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Paddy and banana cultivation in Sri Lanka

- A study analysing the farmers' constraints in agriculture with focus on Sooriyawewa D.S. division

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Abstract

The farmers in Sooriyawewa D.S. division, situated in the Dry Zone in Sri Lanka, are main cultivators of paddy and banana. The agriculture in the Dry Zone is heavily depending on water from the irrigation schemes. The objective of the study is to investigate the methods used in the paddy and banana cultivation in Sri Lanka with focus on Sooriyawewa D.S. division in order to understand the main constraints that the farmers experience in their agricultural practice. Five paddy and banana farmers in the study area were thus interviewed, with help of an interpreter, to gain a comprehensive picture of the farmers' situation. A literature study was also performed and in addition, relevant statistics describing the rainfall, the banana and paddy crops cultivated in the region were analysed. The farmers all stated that the water situation was their main concern, in particular for the paddy farmers since paddy cultivation requires a lot of water. Secondly pests and diseases were the main concern for the banana farmers. The farmers had also observed that the rainfall seemed to decrease in amount, seasonality and reliability. The literature study confirmed that the water situation is the paddy farmers' greatest problem and the statistics indicated that the Yala season (dry season) is getting drier while the Maha season (wet season) is getting wetter. However, the paddy yields are increasing despite the decrease in rainfall during the Yala season. The changes seen in the rainfall pattern indicates that the agriculture in the Dry Zone has to prepare for years with droughts that will be more severe than the droughts in the past.

Keywords: Physical geography, Sri Lanka, paddy cultivation, banana cultivation, rainfall

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Sammanfattning

Bönderna i Sooriyawewa D.S. division, som ligger i torrzonen på Sri Lanka, odlar främst ris och bananer. Jordbruket i torrzonen är till väldigt stor del beroende av vatten från konstbevattningssystemet. Syftet med den här studien är att undersöka de metoder som används vid ris- och bananodling i Sri Lanka med fokus på Sooriyawewa D.S. division för att på så sätt kunna bilda sig en uppfattning av de främsta problemen som bönderna stöter på i deras jordbruk. Fem bönder som är sysselsatta med banan- och risodling i Sooriyawewa D.S. division intervjuades med hjälp av en tolk för att kunna förstå hur böndernas situation ser ut. En kompletterande litteraturstudie utfördes och relevant statistik inhämtades som beskrev nederbörden, ris- och bananodlingen och som sedan analyserades. Bönderna var överens om att den begränsade vattentillgången utgjorde deras främsta problem, detta gällde särskilt för risbönderna eftersom risodling kräver mycket vatten. Bananböndernas största problem var hanteringen av sjukdomar och skadedjur. Vidare hade bönderna observerat att nederbörden verkade minska samt att säsongsvariationen förändrats. Litteraturstudien bekräftade att den begränsade vattentillgången är böndernas främsta problem och statistiken indikerade att Yala perioden (torrperioden) har blivit torrare medan Maha perioden (regnperioden) har blivit våtare. Dock så ökar risskörden trots den minskande nederbörden under Yala perioden. Förändringen som ses i nederbördsmönstret indikerar att jordbruket i torrzonen måste beredas för år med kraftigare torrperioder som sannolikt kommer att öka i intensitet i framtiden.

Nyckelord: Naturgeografi, Sri Lanka, risodling, bananodling, nederbörd

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1 Introduction

Sri Lanka is an island situated in the Indian Ocean 7° of North latitude and 81°of East longitude. The island looks like a raindrop falling from the Indian subcontinent. However, water is often a scarce resource because of the spatially and temporally uneven distribution of rainfall (Peiris, 2006). During the year the island is hit by the Southwest- and Northeast monsoon. Rainfall is thus the parameter used to define the different seasons. The irregular rainfall is, as a consequent, problematic for the agriculture because it contributes to severe droughts and floods (IPCC, 2007). Since Sri Lanka’s economy heavily depends on agriculture, with paddy as the most important crop, the unreliable water supply is of concern (Weerahewa, 2004). The importance of rice can therefore not be over-emphasized. It is not only the staple food in Sri Lanka but also the foremost source of calories and protein. However, during the last years the banana, being the most consumed fruit in Sri Lanka, has gained a considerable position in improving the health of the poorer part of the population (FAO, 2009). A trend of converting paddy fields into banana cultivations has been seen during the last decades (Schubert, 2004) due to the advantage that banana plants require less water.

The farmers in Sri Lanka struggle because of their financial situation is, to a great extent, limited to the income they acquire form the agriculture. Therefore the decisions taken before, during and after the cultivation period are essential since it affects the outcome of the yield and thus their income. The decisions concern cultivation methods, water management, weed- and pest management and what crop to cultivate. In addition the market situation has to be considered and evaluated, especially in the case of banana cultivation. These decisions affect not only the yield and thus the farmers’ economy but also the environment. To gain a full picture of the problems the farmers face in their profession it is crucial to understand the practical processes behind the agriculture, the choice of agricultural methods and the techniques used. Additionally, it is important to understand the physical environment in which the crops are cultivated.

1.1 Objectives of the study

The objective of this study is to investigate the methods used for banana and paddy cultivation in Sri Lanka with focus on Sooriyawewa D.S. Division. In order to understand the most common problems occurring within the agriculture a field study was conducted in the farming community Sooriyawewa Divisional Secretary (D.S.) Division, which is situated in Hambantota District in the Dry Zone in south Sri Lanka. The problematic reflected in this study is therefore more typical for the Dry Zone. To meet these objectives, it is necessary to understand and obtain knowledge about the following:

- The main problems the farmers experience according to their own perception
- The rainfall pattern and the irrigation schemes in the region
- Advantages and disadvantages when cultivating banana and paddy
- The physical environment in Sri Lanka and Sooriyawewa and how it affects the agriculture
- Yield and extent of area cultivated for respective crop over time
- Characteristics of the banana and paddy crops

1.2 Method

This bachelor thesis, which is a part of the Department of Physical Geography and Ecosystem Sciences at Lund University, is a literature study with supplementary information received from five farmers, interviewed in Sooriyawewa D.S. Division. The farmers are represented in the tables, graphs and text by a letter from A to E to protect their identity. Additionally, data and statistics were collected and interviews were conducted at several ministries and organisations in Sooriyawewa, Hambantota and Colombo (see appendix). The interviews with the farmers were carried out with the help of an interpreter. Statistics that describes the paddy production and extent of paddy cultivated was collected at the Department of Census and Statistics's webpage and the statistics showing the extent of banana cultivated in Hambantota District was collected at the Statistics Division at the Ministry of Agricultural Development in Colombo. Parts of this thesis are written by Zanna Sefane and are marked with a different font.

2 Background

2.1 *Study area*

The farming community Sooriyawewa Divisional Secretary (D.S.) Division is the selected area where the field study component was conducted in 2009. Sooriyawewa is located in the north central part of Hambantota District in the southern province of Sri Lanka. Out of the 12 D.S. Divisions in Hambantota District, Sooriyawewa is the driest.

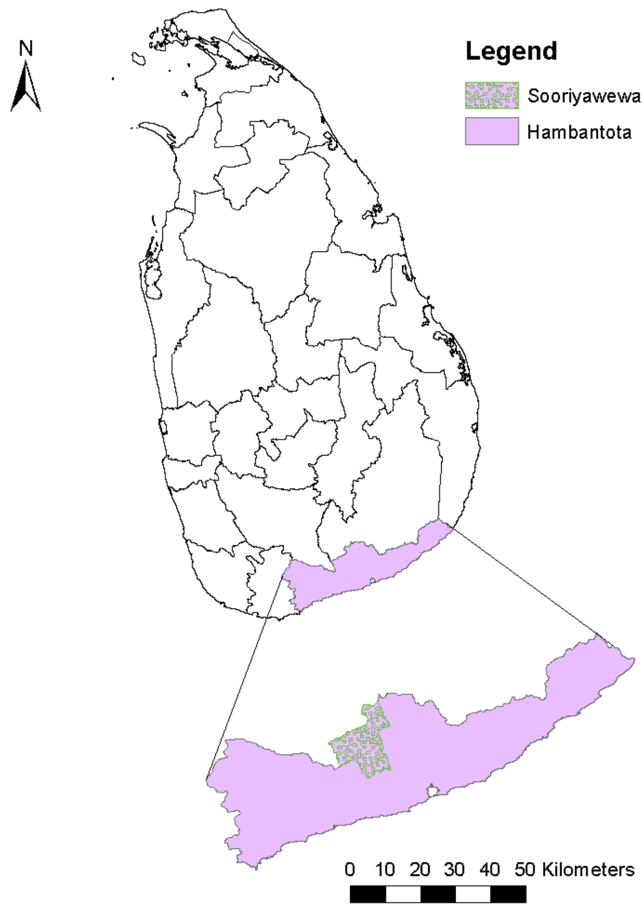

Figure 2:1. Map showing the location of Hambantota District and Sooriyawewa D.S. division.

