Landscape assessment of the Tissamaharama area, Sri Lanka

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1. Introduction

This study was conducted on assignment from Professor Paul Sinclair, Department of African and Comparative Archaeology at Uppsala University. The aim is to provide baseline data on the human and physical landscapes in the Tissamaharama area, southern Sri Lanka, as background for future archaeological projects in the area.

We are grateful to many persons who assisted us and provided information to this study. In Sweden, Professors Paul Sinclair and Lennart Strömquist assisted in the preparations and interpretation activities. In Sri Lanka, the help from Mr Raj Somadewa with arrangements and discussions, in which his colleagues from PGIAR also participated, was invaluable. We are also grateful to Mr Alwis from Sri Jayawardenapura University who was an excellent guide in the field.

2. Methods

The study was initiated by a literature search of relevant readings on the physical landscape history and evolution of Sri Lanka (See References). The literature review was meant to give a background on the physical characteristics of the region and to some extent on the socio-economic factors.

2.1 Manual interpretation of satellite (SPOT) image

The main methodology used in the investigation was manual interpretation of a SPOT satellite image (bands 1,2 and 3)[1]. Interpretations of the satellite image were made before the field work session and had the main aim of identifying and classifying land systems. The interpretations were also supported by literature studies made prior to the start of the analysis.

2.2 Data capture and storage, geographical reference system

On the satellite image, a transparent grid (following the numbering of the Microsoft Excel™ spreadsheets) was overlaid, with the grids being 1x1cm, representing 1x1km (scale of 1:100 000). The geographical positions of several pixels were noted[2]. The image was then analysed and every pixel interpreted and assigned a value for each parameter of interest. The interpretations were then entered into the Excel program, saved as Symbolic Link files (SYLK) and subsequently imported in the GIS program MFWorks were the maps were created. The noted co-ordinates were used to create the geographical reference system on the maps, using the "edit geometry" operation.

2.3 Field work and interviews

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[1] Satellite image corner co-ordinates; NW: N064632/E805944, NE: N064134/E813159, SE: N060942/E812450, SW: N061440/N805237

[2] Here, it is convenient to use the corner co-ordinates of the satellite image and if possible, one or more known and readily recognisable points in the image.

As mentioned above, land systems were used as a starting point for the investigation. The rational behind this approach is that the method provides a rapid mapping approach while at the same time provide information to be used for future, focused studies of different parameters.

2.3.1 The land systems concept

The land systems are based on recurring trends of physical features in the landscape with a specific and uniform character. Hence, areas with similar geomorphology, lithology, soils and vegetation are delineated. The land systems will thus give a good indication towards e.g. the land use in a certain area and will therefore reduce the time needed for mapping of other parameters. Based on the identified land systems, more detailed investigation of the other investigated parameters were undertaken.

During the fieldwork, topographical maps in the scale of 1:50 000 were accessible. The higher level of detail provided by these maps were used to enhance the classifications of land systems.

Interviews were made with persons at several departments, such as the Department of Irrigation in Weerawila and Tissamaharama, Department of Agriculture in Weerawila as well as the Coconut Seedlings Nursery, Weherayaya and National Livestock Development Board (NLDB), Weerawila. The interviews were to supplement and support the findings from the fieldwork and to provide a better picture of the land use in then area. In many cases, interviews are the basis for the various landuse maps, such as salinisation, coconut and sugarcane. The findings from the interviews were as much as possible checked in the field.

2.4 Quality of data

The methodology used in this study, with 1x1-km grids, implies a generalisation as such. One must therefore be aware that the data presented is in most cases a “rough spatial guide” for a number of parameters. In some cases the extent of features may be exaggerated and the borders are thus not exact.

The information based on interviews should be regarded as pointers and in some cases the data can be questionable. In some situations, language problems might also have lessened the quality of the data. To obtain more accurate data, more interviews should be undertaken with persons at different levels and more detailed field checks should be allowed for.

Data derived from the topographical maps were as much as possible checked in the field. Where this could not be done, the information might be questionable, since the maps were approximately 15 years old.

3. The physiogeographic setting

This section describes the landscape in a larger perspective, and is thus meant to complement the findings and discussion in the previous chapters.

3.1. The Sri Lanka landscape

Sri Lanka's morphology has been determined largely by its geological history, rock types and structures. Landscape studies of Sri Lanka therefore relate strongly to the staircase of ancient planation surfaces apparent throughout the island. Researchers argue on the number of planation surfaces, but it is generally agreed that there are three main levels, each of which is divided into sub-levels. The three main surfaces are;
(1) the highland planation surfaces
(2) the intermediate planation surfaces
(3) the lower planation surfaces

Each of the three peneplains rises somewhat on going inland towards the foot of the next peneplain.

The study area is almost entirely included in the extensive *lower planation surfaces,* which surrounds the more complex highland interior. The former can be divided into two levels that have a gentle but distinct seaward slope and reach down almost to sea level. They are well developed and in the actual landscape, the concept of the three peneplains is fairly obvious when looking at a larger area. However, it is not always easy to attribute specific planation surface relics to the different erosion levels because of their relief and general gradient

The interior of Sri Lanka, with the exception of the limestone plateau in the north-west and some narrow coastal and riverine strips, is composed of forms of denudational origin. Most of these are planation surfaces at various levels and in different stages of bevelling. Some parts of the island, however, have a more considerable relief. These include (1) the transitional zones between the planation surfaces (as for landsystem III in the study area) (2) dissected scarps and (3) parts rising above the highest erosion surface, such as the highest peaks of Sri Lanka. In the dry zone, where the study area is situated, locally isolated inselbergs rise above the planation surface.

