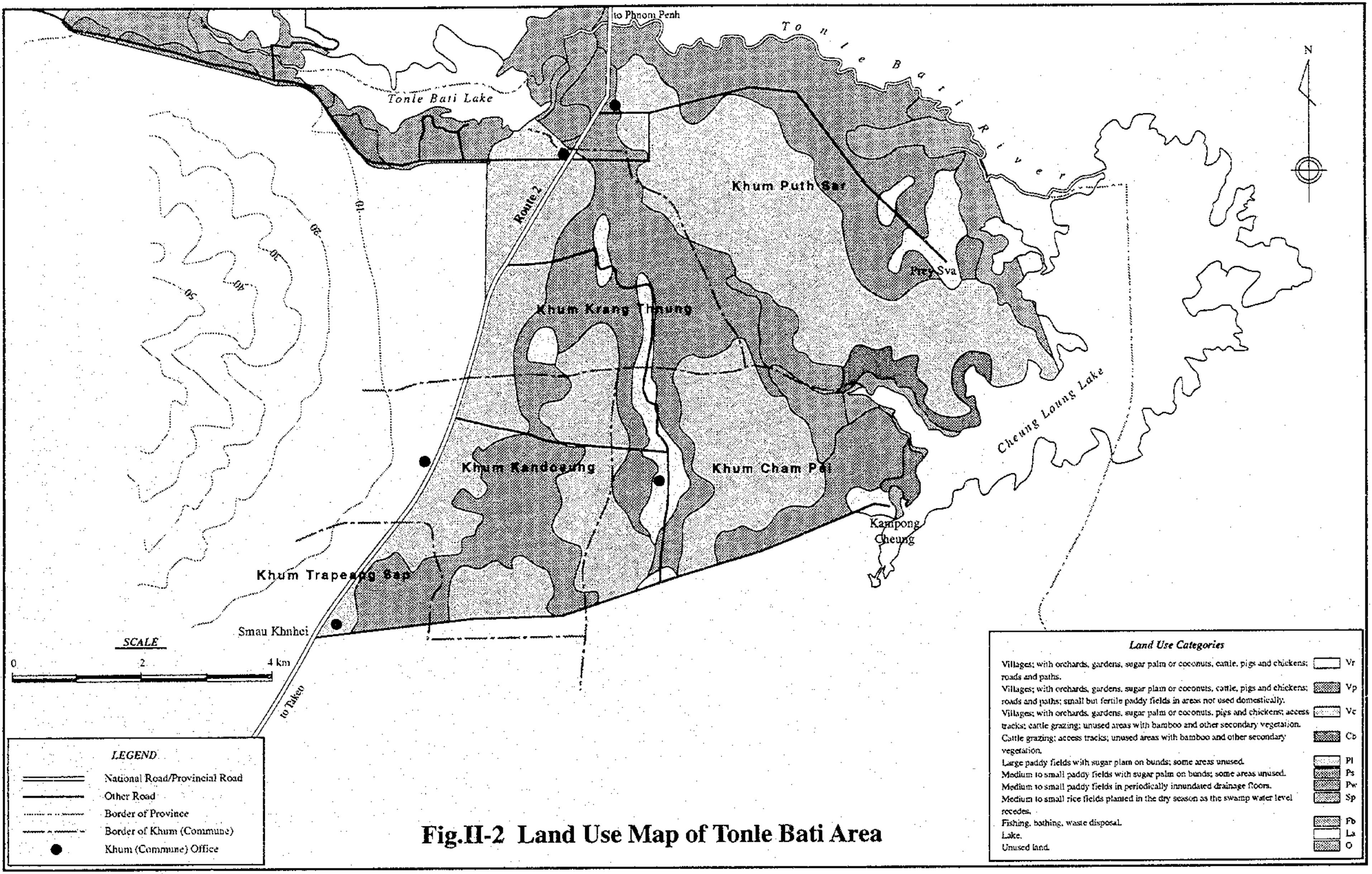

Fig.II-2 Land Use Map of Tonle Bati Area