Due to difficulties with finding adequate statistics from Sooriyawewa D.S. Division, statistics from Hambantota D.S Division situated 24 km south of Sooriyawewa was collected to represent the rainfall and temperature in Sooriyawewa D.S. Division. As can be seen in figure 1:1 October, November and December are the months with most rainfall. However, the temperature does not vary much throughout the year (figure 2:3).

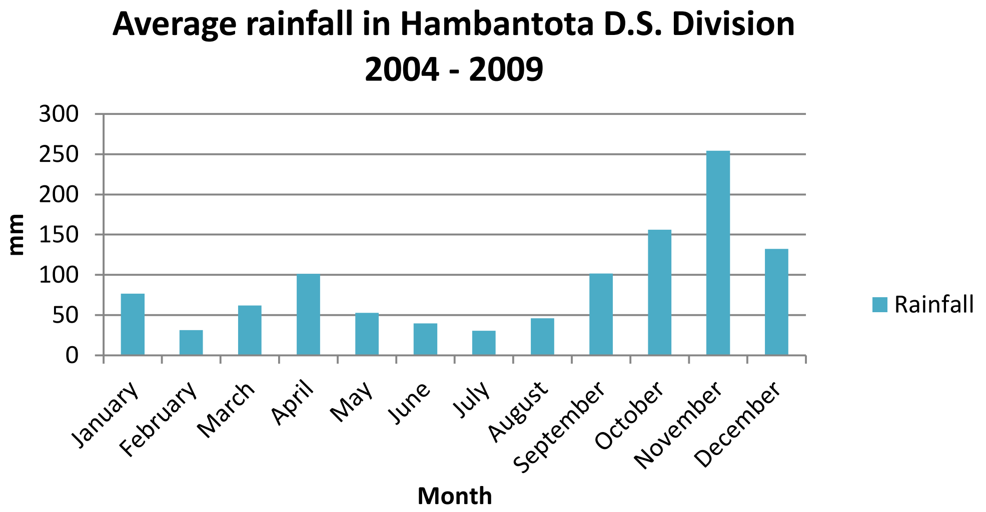

Figure 2:2. Average monthly rainfall in Hambantota D.S. Division during 2004 – 2009. Source: Department of Census and Statistics, Sri Lanka, 2013.

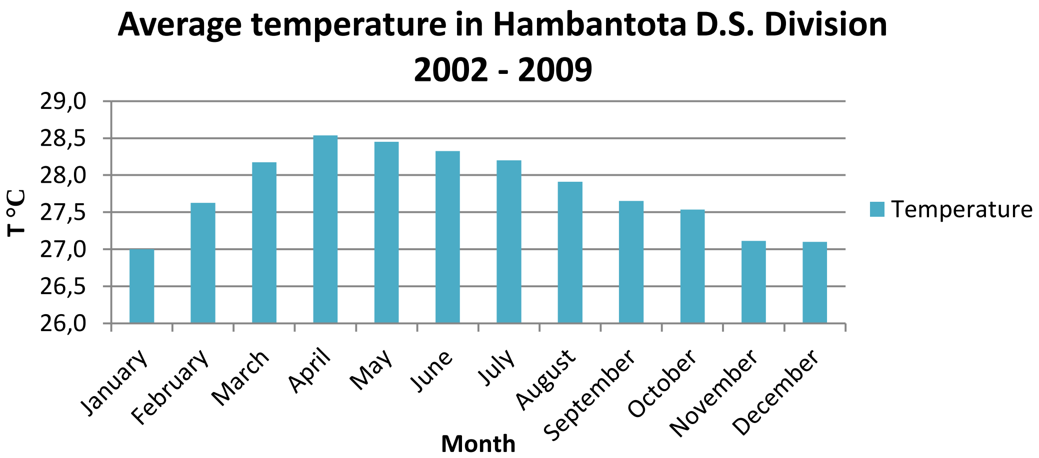

Figure 2:3. Average monthly temperature in Hambantota D.S. Division during 2002 – 2009. Source: Department of Census and Statistics, Sri Lanka, 2013.

2.2 The importance of irrigation through time

Paddy (*Oryza sativa*) has had a substantial influence in Sri Lanka's agriculture for millenniums, as it has been and still is the staple food for the inhabitants on the island (Hirimberagama & Dias, 2004). To meet the agriculture's water requirements, irrigation schemes have always had a significant role. Already in the ancient times around 307 B.C., the Dry Zone lowland (see section 3.3) of Hambantota District was flourishing under the Kingdom of Ruhunu (Wikkramatileke, 1963). The area consisted of several smaller irrigation schemes, which made it possible for people to cultivate paddy on the low-lying land and millet on the higher elevations. In the end of the 12th century most of these ancient reservoirs were, however, abandoned or destructed because soils became unfertile, and people from India started to invade Sri Lanka. The lack of irrigation schemes made the area more sensitive to droughts and floods. Food shortages and diseases like Malaria became a problem in the District, causing the population to migrate to the more prosperous areas.

Little attention was paid to the Dry Zone from the 13th century until the late 19th century, when the British colonisers began to notice the regions potential for agriculture (Molle & Renwick, 2005). At this time most of the area was covered by forest, and the still populated locations were dominated by slash and burn cultivation. Deforestation was initiated and focus was set on how to settle farmers in the Uda Walawe basin (figure 2:4), which is feeding the study site Sooriyawewa. However, the area remained sparsely populated because the initiated development plans were interrupted by the Second World War. After Sri Lanka achieved independents in 1948 the development plans of the Uda Walawe basin, initiated by the British, were continued. The Sri Lankan government planned a resettlement project, which later became known as the Uda Walawe Irrigation and Resettlement Project (UWIRP). Since irrigation was a key factor in the development work, a number of the ancient irrigation schemes in the Uda Walawe basin were restored. As the irrigation schemes improved, the population started to increase (Wikkramatileke, 1963).

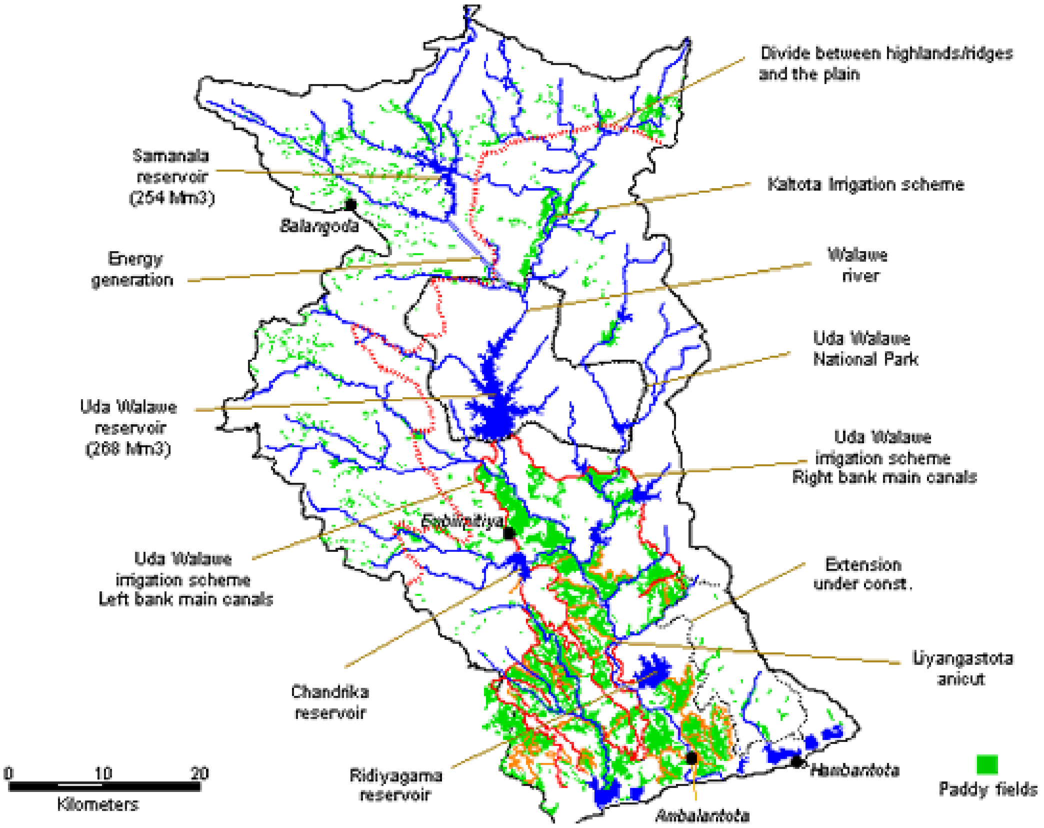

Figure 2:4. Map over Walawe river basin. Source: International Water Management Institute, n.d..