Rivers radiate from the highlands coastward, transporting products of erosion which are deposited in the plains or carried out to the sea. Catchments are relatively small and discharges are correspondingly low. This is particularly so in the case of basins lying wholly in the drier parts of the country.

The age of the planation surfaces is difficult to assess. Suitable conditions for the creation of peneplains have prevailed in Sri Lanka for long geologic periods up to the late Tertiary but the highest level may date back to when Sri Lanka was still part of Gondwanland or shortly after it had drifted apart in the Permian or Jurassic.

Despite lineaments, steep folds in rocks etc., the location of the planation surfaces cannot be contributed to lithology and/or tectonics. According to most authors, including Verstappen (1987), they are ancient and purely denudational forms, the highest level being the oldest part of the "staircase". However, some authors deviate from this view, advocating an uplift in steps of the central parts of the island and claims that the highest parts are the youngest.

The mechanism of the planation processes can be contributed to the strong and deep weathering, which is characteristic of tropical climates. The weathering is an essential initiating factor of humid, tropical planation processes and results in the formation of clay minerals, which form the bulk of the weathering layer. Secondary formations, precipitated from the weathering solution, are also abundant.

3.2 Lithology

The lithology of Sri Lanka is to 90 percent made up of highly crystalline, non-fossilerous rocks of rocks of Pre-Cambrian age. These were originally a sedimentary succession of a great variety of rocks that has since deposition been subjected to intense conditions and transformed into a succession of metamorphic rocks, mainly consisting of gneisses, charnockites and quartzites.

The remaining 10 percent are composed of sedimentary rocks of Quartenary or Miocene age and can be found mainly in the Jaffna peninsula.

3.2.1 The Pre-Cambrian

The Pre-Cambrian rocks are divided into three main groups, the *Highland Series*, the *Vijayan Complex* and the *Southwestern Group*, the latter not being present in the study area and thus left out of the following discussion.

The Highland Series occupies a broad belt running across the centre of the island from southwest to northeast. It thus includes the whole of the central hill area and a part of the northern plain and is mainly composed of charnockitic gneisses and metasediments. In the southern regions, the Series is present on the western side of the road from Timbolketiya to Hambantota, running out to sea near Amblantota. Within the study area the Highland Series is only present north of a line roughly following the road between Wellawaya and Buttala. Here, it forms part of the escarpment and continues up into the hill country, reaching an altitude of 3000 ft. The Kataragama Complex, a group of hills reaching an altitude of 1000 ft is also part of the Series. It is thus mainly present in the higher levels and although only covering approximately 10-20 percent of the area, the Series is morphologically important. According to the literature (National Atlas of Sri Lanka, 1998), the Kataragama Complex also displays some marble (south and south-west of Kataragama city). This could however not be verified by satellite image interpretations or field studies and was therefore left out of the final maps. According to the same source a small area of marble is also present approximately 5 km south-east of the Lunuganwehera tank, as well as in the north-east corner of the satellite image/study area.

The Vijayan Complex occupies the greater part of the lowest peneplain, both northwest and southeast of the Highland Series. The lithology is made up of a varied group of gneisses, granites and combinations of the two. Numerous pegmatite dykes and veins, small bodies of granite and dolerite dykes have also been intruded into the crystalline rock from times between the Precambrian and Tertiary eras. The Complex has the largest aeral extent in the study area, covering approximately 80 percent. It occupies the lower parts of the landscape, displaying flat to gently undulating terrain.

3.*2.2 Quartenary deposits*
Some quartenary deposits can also be found in the study area. Their extent is not as significant as in the northern parts of the coastal belt, although some of the deposits could be potentially economically important. Owing to minor fluctuations in the sea-level after the Miocene, a few of these deposits are of marine origin, but the majority are terrestrial. The quartenary deposits are mostly unconsolidated and partly consolidated clays, sands and gravels, occupying the coastal areas and the floodplains of the major rivers. In the coastal areas, the quartenary deposits consists mostly of wind blown sands, now forming the sand dunes, which are present more or less along the entire coastal stretch within the study area. There are also quartenary deposits in the old lakes and lagoons along the coast, of which some are of marine origin.

Unconsolidated sands are perhaps the most extensive of the quartenary deposits of Sri Lanka as large stretches of unconsolidated sands cover the coastal tracts of the island. These sands have originated in a variety of ways. Apart from the present beach sands, many of these are old beach deposits now raised above sea-level, others are dune sands that have been transported by wind from the beaches and still others are river sands belonging to the existing and to previous systems of drainage. These unconsolidated sands are important as carriers of fresh water and as deposits of economically valuable minerals along the coast.

Sand dunes are striking features on many parts of the coast. Around Hambantota, the dunes separate a line of lagoons from the sea and here the sands are reddish in colour due to the presence of garnet grains. The NE-SW trend of the sand dunes in all parts of the island is very marked. This constant orientation is the result of the dominating influence of the south-west and north-east monsoon winds on the coasts, the dunes being elongated parallel to these directions.