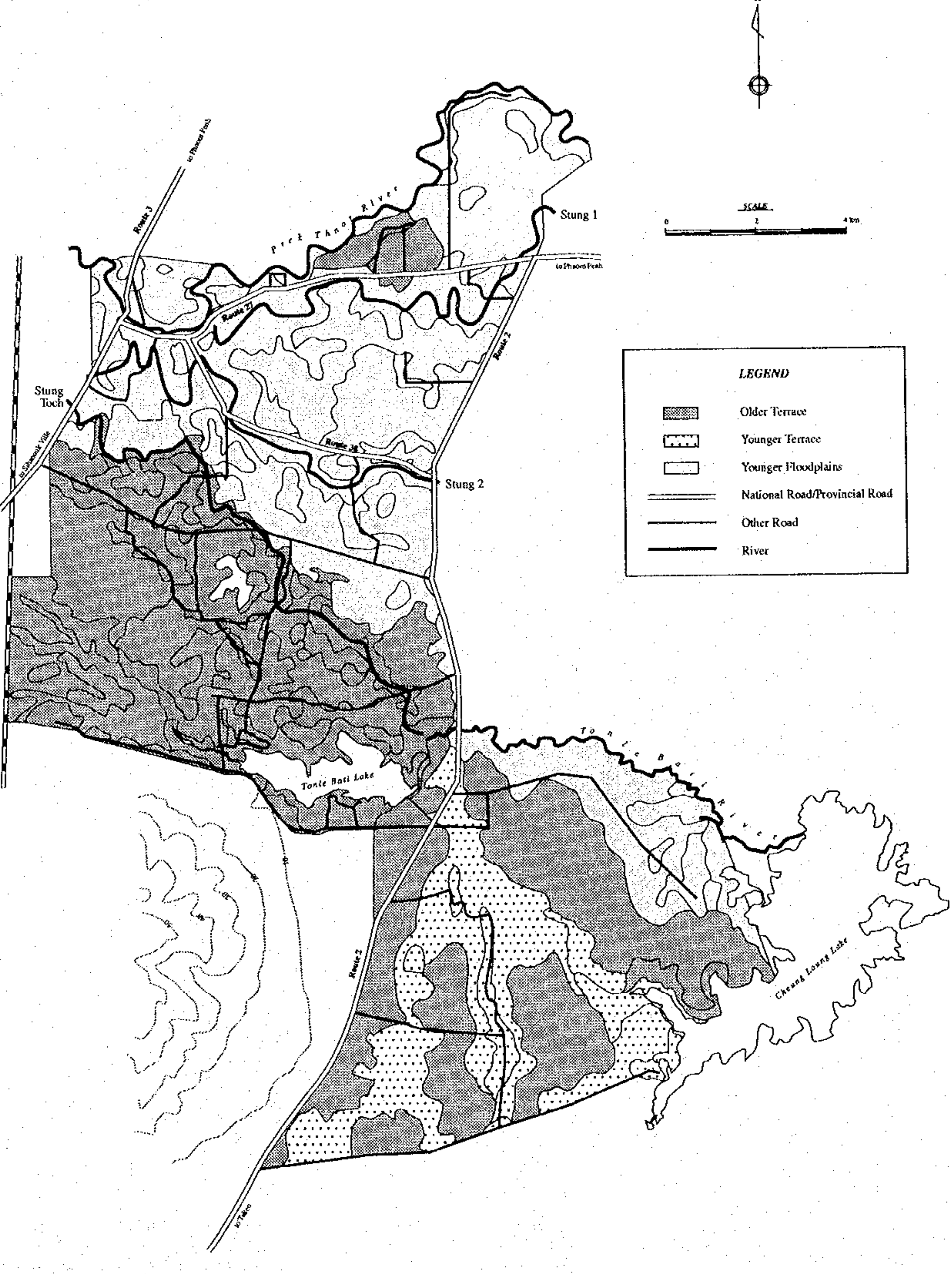

Fig.II-3 Prior Steams and Geomorphic Provinces