The Uda Walawe basin was ready to release water in 1968. During the construction, poor management created setbacks in the project as disputes arose between the villagers and the government. The government's plans were to increase the production in the area and distribute pieces of land to settlers. The farmers were urged to cultivate other field crops (OFC) on the dominating soil type, Reddish Brown Earth (RBE), to achieve an effective production, save up on water resources and prevent soil erosion (Molle & Renwick, 2005). Unfortunately, enough education was not offered for this type of cultivation and the promised subsidises for chemical inputs were sparsely provided. Unconcerned about soil type the farmers converted to paddy cultivation and because water regulation systems had not yet been installed, the farmers could use the water without limitations. This created water shortages, especially for the downstream farmers, damages to the soil structure and reduced crop profits.

The problems were accumulated and because of the poor management the project was handed over to the Mahaweli Authority of Sri (MASL) in 1982.

MASL managed to improve the system and the distribution of water (Divisional Secretariat, 2008). Homeless people were provided with irrigated land, agricultural production increased and the living standard improved. The aim was to develop 32000 hectare of land for irrigation and create settlements for people in the southern Dry Zone with the purpose to reduce poverty and homelessness and to increase the employment (Buysse, 2002). Once again a new attempt to make farmers cultivate OFC, rather than paddy, was initiated and this time results turned out better. A research revealed that since 1986 until 2001, an increase in part of land occupied by OFC occurred from 5 % to 40 %, out of which 30 % were bananas.

2.2.1 Agriculture in Sooriyawewa

Today paddy and Other Field Crops (OFC), including bananas, are the most cultivated crops in Sooriyawewa (Shinkai et al., 2007). The irrigation schemes that were developed in the area made it possible to cultivate paddy (Sooriyawewa D.S., 2008). Initiated in the late 1980's, 1.0 hectare respective 0.8 hectare irrigated land for paddy and banana was allotted to people who movedto the area, which led to an increase of the population in Sooriyawewa. In 1971 the D.S. Division was inhabited by 7522 people. 20 years later the Department of Census and Statistics reported numbers of inhabitants to be 35529. In 2007 the population was 44017 and in 2012 it had gone down to 43002. However, the population is expected to increase further. Table 2:1 features additional statistics from Sooriyawewa.

Table 2:1. Statistical information about Sooriyawewa D.S.

Sooriyawewa statistics	
Average temperature (*1)	27.5 °C
Average annual rainfall (*3)	1148 mm
Area (*1)	158.4 km^2
Agricultural land under irrigation (*2)	91.68 %
General farm sizes (*2)	0.86 ha
Families with incomes other than from farming (*2)	32 %
General farmer family size (*2)	5.08 ppl

Sources: Sooriyawewa D.S., 2008*[1], Shinkai et al., 2007*[2], Boelee & Van der Hoek, 2002*[3].

The agriculture in Sooriyawewa is mainly irrigated with water from the Uda Walawe basin, belonging to the Mahaweli Authority of Sri Lanka (MASL) (Farmer B, 2009). MASL has been responsible for the development, irrigation and restoration of Uda Walawe basin since 1982 (Molle & Renwick, 2005). MASL took several steps to improve the efficiency of the agriculture. One of the steps was to introduce the rotational irrigation system, which made sure that the downstream farmers got access to the irrigation water. Other steps implemented were the improvement of the agricultural support services and introduction of measures which would interrupt the reproduction of pests, which in turn increased the agricultural productivity.

On the local level, MASL has contact with the farmers through farmer organizations, which contact MASL in case of an irrigation problem (Buysse, 2002). MASL has placed a Development Centre in Sooriyawewa, with its main task to test and approve the paddy seeds and other hybrid seeds before sold on the market (Farmer B, 2009). The Mahaweli Development Centre provides farmers with knowledge about cultivation and agriculture for free through farmer society meetings in the village.

2.2.2 Interview methodology

Willis (2005) states that there is not "one right way to conduct interviews", instead the context and the person who is interviewed should be considered. Willis categories interviews into three groups, namely 'structured', 'semi-structured' and 'unstructured', although the categories can be hard to distinguish. The 'structured' interview is based on a set of questions and is the same for all interviewees. The 'semi-structured' interview is based on suggested questions, but there is room for the interviewees to elaborate their response. The 'unstructured' interview allows the interviewees to take the interview in the direction she or he chooses. The 'unstructured' interviews tend to be more conversational and may enter unexpected directions and cover unanticipated topics. The 'structured' interview can be advantageous when time is limited or when answers should be compared but it leaves no room for other information which will come up during the 'semi-structured' or 'unstructured' interviews. During the interviews in this study 'semi-structured' interviews were conducted but the interviews could sometimes become more conversational.

The interviews were carried out with help of an interpreter. The interpreter was a native Sri Lankan with Singhalese as his mother tongue, which was also the language of the farmers. The answers provided are thus not directly from the farmers. The interviews were often carried out in the farmer's home or in close proximity and the farmers seemed comfortable and appreciated our interest in their agricultural practise. Because of the need for an interpreter a question could sometimes be asked more than once or in a different way, if it was suspected that there was a misunderstanding or miscommunication. Therefore there is no reason to believe that the answers given contain any larger errors.

2.2.3 The interviewed farmers

Most farmers in Sooriyawewa D.S. division cultivate either paddy or banana and the division was thus a suitable study site. The farmers interviewed were selected randomly and then asked if they would agree on an interview.

In this study, the interviewed farmers have been assigned a letter from A to E instead of their real name to protect their identity. Longer and more in depth interviews were conducted with Farmer C and E. Farmer E had most experience with banana cultivation than the other farmers. A brief introduction of the farmers is given below to understand their background and situation.

Farmer A has 1 hectare of agriculture land where he cultivates paddy, banana and papaya. About 0.9 hectare consists of paddy cultivation. He studied agriculture in school when he was 15 to 16 years old and has been working as a farmer for 35 years. He manages his land by himself. Since 1987 he has been cultivating bananas and finds it more profitable and less labour demanding. Pesticides are not used, only manure.

Farmer B called himself an agrarian instructor and worked for the Mahaweli Development Centre. At the centre different crops such as paddy, banana, pineapple and grapes, were cultivated and new cultivation methods were tested along with the hybrid seeds.

Farmer C has 1 hectare of paddy cultivation. He started cultivating paddy when he was 18 years old and has been cultivating for 15 years. In school he studied agriculture theoretically and learned the practical techniques by his father at home. Farmer C is the oldest son out of three children.

Farmer D has 1 hectare of land where paddy is cultivated. They were given their land in 1977 and started to cultivate paddy in 1979. The family has tried banana cultivation in their past for a period of 2 to 3 years when water access was scarce. Banana cultivation was seen as a good alternative. This family consisted of a larger number of family members than the other interviewed farmer families.

Farmer E cultivates banana but cultivated paddy 10 years earlier. He has 0.5 hectares of cultivated land and 20 years of experience. The farmer and his wife live with their four daughters.

3 Physical environment

The physical environment, such as climate, geology and soil etc., influence the suitability of the spatial and temporal distribution of the crop cultivation. Therefore it is essential to study the physical environment and its processes in order to understand the constraints of the paddy and banana cultivation in the Dry Zone. The landscape, monsoon and rainfall distribution collectively influence the availability of water in the Dry Zone, whereas different crops are appropriate to be cultivated in different soil types, which depends on the soil type's characteristics.

3.1 Landscape

Sri Lanka's topography is characterized by an elevated south-central area, often referred to as the 'Central Highlands' (Peiris, 2006). The mountainous area occupies approximately 20 % of the land of the island with its highest peak Pidurutalagala reaching 2524 m. The Highland range innermost parts comprise of a plateau stretching from the north to south with an elevation of approximately 1800 to 1900 m. On both sides of this high plateau are two plateaus; Hatton Plateau (west side) and Welimada Plateau (east side), which descend and are found within the elevations of 400 to 1000 m. These lower plateaus are referred to as the 'Uplands' and are characterised by their erosional surfaces and gentler slopes - compared to the Highland. The Highlands are, together with the Uplands, collectively referred to as the Central Highlands. The Central Highlands are surrounded by a plain with an elevation that seldom exceeds 100 m. The plain is, in general, vast and flat in most parts of the island, except for in the southwest where it is narrow and rugged.