The clays, sands and mixtures of clay and sand present in the major river valleys are economically important for several reasons. They are rich in agricultural soils, carry large quantities of groundwater and provide raw material for the brick and tile industry. These alluvial deposits may be quite thick, as much as 20ft in places.

4. Findings

4.1 Climate

The study area is entirely situated within the Dry Zone of Sri Lanka. This zone is generally defined as having a rainfall of less than 1905 mm (75 inches). The average annual rainfall in the study area ranges from 100-150 cm, most of the area receiving less than 125 cm and increasing gradually inland, whereas annual potential evapo-transporation is between 150-175 cm. It should be noted however, that the spatial patterns of water surpluses and deficits vary considerably between years. The amount of rainfall is also highly variable on the temporal scale, showing large variations between years.

The annual water balance in the study area range from a deficit of 75 cm close to the coast to approximately neutral in the northernmost part. In the Maha season (September/October to March/April), the deficit ranges from 0-50 cm, increasing inland. During Yala season (April/May to August/September), the water deficit is above 75 cm in the coastal areas to 50 cm in the northern parts.

Table 1. Annual average rainfall and evapotranporation (mm)

Station	Rainfall	Evapotransporation		
		Potential	Actual	Potential-Actual
Hambantota	1041	1702	1041	-661
Tissamaharama	1067	1702	1016	-686

Ref. Sirinanda (1979)

At the two stations within the study area where recordings are available, Tissamaharama and Hambantota (actually just outside the area covered by the satellite image), there is almost permanent water deficiency, since rainfall during nearly every month fails to meet the water need. Thus this area is frequently exposed to severe drought conditions (atmospheric, hydrological and biological) from June to early September. From January to October there is a continuous cumulative water deficiency of about 635 mm. During November and December, rainfall meets the water need, but the small excess is not sufficient to recharge soil moisture to field capacity. June-August shows the highest water deficiency of up to 130 mm. Further inland, it can be expected that periods of deficit alternate with those of surplus, but the data was not detailed enough to verify this situation.

In general the study area can be said to have no water surplus in the coastal areas whereas the extreme northern part have an annual deficit with a wet season surplus.

In the study area, frequent droughts and occasional floods constitute severe environmental problems to economic development in general and to optimisation of agricultural production in particular. The safety margin in agricultural water supply can be extremely narrow, especially in the view of the high variability of rainfall during the dry season.

4.2 Land systems

As recently mentioned, the land systems approach was chosen as a basis for the entire landscape investigation. The land systems found are presented in Appendix 1 and in map "Landsys". To get an appreciation of the landscape, it might also be beneficial to view the land systems map together with the map showing elevation (map "Elev").
The landscape of the study area can generally be described as low, flat and slightly undulating. At some points, higher terrain appears, such as in the NW corner (Land system III) and in the central eastern parts (Land system IX).

The *low planation surface* (previously described in Section 3.1)is the dominating terrain in the study area, constituting approximately 60 percent of the study area (land systems IV, V and VI). The three land systems of the lower planation surface differ only slightly in lithology and soils as well as vegetation pattern and are all of similar topography and geomorphology. Land system V (Low planation surface with thicker soil cover) has a thicker soil cover due to the influence from the more humid Wet Zone, whereas land system VI (Low planation surface with fissures) is characterised by thinner, dryer soils and dryer vegetation.

Land systems I and II are both part of the *intermediate planation surface*. They have very similar properties but differ somewhat in lithology, and thereby drainage pattern, as well as vegetation. Most of the area is protected and falls under the Yala-Ruhuna Nature Reserve as well as a few other sanctuaries (see map "Protect"). The geomorphology is characterised by a gently undulating terrain of plateaux and fissure valleys. Field checks in this area were however limited due to the security situation.

Land system III (Intermediate planation surface – "Highland") is actually not the highlands itself but part of the intermediate planation surface and the transitional slopes towards the highlands in the interior of the island. The name merely suggests a relatively high elevation compared to the rest of the study area. The soils and land use of the area are clearly marked by the steep terrain. Hence, cultivation is oftentimes carried out with terracing and the crops differ from the once found in the lower parts of the terrain. Apart from the usual garden crops, rubber, tea and pepper were encountered during field checks.

The distribution of the landsystems is found in table 2, as percentage of the study area (tanks, lakes and sea excluded).

Table 2.

Landsystem	**Percent of study area**
I	14,6
II	8,9
III	7,3
IV	49,6
V	4,4
VI	2,8
VII	7,9
VIII	2,2
IX	2,2

4.3 Soils

The rough soil survey of this study was performed with the help of the soil map in the National Atlas of Sri Lanka, the geomorphology map from ITC Journal (no. 1, 1987), the satellite image, as well as some additional literature (see reference list). The conclusion is, with the input from field checks, that the soil pattern is too complex and time demanding to allow for the construction of a complete, separate soil map when based on the material available. The only reasonable level of detail is the one

presented in the delineation of land systems (see map Landsys). Too increase the level of detail, it is necessary to either acquire more detailed soil maps (some are available at the Sri Jayawardenapura University in Colombo) or allow for a more comprehensive field study.

Some features and patterns are however possible to identify at this stage. The main part of the study area is characterised by Reddish Brown Earths and associated soil forms. Depending on topography, groundwater situation and drainage pattern, the Reddish Brown Earths are replaced by Low Humic Gley Soils, Immature Brown Loams or Solodised Solonetz. By the coast, Regosols and alluvial material dominate. These soils are briefly described in Appendix 2 and the distribution is outlined in the "Landsys" map.