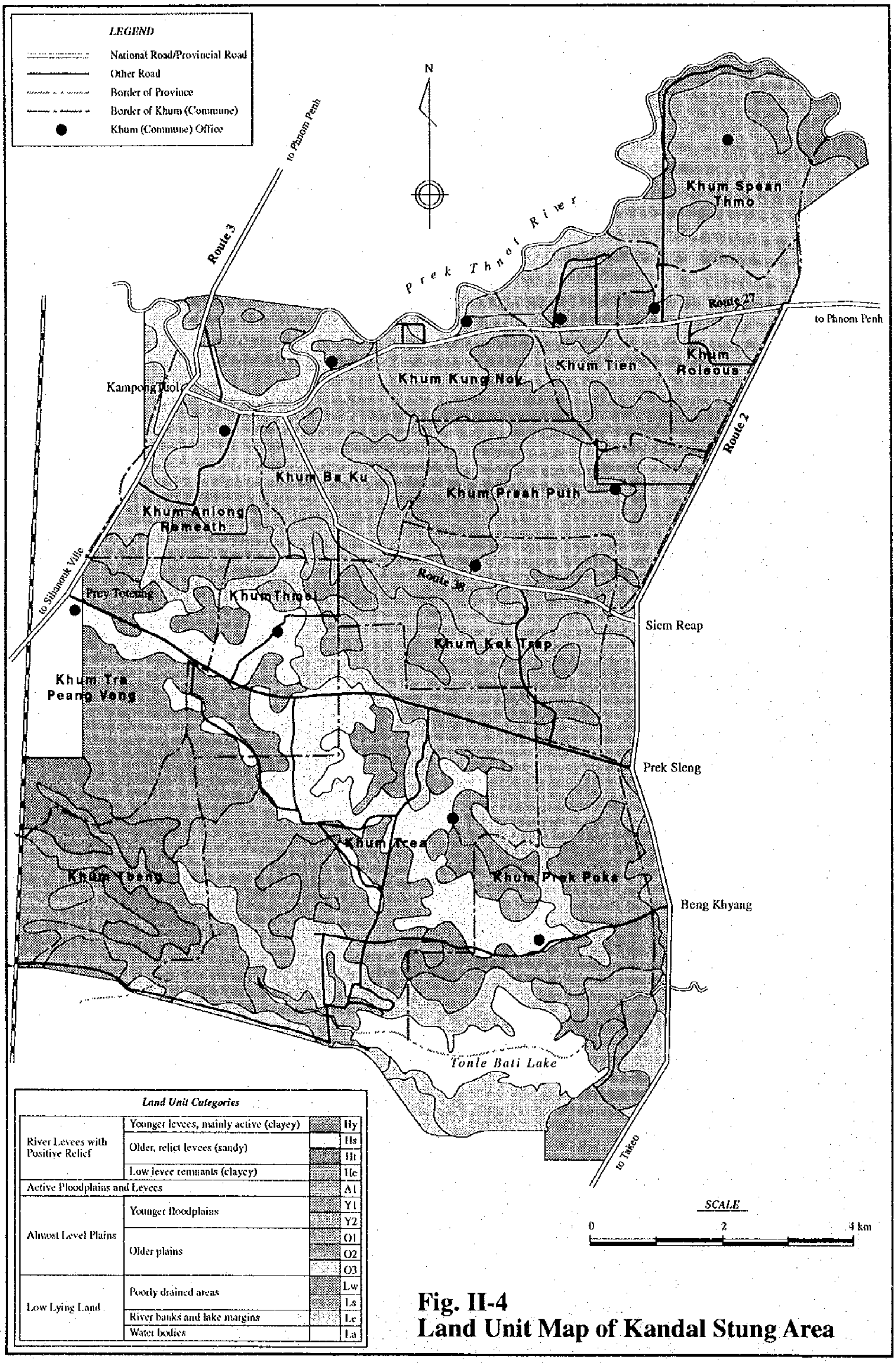

Fig. II-4
Land Unit Map of Kandal Stung Area