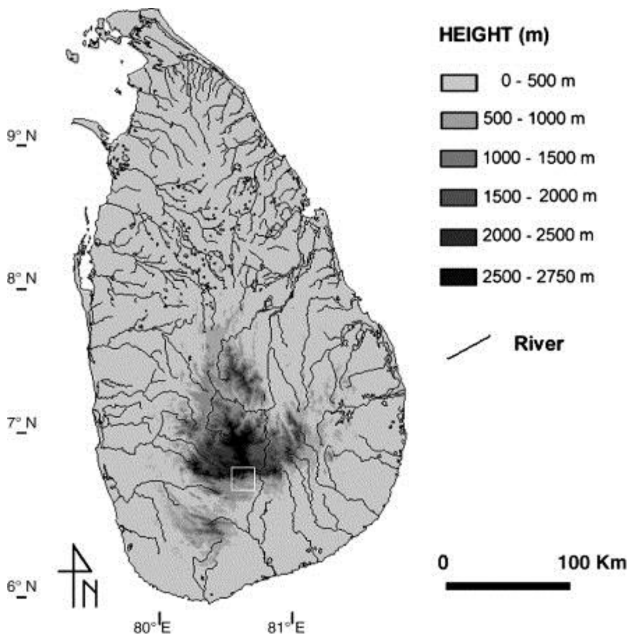

Figure 3:1. The topography in Sri Lanka. Source: Vanacker et. al., 2007.

3.2 Rainfall distribution

Estimations of the average annual rainfall in Sri Lanka have been made by several organisations and the outcome varies between 1800 mm and 2000 mm (Peiris, 2006); the methods used for estimating the rainfall in Sri Lanka has been criticised for not being carried out thoroughly. The annual distribution of rainfall varies from approximately 900 mm to over 5500 mm (Department of Meteorology in Sri Lanka, 2012) depending on the region, see figure 3:2. Areas receiving maximum rainfall are situated on the higher elevations, subjected to winds that bring moisture from the monsoonal, cyclonic, and convectional atmospheric processes (Peiris, 2006). The Central Highlands receive significant amounts of rainfall during the Southwest Monsoon while some areas located in close proximity are subjected to a rain shadow and are therefore substantially drier. The rainfall in the wet southwest part of the island does not fall below 150 mm per month during a year (Peiris, 2006) and thus the southwest region has the island's highest annual amount of rainfall. The northern and eastern parts of the island have a distinct dry and wet season with an annual rainfall below 2000 mm (Peiris, 2006). The rainfall in Sri Lanka is therefore not only unevenly distributed spatially but also annually. The coastal plains on the southeast and northwest parts of the island are the drier areas because the low altitude is protected from the humid orographic winds. The driest locations receive less than 1000 mm rainfall annually (Peiris, 2006). Normally these parts of the island have two months per year with no or very little precipitation but it is not unusual that the drought lasts for more than four months.

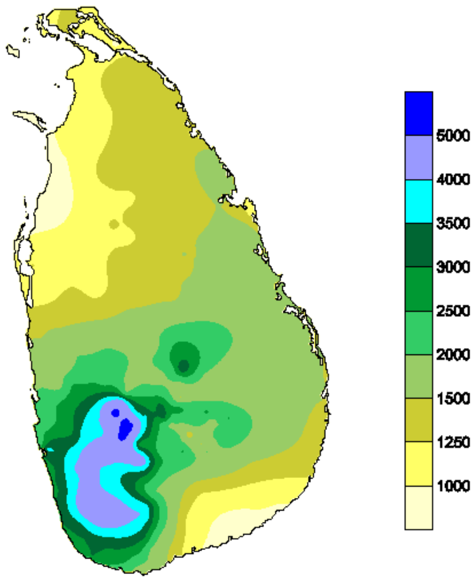

Figure 3:2. Annual distribution of rainfall (mm) in Sri Lanka. Source: Department of meteorology, Sri Lanka, 2012.

3.2.1 The monsoon seasons

Since rainfall varies more than
The temperature in Sri Lanka remains rather stable throughout the year but the amount of rainfall that falls varies spatially and temporally. Thus rainfall is used as the main factor that determines the climatic seasons (Peiris, 2006). The Department of Meteorology has identified four climatic seasons with varying length based on rainfall (Table 3:1).

Table 3:1. Sri Lanka's four climatic seasons as defined by the Department of Meteorology – Sri Lanka, 2013.

	Share of the year (%)	**Period**	**Description**
First Inter-Monsoon	21	March to mid-May	Most parts of the island receive 100 – 250 mm of rainfall. The Jaffna peninsula in the north is an exception and receives less (Jaffna 78 mm).
Southwest Monsoon	38	Mid-May to September	Heavy rainfall in the southwest (over 3000 mm of precipitation during these 4.5 months) and droughts prevailing in the eastern and northern parts (as little as 100 mm in some parts).
Second Inter-Monsoon	16	October to November	The period when the whole island receives most of its rainfall and the contrasts between the different Zones are not as pronounced.
Northeast Monsoon	25	December to February	The north and eastern parts of the hill country receive the highest amount of rainfall (maximum ~1200 mm) while the central western and the very south part receive the small amounts of rainfall (smallest amount ~180 mm).

The First Inter-Monsoon season runs from March to mid-May and is hit by convectional air circulation as a result of the Inter Tropical Convergence Zone moving across the island. The season begins with dry weather in most parts of the country apart from the southwest where the convectional air circulation creates thunderstorms. It continues with a gradual increase of rainfall, which soon marks the transition into the Southwest Monsoon season. During the Southwest Monsoon, rainfall increases in the southwest part of the country, including the southwest Highlands. Usually the rainfall occurs in spells but becomes more intense and lasts for longer as the altitude elevates. Meanwhile, the eastern and northern areas of the island experience a rain shadow and most parts face their driest months.

It is widely assumed that the island receives the majority of its rainfall when the Southwest Monsoon is present. This is, however, incorrect since the island receives more rainfall during the Second Inter-Monsoon season, running from October to November. This is partly due to the low pressure and the strong winds that come in from the southwest as a result of the surge that is created after the Southwest Monsoon. From December to February the regions subjected to drought during the Southwest Monsoon experiences their monsoon season named the Northeast Monsoon. The elevation is again an important factor determining the amount of rainfall that an area is subjected to. The northeast Central Highlands receive a significantly greater amount of rainfall compared to areas situated on lower altitudes. February is the last month of the Northeast Monsoon season and is also the driest month of the year.

3.3 Agro-ecology

To differentiate the locations in terms of the amount of rainfall received, the island is divided into climatic zones (Table 3:2). In literature before 1956 the island was divided into a Wet Zone and a Dry Zone (Panabokke, 1996). During 1956 and 1961 the deviation was extended and an additional zone was added, which is known as the Intermediate Zone. The Wet Zone is mainly found in the south-western quadrant of the country, subjected to the Southwest Monsoon, while the Intermediate Zone forms the transition between the Dry and the Wet Zone. The Dry Zone occupies 70 % of the land area (Panabokke, 1996) and is only found on the north, east and southeast plains (Peiris, 2006).

Table 3:2. The table shows the geographic distribution of climatic zones in Sri Lanka and the amount of annual precipitation in respective zone. Also featured is the zones' subdivision into agro-ecological zones and what factors determine their subdivision into agro-ecological regions.

Climatic zones and its share in %	Geographical distribution	Precipitation (mm/year)	Agro-ecological zone	Parameters deciding agro-ecological region
Dry Zone (63.5 %)	In the north, east and southeast.	Below 1500	Low Country Dry Zone.	Soil type.
Intermediate Zone (13 %)	In the transition between the Dry and the Wet Zone.	1500 to 2500	Low Country, Mid Country and Up Country Intermediate Zone.	Soil type and rainfall amounts.
Wet Zone (23.5 %)	In the southwest.	Above 2500	Low Country, Mid Country and Up Country Wet Zone.	Rainfall amounts.

Source: Agro-ecology of Sri Lanka, n.d. and Peiris, 2006.

3.3.1 Agro-ecological zones

A further subdivision into agro-ecological zones and regions was developed for a clearer identification of where about on the island different farming systems and crops are suitable. The sub-division is based on the distribution of tree species, rainfall, temperature, relief and soil type (Climate of rice growing regions in Sri Lanka, n.d. (no date)). The agro-ecological zones are determined by rainfall distribution throughout the year, as well as by temperature variations that occur in the Wet and the Intermediate Zones. Since temperatures have an apparent correlation with elevation, it has been divided into three stages: the Up Country which is defined by elevations exceeding 900 m, the Mid Country, ranging between 300 to 900 m, and the Low Country on elevations below 300 m (Agro-ecology of Sri Lanka, n.d.). The Dry Zone is only defined in the Low Country and consequently, seven agro-climatic zones are identified in Sri Lanka (Agro-ecology of Sri Lanka, n.d.).