4.4 Land use

The land use in the area around Tissamaharama is focused on agriculture. There is no shortage of land (Pers. comm., Mr Alwis), rather water accessibility is the major constraint to productive land use. Water is thus the deciding factor and in the area tanks and irrigation systems plays a vital role for the land use as well as the economy of the area. Thus the abandoned and active tanks were mapped as they give a good indication as to where the most intensive agricultural practises takes place (see map "Tanks").

There are two major growing seasons that govern the land use, the Yala season and Maha season. The Yala season is the drier of the two and has the higher requirements of irrigation water for paddy cultivation due to evaporation, about 2 meters per unit area, whereas during Maha the requirements are approximately 1.5 meters (Pers. Comm., Mr Singhe).

Regarding the mapping of different land uses, the distribution over small areas makes detailed classifications quite difficult when working with satellite images. The structure of the image appears broken and only the larger areas with homogenous plantations can be mapped with any degree of certainty. These are most often paddy fields and in the northern parts sugar plantations. However, even in these areas, other forms of land use such as gardens and coconut plantations are common even among the larger plantations. In order to give a detailed analysis of the distribution of the different crops, aerial photography needs to be used. Further, within the Maha and Yala seasons, paddy is often in different stages of growth, which gives differing spectral signals. The time from bare soil to a complete groundcover by plants can take only a couple of weeks making the timing of the aerial photograph important. All the factors taken into account, a thorough knowledge of the area is therefore required in order to minimise field checks and secure a detailed analysis.

4.4.1 Agriculture

The agricultural practice of the area is centred on the production of paddy but several other forms exist as complements to the rice production. Most families have, further than paddy fields or other commercial crops, such as bananas or coconuts also a home garden in which Other Food Crops are grown.

An important event concerning agriculture in the Tissamaharama area took place in 1982 with the initiation of the Kirinde Oya project. Prior to 1982, there was extensive cultivation of Other Food Crops on the higher levels of terrain and paddy cultivation occurred mostly in the lower lying fields below the four original dams. Today, this distinction is no longer suitable since paddy is grown practically everywhere in the area. The higher areas that have come into cultivation after 1987 (since the completion of the Lunuganwehera wewa) consists mainly of Reddish Brown Earths which at the initial stage have approximately twice the water requirement of the alluvial soils in the lower fields. After 3-4 years, the pores in the Reddish Brown Earths becomes clogged by the smaller particles transported in the water, successively lessening the water requirements.

Since the production of paddy is dependent on irrigation, the paddy fields are almost without exception found in close relation to tanks or irrigation channels. This is also true for most other crops, which concentrates the plantations around the irrigation systems. On lands that do not have access to irrigation or are otherwise unsuitable for intensive agriculture, chena cultivation or pasture are the most common forms of land use.

Every family is allocated 2,5 acres and there are approximately 10 000 families with 5-7 persons on average in the Tissamaharama area. In most cases, the preferred crop is paddy and if there is sufficient water farmers grow paddy on all of their land (Pers Comm., Mr Singhe). However, in seasons with insufficient rainfall farmers substitute paddy for bananas, chillies and onions as well as other garden crops.

The use of fertilisers is common, especially on paddy fields, where requirements are approximately 150kg/acre (Pers. Comm., Irrigation Engineer in Wellawaya). Coconut and sugar plantations also require fertilisation. To what extent did not become known.

In Appendix 3, statistics of the crop production in the area irrigated by the Lunuganwehera wewa for the last five years can be found.

Paddy varieties

There are several different varieties of paddy grown in the area. The Department of Agriculture have research stations that are developing suitable varieties for various conditions. The most common varieties are called 80-353 and BG-350, which are both red (brown) rice and 80-354 and BG-352, which are white rice. The favourable market price of the red rice makes them attractive to grow (See Table 3). The 80-354 variety is salt tolerant and is primarily used in the lower lying fields. This variety gives about twice the yield of the BG-352 variety but have stronger husks and are therefore harder to thresh and consequently less popular. Both red and white rice are commonly grown in the area du to there short growing period of 3-3.5 months whereas “Samba” rice is not suitable for the Dry Zone with its required growing period of 4-4.5 months.

Table 3. Distribution of varieties during 1998 Yala season.

Variety	Cultivated area (ha)
80-353 (red)	4432
BG-350 (red)	2163
BG-352 (white)	1725
80-354 (white)	394

Ref. Pers. Comm., Mr Singhe

Banana

Since 1990, the agricultural department has made efforts to promote banana cultivation in the area in stead of Other Food Crops. The Other Food Crops are short-term crops and does not give income for the whole year whereas bananas grow throughout the year. 90/91 bananas were grown on 10-12 ha in the area. Today there are at least 400ha of bananas and the Department of Agriculture is expecting further increases in the area used for banana plantations. Recently, however, problems with viruses have been encountered but efforts to solve these problems are being made.

There are mainly three varieties of bananas. Of these two are table bananas; "Ambul", which have shown some resistance to viral infections; and also "Colikutta". The third variety "Alukessel" is a vegetable banana, which is quite resistant to the Panama fungi[3].