3.3.2 Agro-ecological regions

The agro-climatic zones are further divided into 24 agro-ecological regions, subdividing the Wet Zone based on distribution of rainfall, while soil type is the key parameter when the Dry Zone is subdivided (Climate of rice growing regions in Sri Lanka, n.d.). The Intermediate Zone is influenced both by soil type and rainfall distribution and is subdivided after the two parameters. Subsequently, ten agro-ecological regions fall under the Wet Zone, nine under the Intermediate Zone and five under the Dry Zone. As an example, Sooriyawewa and most of Hambantota district is situated within the agro-ecological region called DL5, defined as having a surface that is mainly undulating with a varying slope of 2-8%. DL5 is also a region where most of the land is prepared for cultivation of paddy during both the cropping seasons, Maha and Yala, see below (Domrös, 1974).

3.4 The cropping seasons

Maha and Yala are two terms frequently used in agriculture to distinguish the wet and dry season in Sri Lanka (Senewiratne et al., 1966). Maha begins in October and ends in March and represents the wet season of the Northeast Monsoon (Domrös, 1974). Yala is the name of the drier season of the same region and lasts from April to September. For cultivation during Yala, water derived from irrigation is usually required. Note that the south-eastern quadrant of the island receives most of its rainfall during the Yala season due to the presence of the Southwest monsoon (Department of Meteorology Sri Lanka, 2012), while the rest of the country experiences its dry season (Peiris, 2006).

3.5 Water availability in agriculture

The amount of water available for paddy and banana cultivation is influenced by factors like precipitation, availability of irrigation, topography, elevation and soil type (Wikkramatileke, 1963; Peiris, 2006). Because of the low and unpredictable rainfall in the Dry Zone most of the agriculture is irrigated and relies on the amount of water available in the region's reservoirs and canals. The stored amount of water depends on how much water that has entered the catchment area and found its way to the reservoirs as well as the amount of rain falling, which makes size and location of the catchment area important (Wikkramatileke, 1963). The rate of the surface drainage in Sri Lanka's uplands is high due to the steep topography and the enhanced rainfall that generally prevail at these altitudes (Peiris, 2006). The impermeable characteristic of the crystalline bedrock, which constitutes about 90 % of the whole island's bedrock, helps to increase the rate of the surface drainage even more. Since the landscape is flatter in the lowlands and the rainfall is not as abundant as in the highland the surface run-off is reduced (Wikkramatileke, 1963).

The soil types and their physical and chemical characteristics determine how well the water is kept in the ground (Peiris, 2006). The characteristics of the soil particles and the space between them determine the properties of the soil (Chapin III et al., 2002). A soil consisting of fine soil particles generally group together and forms aggregates between which space is created that makes the soil more porous compared to a soil consisting of coarse particles. These aggregates are formed when soil particles sticks together and cracks into pieces during the process of freezing and drying. Clay and loam soils are soil types in which aggregates often are formed in opposite to sandy soils. The materials responsible for the soil particles to stick together and form aggregates are, among others, organic matter, iron oxides, polyvalent cations and silica. The aggregates help to improve the circulation of water, gases and nutrients in the soil.

The water holding capacity of the soil increases when the soil particles decrease due to increase in surface area (Chapin III et al., 2002). A sandy soil will thus have a lower water holding capacity than a clay soil. However, a sandy soil will become saturated faster than a clay soil after rainfall due to its larger pores, but a sandy soil will consequently not be able to retain water at the surface level, where the water is available for most plants. A soil's characteristics therefore determine the ability for plants to absorb water and thrive.

3.6 Soil type distribution

The soils types in Sri Lanka are mainly distributed based on the island's climate and topography (Peiris, 2006). This becomes evident when the geology of the Dry Zone is compared to the Wet Zone. The Dry Zone is dominated by the Red Brown Earth (RBE) while the Red Yellow Podzolic Soil dominates the Wet Zone (see figure 3:4). Together these two soil types cover a land area of approximately 65 %. Regosols, found around the coast line, which constitute the beaches and dunes, and alluvial soils, present in river valleys and flood plains, are the only soil types present in both zones.

In Uda Walawe basin and in Sooriyawewa, together with the rest of the Dry Zone, the well-drained RBE (Table 3:3) covers about 50 % of the land area (Molle & Renwick, 2005). The soil occupies crests as well as upper and mid fractions of slopes. When dry, the soil is very hard but changes from brittle to solid when it is moist and into sticky and plastic when wet (Panabokke, 1996). The other widely distributed soil type in Sooriyawewa and Uda Walawe is the hydromorphic Low Humic Gley Soil (LHG) (Table 3:3) which is found in upper parts of valley floors and on lower topographical positions where the drainage is poor (MASL, 1995). When the soil is dry it is characterised as hard and when wet it gets sticky due to slightly higher clay content (Panabokke, 1996). Where neither LHG nor RBE dominates, the soil is usually a mixture of these two (Shinkai et al., 2007). The mix is an imperfectly drained soil type.

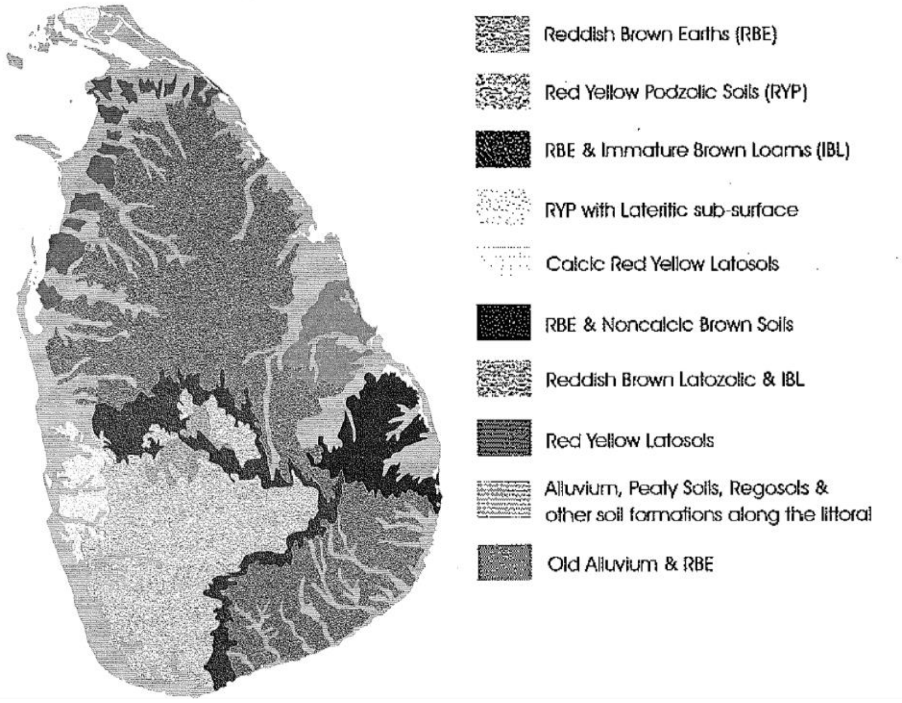

Figure 3:4. Map of the soil distribution in Sri Lanka. Source: Peiris, 2006.

3.6.1 Low Humic Gley Soil and Red Brown Earth

Both the LHG and the RBE are under the U.S. soil taxonomy order Alfisols, well known for having a high clay content and low acidic level (Chapin III et al., 2002). The soils have low organic matter content, between 0.5 to 2.0 % (MASL, 1995). LHG has higher water holding capacity, defined as fairly good, compared to the low water holding capacity of the RBE. Because of this the LHG is more suitable for cultivation of paddy. RBE on the other hand is suitable for cultivation of OFC i.e. banana.

Table 3:3. The table shows the properties of the two soil types that dominate in Sooriyawewa and in the Uda Walawe area: the RBE and the LHG.