Other Food Crops

Several other crops are grown in the area. These crops are grown primarily in gardens and are classified as Other Food Crops. According to Mr Singhe, the most common Other Food Crops are onions, chillies and pulses such as mungbeans and cowpeas. The Department of Agriculture is promoting the cultivation of red onions, which is a profitable cash crop. During the 1998 Yala season, 22.5 ha of red onion were grown out of 198 ha of Other Food Crops. Other vegetables and fruits are also grown in the home gardens.

Commercial plantations

In the northern part of the study area there are some commercial plantations which are run by different co-operatives. Of these, the crop with the largest aeral extension is sugarcane. The sugar plantations are situated north of the Wellawaya-Buttala road and south of the same, west of the Menik Ganga where a refinery is situated (See map MF_Sugarcane). In the same area there are also some tobacco plantations of limited extent. In the mountainous area on the road between Wellawaya and Haputale there is a minor rubber plantation.

The sugar industry is relatively new, less than 20 years and employs a substantial amount of workers and can thus be expected to have a not insignificant impact of the economy of that area. Field observations of the rubber and tobacco plantations indicate that these are of a limited extent.

[3] The spelling of the varieties are very uncertain and should be regarded as phonetics.

There are also coconut plantations of limited extent within the study area (see map "Coconut"). Coconut is not well suited for cultivation in the Dry Zone due to water deficiency and it is thus not economically viable to have any large-scale production. Mr De Silva, the manager at the Coconut Board seedling station estimated the aeral extent of coconut plantations around Wellawaya to approximately 400ha and in the Tissamaharama area to 500ha. According to Mr De Silva, coconut and paddy are not generally grown in the same areas since the water requirements are different. This is however contradictory to field observations, where it can be noted that the two plants are often grown on neighbouring plots.

Coconut prefers clayey soils, but Mr De Silva did not regard soil as a problem, rather water is the limiting factor. Since water is mainly available in the proximity of irrigation networks, this seems to support the field observations.

Chena[4]

About one half of the Hambantota District is classified as arid and falls under the classes *scrub jungle* and *scrub/grassland* on the produced land use map. On this type of land chena cultivation is the most suitable land use and is thus common. When chena cultivation is practised, the scrub jungle is cleared early in the Maha season and cultivated with Other Food Crops such as mungbean, cowpeas, maize and chillies. The same land is only cultivated during one year before another area will be used. Due to the small size and irregularity of the chena lands they are hard to map from a satellite image.

4.4.2 Livestock

An interview with the manager in charge at the National Livestock Development Board (NLDB) at Weerawila provided some estimated figures on the number of cattle in the area. According to the manager, the minimum number of cattle per family is 25, which includes both buffaloes and meat cattle, most of the animals being buffaloes. The distinction is made between buffaloes and meat cattle[5]. The manager were of the opinion that "there are not many cattle in the area" whereas Mr Singhe thought there to be "very many cattle", especially in the area covered by the Kirinde Project. Mr Singhe's estimate was that there are approximately 100 000 cattle in an area of 25 000ha in the Kirinde Project and regarded the cattle as a serious problem. Observations in the field also suggest that cattle, especially buffalo are quite common.

The main areas were cattle can be found are in the south-west corner of the area, around Badagiriya Wewa and in the Weerawila area. According to the manager at National Livestock Development Board, most of the cattle outside this area are close to the tanks and along the Kirinde Oya up towards Wellawaya. Cattle can be seen in the entire study area, but the number of animals seems to decrease further inland[6].

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[4] The information in this section pertains mostly to the area around Tissamaharama

[5] In this text the term "cattle" is used for both kinds of animals unless clearly stated.

[6] This is however a field observation and there are no data to support it.

Buffaloes are solely for milk production and subsequently to make curd (yoghurt), which is sold commercially. They are not used as draft animals. Meat cattle are kept for meat production only. They are small and produce small amounts of milk. The meat, however can be sold for "relatively good money" (Pers. Comm., Mr Singhe). The meat cattle are mostly held in drier areas and by relatively poor people. On lands under chena cultivation, they are an alternative that can give higher incomes than chena (Pers. Comm., Mr Singhe).

The coastal fishermen are not believed to keep cattle to any great extent, a view that is supported by Mr Sunil Abedira (fisherman at Kirinde) and the NLDB manager. Inland, where people are fishing in the tanks and rivers, they also keep cattle though it could not be distinguished which activity was the main source of income for this group.

The NLDB farm is a breeding station for that serves the southern parts of the Dry Zone. The government finances the station but curd and to some extent meat is sold to generate income. At NLDB there are 108 cattle and 1000 goats on an area of 820 acres.

In the villages nearby the farm, as elsewhere in the study area, the cattle are allowed to walk freely during the days but do not roam over very large distances. NLDB have experienced problems with the people in the surrounding villages letting their cattle on to the farm to graze, which means there is not enough grass for the NLDB cattle. The families have been given land but there is either not enough grass or it is situated too far away. Hence the conclusion that the cattle is not walked for very long distances, at least not in the Weerawila area. The animals also stay in the same area throughout the year but in general stay closer to the tanks during the dry season.

Other animals are not common. Goats exist, but only in very limited numbers whereas sheep and pigs are practically non-existent.

4.4.3 Irrigation[7]

Irrigation is extremely important to the land use in the area. For the cultivation of most crops and particularly for paddy, water is the limiting factor. Most agricultural activities are therefore centred around the tanks and irrigation channels.