	Texture *1	**pH** *1	**Seepage and Percolation** *2	**Suitable crop** *1
RBE	*Surface*: sandy clay loam to clay loam *Sub surface*: sandy clay loam, sandy clay to clay	5.5 to 7.7	7 to 30 mm/day Imperfectly drained to well drained.	Banana
LHG	*Surface*: sandy loam to sandy clay loam *Sub surface:* sandy clay loam to clay	5.5 to 6.5	3 to 4 mm/day Poorly drained.	Paddy

*Sources: *1: MASL, 1995. *2: Rice Knowledge Bank, 2007; Ohtani, 1993*

3.6.2 Soil problems

Generally LHG and RBE are free from chemical disturbances but can in cases nevertheless be subject to such problems (Panabokke, 1996). LHG easily obtain a high ground water table, a condition that increases when water is provided from irrigation, which may damage the crop roots (MASL, 1995). At lower profile depths, the soil may contain concentrations of carbonates, which in combination with a high ground water table may contribute to salts moving upward when dissolved in water. In worst case scenarios, the increasing and ascending high salt level causes a too high salinity environment for the roots. For this reason a good drainage system is important on LHG. Sufficient drainage is also necessary to prevent waterlogging. When LHG is waterlogged, gleying can be recognized in the soil, which means that the iron content in the soil is reduced under the existing anaerobic circumstances and concentrates to the spots where oxidation can still occur (Pitty, 1978). The RBE can sometimes receive a duricrust, which makes percolation more difficult.

4 The crops

Today both banana and rice cultivation are important for Sri Lanka's population. Rice is the most consumed product and banana is the most consumed fruit and both crops are widely distributed in the Sri Lankan agriculture (Hirimberagama & Dias, 2004). The term *paddy* refers to the rice crop before it has been milled. After paddy is milled it is recognized as rice (Werrahewa, 2004).

In 2009, the extent of banana cultivated occupied an area of 48,044 ha (Ceylon Chamber of Commerce, 2011), while paddy occupied and area of 611 074 ha during the Maha season 2011/2012 and 272 370 ha during the Yala season in 2012 (Department of Census and Statistics Sri Lanka, n.d.). Paddy is the most common land use class in Sri Lanka (Peiris, 2006). However, it is not possible to cultivate the two crops everywhere on the island. According to Domrös (1974) paddy cannot grow in areas situated on higher elevations than 1200 m and DOASL (Climate of rice growing regions in Sri Lanka, n.d.**)** report that paddy is cultivated in all agro-ecological regions except from the regions situated in the Up Country Wet Zone, and only in one of the regions in the Up Country Intermediate Zone (see table 3:2). The banana is also limited by the elevation and is recommended to grow below 1500 m because of the higher altitude's effect on temperature, rainfall, humidity and light intensity (Nippon KOEI Co., n.d.).

Figure 4:1. The paddy and banana crop are the most cultivated crops in Sooriyawewa and are often seen cultivated next to each other. Picture: Erica Perming, 2009.

4.1 Paddy

Paddy cultivation has increased significantly since the mid-1950 to the mid-1990 due to the development of irrigation schemes in the dryer areas of the island (Peiris, 2006). The land which is occupied by paddy cultivation continues to expand but it is believed that it is reaching a point in which it will not be economically feasible to develop irrigation schemes that will not cost more than it yields. In the future it is estimated that the paddy cultivation will occupy a maximum of 900 000 hectare (Peiris, 2006). Currently about two million hectare is under permanent agriculture and paddy stands for about 40 % of the cultivated areas.

There are different varieties of paddy which can grow in different environments on the island (Wikkramatileke, 1963). The major part of paddy is cultivated in so called homesteads where the land seldom is larger than one hectare and where a variety of other crops, apart from paddy, also grows. A homestead is a family who uses their land to grow different crops for own use and for selling. Since homesteads only cultivate crops in smaller scales, this group has difficulties to provide the family with basic needs (Weerahewa, 2004). It is debated whether paddy is a more profitable crop to grow than other crops. Many factors influence on the cost of paddy cultivation. Large scale cultivation when paddy can be harvested twice a year is to prefer rather than small scale cultivation in terms of costs. The price of paddy is a factor which determines how profitable paddy cultivation is. This in turn depends on the market and is therefore subjected to fluctuate. Sri Lanka is self-sufficient to approximately 95 % for rice but this figure fluctuates depending on the market (Rice, n.d.). About 1.8 million families rely on paddy cultivation and in 1970 the paddy production was 1129 kg per hectare (Weerahewa, 2004). However, the production has increased since then and the production was 4295 kg/ha in average for the Maha and Yala year 2011/2012 (Department of Census and Statistics Sri Lanka), which correspond to an increase that is almost four times as large.

4.1.1 Water problems during paddy cultivation

Paddy is generally considered to be a ‘semi-aquatic annual grass’ when it is cultivated and therefore grows well in flooded environments (Chandrasekaran et al., 2007). The demand for water is higher for paddy than for other crops but it is debated whether it is necessary for the crop to grow in standing water to the extent that is practised today. Experiments carried out in India and especially in Tamil Nadu showed that the yield was higher if the crop was under a shallow depth of water throughout the cultivation (Chandrasekaran et al., 2007). It was enough to flood the field to a level of five cm, which would percolate after a day or a few days depending on the soil. Thus, the water did not have to remain on a standing level, instead it was enough if the soil was kept soaked and irrigated when the water had percolated (Chandrasekaran et al., 2007; Senewiratne et al., 1966). It is, however, acknowledged that there are advantages when paddy cultivation is flooded with water (Senewiratne et al., 1966). The water acts like a buffer against temperature changes and the standing water eliminates some of the weed. Some disadvantages have been reported with standing water method, one is that the muddy water can damage the stomata function. A study by Senewiratne (1966) has also been made for how the paddy will respond to a saturated soil compared to standing water. The outcome of the study gave the same results of the experiment later conducted in Tamil Nadu. The study showed that the saturated soil gave very good results and the only advantages with standing water were the weed reduction. The benefits with the standing water method are otherwise the same as from saturated soil. For this reason soil saturation is to recommend instead of higher level of standing water according to Senewiratne (1966), since standing water demands a lot of water, which in many areas are scarce and weed can be eliminated using other methods. Senewiratne (1966) states that if paddy was cultivated with techniques, where the soil only would be given enough water to be saturated, a greater area could be cultivated with the same amount of water. On the other hand, the need of water for paddy depends heavily on the soil type (Peiris, 2006). For example, RBE needs approximately 1057 to 1751 mm water for one season while LHG need water ranging from 402 to 1128 mm (Peiris, 2006).

4.1.2 Methods of paddy cultivation

The methods used for paddy cultivation has changed significantly since the human first began to cultivate paddy thousands of years ago (Chandrasekaran et al., 2007). In the beginning paddy was cultivated in rain-fed areas. No bunds were used in the fields for water harvesting and only the Broadcasting method (see below) was used. Later when the cultivators became more permanently settled, the bunds were introduced and the Parachute method (see below) was developed. Today the methods have evolved to include advanced machines and extensive irrigation schemes.

4.1.2.1 Sowing of paddy

During the interviews with the farmers it became evident that there are mainly three different methods used for planting the paddy seeds. One method is the Parachute or Transplanting method which consists of a so called green disk (see figure 4:2) with a lot of small pits filled with clean soil in which 2 to 3 paddy seeds are planted, yielding about 20 to 30 plants. The green disk is thereafter covered with old paddy straws and when the sprouts become visible the cover is removed. After 10 to 12 days the plants are removed from the green disk and planted in the field by hand. The Parachute method is preferred because it gives a higher yield. The disadvantage is that it can be very expensive since it demands a lot of labourers (Table 4:1). This method was used by farmers with larger families and by the agrarian instructor at the Mahaweli Development Centre in Sooriyawewa. The water needed for this method is less the first 10 days than for the other methods and thereafter the amount of water is the same for all methods.

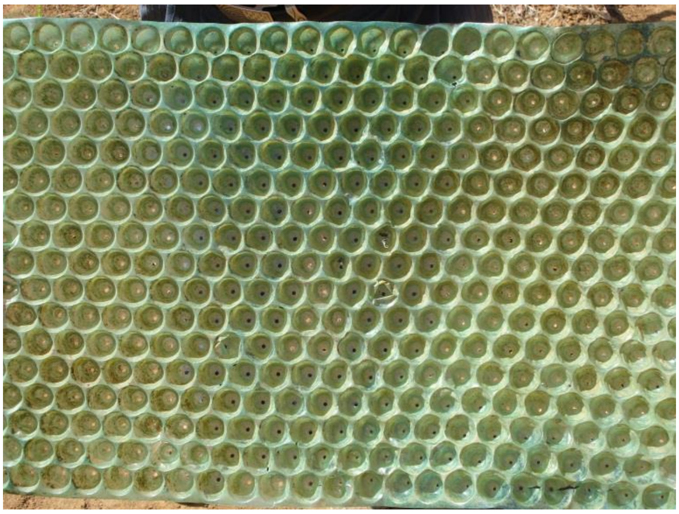

Figure 4:2. The figure shows a green disk used during the Parachute method, also known as the Transplanting method, in Sooriyawewa D.S. division. Photo: Erica Perming, 2009.

Another method, which seems to be used more frequently, is the Spray or Broadcasting method. It works as it indicates; the seeds are thrown out on the fields instead of planted plant by plant neatly by hand as described above. This method does not demand much labour and is therefore cheaper but the amount of seeds that are used is larger than for the Parachute method and the yield is not as high. The third method is a combination of the previous methods but prior to Broadcasting the paddy seeds are drenched in the farmer's water container for 24 hours. Thereafter the paddy seeds are put in bags to soak for three days.

These bags are covered to be kept warm. During the course of the three days, small sprouts will have grown from the paddy seeds and they can then be thrown out on the fields. The advantages with this method are that it does not demand as much labour and that the amount of used seeds needed is smaller than for the Broadcasting method which makes it less costly. Farmer C said that about ten kg of paddy seeds are used for one hectare. If the Parachute method is implemented the weed control will be better and the crop will maturate more evenly which will result in a higher grain yield (Chandrasekaran et al., 2007).

Table 4:1. A summary describing the advantages and disadvantages with the different paddy sowing methods.

	Parachute method	**Broadcasting method**	**Combined method**
Advantages	Gives, according to the farmers, 25 to 30 % higher yield than the Broadcasting method.	Does not demand many labourers and is simple to implement.	Gives higher yield than the Broadcasting method and less seeds are used.
Disadvantages	Demands labourer which is costly unless the farmer has a big family that can help.	The yield is not as high as for the Parachute method and more seeds are used.	Yields less than the Parachute method.

4.1.2.2 Paddy cultivation practices

Before cultivating paddy it is important to prepare the land in order to eliminate a denser growth of weeds and to even out the ground in order to maximizing the yield (Widusara Science Magazine, 2003; Farmer C, 2009). The following paragraphs, which describe the cultivation practices, were obtained from the interviews with Farmer C. The paddy farmers are given the Widusara Science Magazine, which recommends the amounts of fertilisers used and gives further advices on how to best manage the paddy cultivation. The figures in this section is thus from the Widusara Science Magazine unless some other sources are stated.

Figure 4:3. The hand tractor, also known as the land master, is used by the farmers when preparing the paddy field for cultivation. Different tools can be attached to the hand tractor and it can therefore be used when for several different purposes. Photo: Erica Perming, 2009.

The field is, to begin with, filled with water to make the soil muddy and easier to plough with the hand tractor (sometimes called land master, see figure 4:3). The ploughing has the effect of decreasing the growth of weed when the soil is turned upside down as the soil becomes more porous when it is let to stand to dry for a week. In the meantime the weed is removed from the bunds (see figure 4:4), which captures the water. The field is continuously filled with water and the surface of the land is evened with a rake which is mounted to the hand tractor. The bounces are stabilised and strengthened. The procedure of making the surface even is repeated two times and takes eight to ten hours for a paddy field of one hectare. The day before the last day of raking the preparation of the seeds starts when using the Combined Broadcasting method. Before sowing, the field has to be drained from water and therefore smaller drainage canals, connected to the main drainage canal, are dug with a depth of 5 cm and with a distance of one meter. Note that there is one canal which fills the field with water and one that drains the field. When the farmer later manages the field with fertilisers and pesticides it is possible for the farmer to walk in these drainage canals without disturbing the paddy plants. Before using fertilisers the field has to have a thoroughly evened surface so no cracks will develop and this is done by using a flat rake. The procedure of draining, evening the surface with a flat rake and distribute fertilisers to the field is in the study area done by eight people for one hectare and takes about eight hours.

Figure 4:4. Bunds are prepared during paddy cultivation to capture the irrigation water. The farmers use the bunds to walk on them so the paddy will not be destroyed and for the sake of simplicity. Photo: Erica Perming, 2009.

Subsequently the field is prepared for spraying and then left three days for the seeds to take root. The following 30 days the farmer is supplied with as much water as needed for the reduction of weed but there is only as much water standing in the field to cover the top of the paddy plant. During this stage the paddy seed itself does not need much water. After six hours the field is drained to prevent the paddy plant from drowning. This is repeated again after two to three days for about six days. The method of standing water, when paddy is cultivated under water is a very effective way of eliminating the weed in the early stage of cultivation, according to the farmers. It is of vital importance that the weed does not overgrow the paddy because it affects the harvest, which would turn out less prosperous. To eliminate the weed further herbicides are used on the drained field. During these three days when the herbicide is left to reduce the weed, it is essential that no rainfall is present because the herbicide would be dissolved in water and be useless. By now the paddy plant have grown to approximately 12 cm which is higher than any weed and when the field is filled with water it should be filled as high as seven to ten cm or to the height in which the water will reach the paddy plants' leaves. The waste water is then removed after two days and this process is repeated twice. When approximately 14 days have passed since the paddy seeds were sowed, it is recommended to use 75 kg of urea for one hectare of paddy land. For the next seven days the paddy field stands under water with a water level of 5 to 8 cm.

When the field has been drained a fertiliser named broad-leaved herbicide is used and the following three days there is no water supply. The final process to eliminate the weed is to fill the field with as much as 20 to 25 cm of water kept on a constant level for three days. The water is then removed and the field is without water for three days. During the remaining of the cultivation period water will only be provided to the farmers 10 to 12 hours for four to nine days and then no water for four to nine days, since it has now been 30 days since the cultivation started. Paddy can survive up to 10 days without water but more than that will kill the paddy plants. Due to the sprouts growing from the paddy plants, too much water will drown the sprouts. During the remaining cultivation less water is recommended, since it is enough if the soil is soaked. Five days later 135 kg of urea and 50 kg of Muriate of Potash (MOP) is added for one hectare. From now on the field will be left to grow and it is only the water that needs to be regulated or pesticides that needs to be used if there is any fungus or other disturbances. The farmer looks after the field every day or every second day to make sure there is no disturbance.

Approximately two weeks before harvest the water supply is stopped for the soil to be dry when the paddy is cut which will prevent the paddy from attract fungus. However, other sources states that to obtain the maximum yield the field should be drained from water seven to ten days before the harvest is due (Chandrasekaran et al.,2007) The draining also has the advantage that it speeds up the ripeness. The maturity of paddy is confirmed by opening the husk of a few grains to confirm that the rice seeds are firm and has the right colour. It is beneficial to harvest when the paddy is mature and has the right moisture level of 19 to 23 %. The maturity can be hurried by spraying water mixed with 20 % of sodium chloride one week before the expected harvest date to avoid the monsoonal rains by three to four days. The harvest can be postponed if heavy rainfall occurs (Farmer C, 2009).

4.1.2.3 Harvesting of paddy

The harvest of paddy is today largely executed with the help of machines which have replaced a lot of labourer. In Sooriyawewa there are two main methods used for paddy harvest. The method which is used depends on the size of the paddy land and whether the land is muddy or not. For the smaller paddy fields the harvest is executed by cutting the paddy straws by hand with a sickle (figure 4:5). The paddy straws are cut closer to the root, which facilitates the bundling.

Figure 4:5. The figure shows the paddy straws being cut by a sickle. This practice is used when the paddy fields are within the small size range. Photo: Erica Perming, 2009.

Normally it is recommended to perform this process within one day and the time it demands depend on the size of the field and the number of labours. The farmer who cultivates paddy for economic reasons but does not own a field big enough for more advanced machines will need more labours for the paddy harvest. When the paddy field has been cut down the paddy straws are collected and tied into a bundle and then carried to the combine thresher, which separates the paddy grain from the straw. The step in which the paddy grain is separated from the straw is called threshing. The paddy that has been threshed has a lot of paddy waste and foreign material such as bits of soil and it is important to remove these parts to make sure it will not damage the paddy. This step of the process is called cleaning of paddy and it is performed with help of a winnower with a fan that, because of its light weight, blows away the straws, paddy waste and the foreign materials as shown in figure 4:6.

Figure 4:6. The bundles of paddy straws are carried to the combine thresher where the paddy straws are separated from the paddy grains. The straws and waste materials are blown out from the machine, which can be seen on the picture. Photo: Erica Perming, 2009.

What remains is the good paddy which goes straight from the machine into the bags and is then ready to be stored or sold to the miller. This process of separating the paddy from the straw and remove weeds are sometimes done by smaller machines with less capacity of performing the separation thoroughly and therefore the process has to be repeated. For farmers with larger paddy fields it is profitable to rent a more advanced machine namely Combined Harvester, which will perform the whole process at once, including cutting the paddy straws. After the Combined Harvester has harvested the field it stops and empties the paddy (figure 4:7). This machine demands less labour and execute the process considerably faster. One farmer said that when using this machine it only takes four hours to harvest one hectare of land.