The Irrigation Department in Tissamaharama controls the area downstream from the top of the Lunuganwehera Wewa. This includes the Weerawila, Tissa, Yoda, Debara and Badagiriya tanks. In 1982, the Kirinde Oya project was initiated with the aim to increase the potential for agriculture in the area. A major component in the project was the completion of the Lunuganwehera wewa in 1987. The new tank doubled the area under irrigation from 5000 to 10000 ha (see map "Irrigat").

The Lunuganwehera, with a water storage capacity of 180 000 acre-feet has two canals, the left and right bank. After the water has flowed through the fields under irrigation from the Lunuganwehera it is recollected in the lower dams, Tissa, Yoda,

[7] The information is this section is drawn from interviews with the irrigation officer and engineer at the Irrigation Department in Tissamaharama, 99-06-07.

Weerawila and Debara. This has unfortunately contributed to the problem of salinisation since the new fields are situated on Reddish Brown Earths, which contain salt that is now released. The lower tanks thus receive saline inflow and their waters are becoming increasingly salty. As this water is being released on the lower lying fields, the salt is enriched into the soil with decreasing productivity as a result. Water is also reused in the fields below the four tanks and these fields are not properly drained, which further increases the problem. The Lununganwehera wewa in itself is also accentuating the problem since it now controls the floodings that used to take place on the lower fields. As the soils were flooded, the salt was carried away and the condition of the soils improved. The only measure against the problem is to widen and deepen the canals to the sea, thus improving the drainage of these fields. However, this is only a partial solution (Pers. Comm., Mr Singhe).

The salinisation problem is mainly present downstream of the Yoda and Tissa Wewas (see map "Saline"). 500-600 acres have been abandoned due saline soils in this area and approx. 25 acres in the Kirinde area. Paddy fields in the Magama area have also become affected recently (Pers. Comm., Mr Singhe). The areas affected are low lying, close to the sea. However, there is no salinisation due the encroachment of the sea.

The Irrigation Department at Wellawaya controls six schemes of medium size, most of them being between 25 and 100 years old. Medium size tanks are defined as having an irrigatable area of 200-2000 acres. With an interval of approximately 50 years, the need for rehabilitation of the dams occurs. The tanks need to be dredged and weeded on a yearly basis, and the farmers contribute ten percent of the repairs, either in cash or the equivalent amount of work. There is as yet no sedimentation problem in the Lunuganwehera tank but the channels are cleared twice a year, before every cultivation season.

The Irrigation Departments in Tissamaharama and Wellawaya are conducting rehabilitation of abandoned tanks in order to increase the area under irrigation. The abandoned tanks are also suitable sites for new paddy fields as they are situated on "alluvial" soils, i.e. finer material deposited when the tanks were in use, providing favourable soil conditions.

Before every season, the farmers meet with the Irrigation Department to discuss when and how the irrigation is to be conducted. The most important crop on the irrigated lands is paddy and if there is sufficient water, farmers grow paddy on all their lands. Paddy cultivation in Maha season requires 6 acre-feet and slightly more in Yala. Water availability is lowest in August-September and highest in November-January[8]. In seasons with insufficient rainfall farmers substitute paddy for bananas, chillies and onions as well as other garden crops.

Notable is that the sugar plantations in the northern part of the study area are not drawing their water from the irrigation department. Instead they are using their own wells for water supply.

[8] There is a rainfall gauge in Lunuganwehera wewa. The records are stored at the Irrigation Department in Tissamaharama.

4.4.4 Protected areas

In the study area there are several protected areas, the largest being the Ruhunu/Yala National Park. These areas are being used to some extent for collection of resources such as wood collection for fuel and building material and harvesting of coastal resources, mainly fishing and shellfish. If there is a conflict situation regarding conservation and utilising of resources could not be established (see map ”Protect”).

4.5 Population

The material used in the mapping of population was mainly topographical maps complemented by field observations. Satellite imagery does not provide sufficient detail to allow high quality population mapping. The mapping of population centres were therefore made largely based on the topographical maps and complemented by field observations. To perform an investigation with higher detail and better time efficiency, aerial photography would be well suited. With this material an estimate of the population density can be made. In this case, when neither aerial photography nor population statistics were available, the choice was made to map the location of main population centres. The map is thus not an estimation of population density (see map “Pop”).

In addition to the main towns and villages, the main population centres are situated in the vicinity of tanks and cultivated fields. The concentration of housing in these areas made them quite easy to map. During the fieldwork, it was also found that settlements are also concentrated along the main rivers and roads, especially along the Kirinde Oya and the road between Tissamaharama and Wellawaya. The extent of settlements in these areas is rather strictly limited to the road and rivers but they are spread over long distances. It was therefore estimated that a mapping of these areas as population centres would create an impression that would overestimate the population.

4.6 Coastal resources

The coastal strip of the study area was mapped using the satellite image, topographical maps and field checks. Time only allowed for a rough mapping of coastal types (beaches, headlands and harbours). If a more detailed investigation of the coast should be undertaken (showing for example evidences of former sea levels), aerial photographs would be a necessity (unfortunately not available at the time of the fieldtrip) as well as more extensive field studies and interviews.

As for large parts of Sri Lanka, the coastal strip in the study area is characterised by continuous sandy beaches interrupted by headlands, about 100-300 m apart. Lagoons as well as dunes appear at several points along the coastal stretch and could be mapped with high accuracy using material with a scale of 1:50 000 or 1:100 000. Further inland, on the old littoral deposits (land system VIII), vegetation consists mostly of scrubs, bushes and scarce trees.

Origin of beach sands
The sands of the beaches, dunes and the sea floor nearby, are mainly terrigenous (originally supplied by rivers, erosion of bedrock sectors of the coast and from the continental shelf). Today, rivers are the main sources of sand supply. The amount (and distribution over the year) of sediment supplied varies greatly from one sector of the coast to another. Rivers traversing the wet zone deliver sand to the coastal area regularly through the year, whereas those originating in and flowing through the foothills and lowlands of the dry zone are more spasmodic in this respect. Not all rivers deliver their full load to the sea. Many cross broad flood plains in their lower reaches, or enter lagoons which act as traps where the coarser parts of their load (including sand) is deposited. From these, material can be washed into the sea during severe floods.

The fishing industry
In the waters off the coast of Kirinde and Hambantota fishing is a very important industry. During the fieldtrip, an interview was carried out with Mr Sunil Abedira, a fisherman at Kirinde Harbour. However, Mr Abedira was not fluent in English and some of the information can therefore be questionable.

According to Mr Abedira, approximately 2500-3000 fishermen are working in the recently constructed Kirinde Harbour. Out of these, about 2000 operate smaller outboard engine boats that only fish near the shore. The rest operate the 150 larger boats that travel as far as Sumatra and Somali, over 1100 nautical miles away. The most common species of fish to be caught by fishermen from the Kirinde-Hambantota area are tuna, yellowfin, skipjack and shark.

Shellfish are caught mostly from January to April on rocky bottoms above the depth of 100 fathoms. The method is line and hook fishing from smaller outboard engine boats, and also diving. The most common species are lobster, of which tiger lobster gives the highest price. This type of fishing is mostly done by relatively poor people. Some of these people are also believed by Mr Abedira to keep cattle as well as gardens.

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Appendix 1. Land systems

Appendix 2. Soils

This information is derived from Moorman and Panabokke (1961) and The National Atlas of Sri Lanka (1998).

Reddish Brown Earths

In extent the Reddish Brown Earths are the most important soils of Sri Lanka. They occupy by far the largest part of the lowland dry zone in the north, north-central, east and southern provinces.

Reddish Brown Earths are fairly young soils. Still, in the tropics these often show a considerable degree of weathering and are very close to the Acrisols and Ferralsols (low fertility soils). The Reddish Brown Earths of Sri Lanka are well to imperfectly drained, moderately to fine-textured. They are found on the crest, upper and midslopes of the undulating landscapes.

Relief is not an important factor in the formation of these soils. Although they are often found on undulating to gently rolling mantled plains, they do occur in hilly terrains as well. Free drainage is however necessary and in the depressions this soil group is replaced by hydromorphic soils (alluvial soils, low-humic gley soils).

The natural vegetation most commonly found on Reddish Brown Earths, is dry mixed evergreen forest, characterised by the predominance of evergreen species with an admixture of deciduous species. Most of the forest is secondary, the original forest having been destroyed by shifting cultivation at one time or another. In the dryer zone, such as the study area, low open thorny shrub with isolated trees is found.

According to Moorman and Panabokke (1961), a greater part of the Reddish Brown Earths are uncultivated or else have been regularly used for “chena” or shifting cultivation since medieval times. The period of forest fallow varies with the population density of the region, often approaching 3 years in some areas. However, where sufficient underground water is available, such as around the frequent tanks in the study area, crops are grown with supplemental water. These soils are therefore suitable for subsidiary food crops with irrigation in the dry season and with or without supplemented irrigation in the wet season.

Low-Humic Gley Soils

These are poorly drained, moderately fine to fine textured soils that occur in the lower parts of the slopes and valley bottoms. The Low-Humic Gley Soils are found throughout the lowlands of Sri Lanka, usually in the lower topographic sites. These soils are associated with the main soil groups such as the Reddish Brown Earths. In such associations they are usually the lower members of the drainage catena, unless they are replaced by hydromorphic alluvial soils.

The dominant governing factor is the periodically high groundwater level; this may be a true groundwater level or a water table developed during the rainy season. The Low-Humic Gley Soils are therefore generally found in flat or depressional areas, quite often in the border zone of the depression. This soil group is generally found on alluvial material (flood plains), occasionally on transported residuum (colluvium) of varying lithology.

These soils are well suited for rice cultivation with or without irrigation and are used for this purpose in the study area.

Solodised Solonetz

Solodised Solonetz are soils of semi-arid areas. They occur along the coast in all provinces of the dry zone and the occurrence seems to be related to the presence of salts in the parent material. Thus, they are found on clayey parts of the tidal flats and the estuary deposits. Some of these deposits are semi-recent, while others (situated higher) may be much older, probably from the upper Pleistocene era.

Solodised Solonetz area unsuitable for any crops due to their alkalinity and high exchangeable sodium but can be used for rice or pasture after reclamation. Vegetation is predominantly grassland with thorny shrub and a few scattered trees.

These soils have a moderately coarse textured, brown to dark brown, slightly acid topsoil which overlie a moderately fine to fine textured grey alkaline subsoil and occur in the nearly flat bottom land.

Immature Brown Loams

The Immature Brown Loams occur in scattered locations throughout the dry zone. They rarely occupy a large surface area and are most frequent in areas having a marked relief as well as on rock knob plains. In their local distribution they are closely associated the Reddish Brown Earths. In the study area, these soils seem to be found in the mountainous region in the north-east.

The Immature Brown Loams are young soils formed on surfaces that have been continuously exposed to erosion or alternatively, in places where transported colluvium has had a chance to accumulate. In the dry zone these soils are observed on the slopes of hills and rock knob plains.

The range of parent rocks includes most Archaean rocks and also the colluvium derived from such rocks.

The natural vegetation is usually dry mixed evergreen forest, while anthropomorphic forest savannah may also occur.

In the dry zone, the Immature Brown Loams, being found on steep slopes and rock knob plains, are oftentimes unused and has no potential for any economic development. The deeper and less sloping phases could be used in the same manner as the Reddish Brown Earths, with main emphasis on pasture.

Alluvial soils

Alluvial soils occur all over Sri Lanka, usually in narrow strips in the valleys and in the flood plains of rivers.

Time is an important factor in respect of these soils. Since these soils are of recent age, no genetic soil horizon has had a chance to develop. Parent material is water transported and sedimentary. Topography is flat to slightly concave (flood plains and valleys).

Natural vegetation is usually absent due to cultivation, but is extremely variable and related to the hydrography, texture and salt content of the soil. Dry mixed evergreen forest is found on most of the well drained soils in the dry zone, swamp forest in the backswamps of the rivers, and salt tolerant plants including mangrove swamps on the tidal flats.

A large proportion of the alluvial soils of Sri Lanka are used for rice cultivation and are the main rice producing soils of the country. The somewhat better drained members of the catena are used for coconut where the moisture conditions permit.

Regosols

There are two main types of regosols present in Sri Lanka:

1) sandy regosols of the dunes and elevated beaches of the coastal area. Very deep, generally over 3 m. Structureless, single grain, whitish, excessively drained sands.
2)The medium textured, often stony or gravely regosols on recently deposited erosion products, i.e. slope colluvium.

Sandy Regosols occur in more or less narrow strips in all coastal areas of Sri Lanka. Colluvium regosols are mainly found on the lower aspects of the slopes in hilly areas.

Time is an important factor for these soils as in the case of alluvial soils. Regosols are so young that no genetic horizon could possibly have formed. Man's activity is an important factor in the case of colluvium regosols since these are mainly erosion products resulting from the cultivation of slopes.

Regosols generally have very low potential value. However, on flat land, regosols are suitable for coconut in the wet zone and cashew in the dry zone.

Appendix 3. Crop statistics

Year	Season	Crop	Area (ha)
1994	Yala	Paddy	9183
		Other Field Crops (OFC)	51
		Banana	85
		Vegetable	30
		Yams	3
1994/95	Maha	Paddy	9616
		OFC	1351
		Banana	87
		Vegetable	160
1995	Yala	Paddy	9140
		OFC	155
		Vegetables	142
		Banana	95
95/96	Maha	Paddy	9100
		OFC	955
		Banana	130
		Vegetables	76
1996	Yala(very dry)	Paddy	2719
		OFC	413
		Banana	166
		Vegetables	127
96/97	Maha	Paddy	5190
		OFC	1149
		Banana	180
		Vegetables	165
1997	Yala	Paddy	4838
		OFC	485
		Banana	190
		Vegetables	100
97/98	Maha	Paddy	8481
		OFC	423
		Banana	200
		Vegetables	153
1998	Yala	Paddy	9268
		Banana	400
		OFC	198
		Red onion	22.5
		Vegetables	90

Appendix 4. List of contacts during field trip

Mr Perreira, Irrigation engineer, Tissamaharama

Irrigation Officer, Tissamaharama

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Mr Sunil Abedira
Fisherman
Tissamaharama
Kirinde

Mr Asoka Mathala Singhe
Agricultural Officer
Weerawila

Residential Nursery Officer
Gamini De Silva
Abesundara Coconut Seedlings Nursery
Handapanagala
Weherayaya

Appendix 5. Table of digital files

Map	SYLK-file	Description	Sources of information
Landsys	Landsys	**Land systems**, delineated with respect to topography, geomorphology, drainage, soils, lithology, vegetation and land use	Satellite image, literature on geomorphology, lithology and soils, topographic maps and field checks
Lithol		**Lithology**	Extracted from land systems map
Soils		**Soils,**	Extracted from land systems map
Elev	Elev	**Elevation**	Topographical maps, scale 1:50 000
Coast	Coast	**Coastal types**	Satellite image, topographic maps and field checks
Coconut	Coconut	Major areas of **coconut** cultivation	Topographic maps and field checks
Irrigat	Irrigat	**Areas irrigated** under the Kirinde Oya Project, before and after the construction of the Lunuganwehera tank	Satellite image, Topographic maps interviews and field checks
Landcov	Landcov	**Land cover**	Satellite image, field checks and interviews
Pop	Pop	Main **population centres**, N.B only geographical position, no quantitative aspect	Topographic maps and satellite image
Tanks	Tanks	Distribution of abandoned and active **tanks**	Topographic maps and satellite image
Saline	Saline	Main areas affected by **salinisation of soils**	Interviews
Protect	Protect	Areas under some	Topographical

		form of protection, i.e. national parks, sanctuaries etc.	maps and satellite image
Sugar	Sugar	Areas with **sugarcane cultivation**	Interviews, field checks, topo-graphical maps and satellite image