Figure 4:7. The Combined Harvester executes the whole procedure of cutting, separating paddy seeds from paddy grains and cleaning of paddy all at once. This method is used for larger fields where it is profitable to rent the machine. Photo: Erica Perming, 2009.

4.1.2.4 Post harvest

It is recommended that the paddy is dried after the harvest, if possible within twelve hours, to reduce the level of moisture and thus the risk to attract fungus (Chandrasekaran et al., 2007). The drying is performed while the paddy is stored after threshing and it cannot be over emphasized to execute the drying in correct manners since it ensures that there will be no product loss. It is advantageous to store the paddy before it is milled since the husk protects the enclosed rice seed from storage pests, fungus etc. If this process is managed poorly the consequence will be a loss in production. The drying is unfortunately often neglected because of lack of knowledge. Storage of paddy for a longer period of time demands lower moisture content. If stored over a year it is recommended that the moisture level is 9 % or less and for storage of eight to twelve months, the moisture level should be 13 % or less. For short time storage of two to three weeks it is enough to reach a moisture level of 14 to 18 % (Chandrasekaran et al., 2007). Since paddy is cultivated in environments with high relative humidity and high temperatures the paddy can increase its moisture level after drying if the storage management is not carried out correctly. To protect the crop from being subjected to fungus the paddy should be harvested when the moisture level is right. To clean the machines before harvest to prevent dirt, dust and other unwanted materials from coming in contact with the paddy is also important. When stored, the grain should be controlled regularly to make sure no moisture enters the grain. The usage of safe bags impregnated with chemicals will limit the moisture, insects, micro-organisms, etc., to get into the bag. The quality of the grain does not only depend on the time it was harvest and the drying and storage process but is also determined by its physical and genetic features such as shape, size and the chemical characteristics.

In the process of milling the husk is removed from the paddy and it is thereafter known as rice (Chandrasekaran et al., 2007). The husk yield 30 % of the total mass and the rice seed yield the remaining 70 % and thus paddy weights more than rice. The machine used for this process also polishes the rice so the rice will not become rancid. If polished too much, the nutrients will be reduced to some extent (Chandrasekaran et al., 2007).

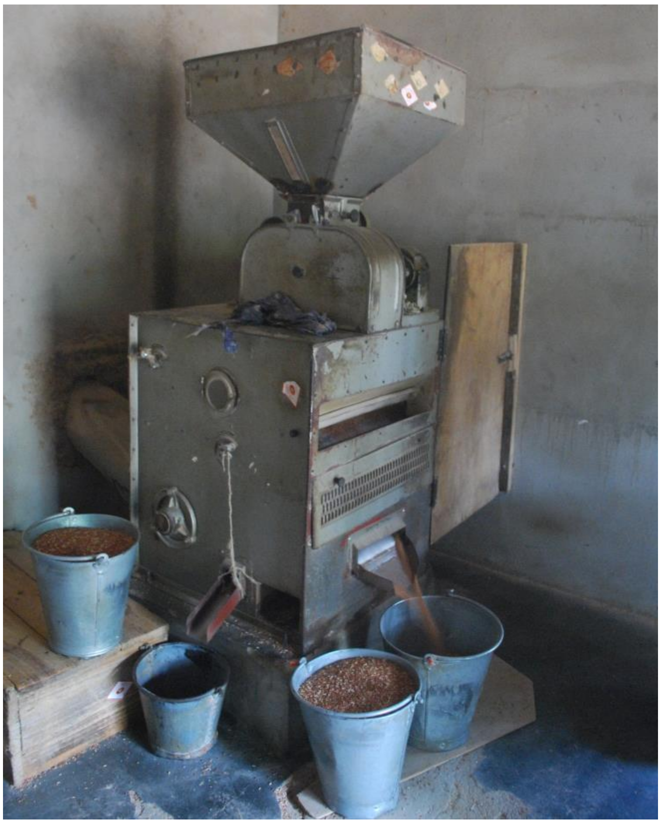

Figure 4:8. This machine is used when the husk is removed from paddy. The paddy seeds are put into the machine where the husk is removed and the rice comes out and land in a bucket, while the waste of the husk lands in another bucket, as seen in the figure. Photo: Erica Perming, 2009.

4.2 Banana

The banana (*Musa sp.*) is counted as the world's fourth most cultivated fruit crop and is the most popular fruit in Sri Lanka (Arvanitoyannis & Mavromatis, 2009). According to Ratnasinghe (2002), a total of 29 varieties are cultivated on the island and the varieties differ in appearance in their ripen state. The varieties can be seen with skin colours such as reddish purple, yellow, green and silver and the sizes vary significantly, from lengths between 3 to 40 cm, and diameters from 2 to 8 cm (Arvanitoyannis & Mavromatis, 2009). Ratnasinghe (2002) mentions 6 popular varieties in Sri Lanka, out of which the Farmers mentioned Embul, Kolikuttu and Seenikehel as the most common to cultivate in Sooriyawewa.

4.2.1 Crop requirements

As bananas thrive best in an environment between 20°N and 20°S the narrow latitudes of southern Sri Lanka makes a suitable setting for the plant (Hurlston, 1991). Sufficient sunlight and temperatures between 26°C to 30°C are preferable in order to achieve a healthy development. At about 16°C the leaves stop growing and by 10°C the banana fruit will no longer develop because of its frost sensitive nature (Flagg, 2004). Temperatures that exceed 36°C enhance the transpiration rates as the leaves are sensitive to the heat (NIIR Board, 2004). High temperatures in combination with water stress can cause cracks in the fruit tissues and result in a weak pseudostem (fig 4:9). Windy environments are also not suitable for the banana.

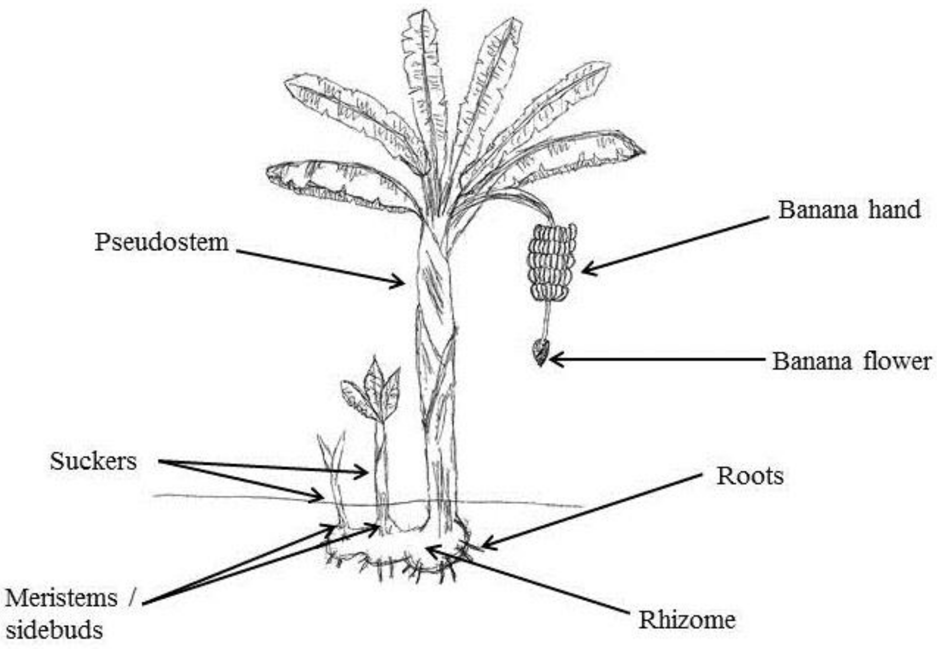

Figure 4:9. He drawing shows the names of the different parts of the banana plant. Drawing: Erica Perming, 2013.

Apart from the fact that the banana has evolved in a warm climate the crop has also developed to prosper in a wet environment, making the water supply an important factor (NIIR Board, 2004). The ideal situation is an even distribution of rainfall throughout the year. The amount of rainfall that is thought to be required for banana cultivation varies a lot depending on the literature source. NIIR Board (2004) suggests an annual rainfall of 500 mm to 2000 mm while Kudagamage (2004) proposes amounts between 2000 mm to 2500 mm. Kudagame's recommendations may, however, be more relevant in this case since the article is written based on Sri Lanka's physical environment. Too much water during the growth period generates damage and oxygen deficit to the banana plant. The main parts of the roots grow within the depth of one meter below ground and a high ground water table may therefore cause severe destructions to the roots (Hurlston, 1991). 24 hours with a high water table level is enough to kill the roots and a high water table that continues for several days makes the colour of the leaves turn pale.

Bananas grow in most soils but have no tolerance for salinity (Arvanitoyannis & Mavromatis, 2009). The desired types are the loamy soils with a coarse texture and a depth of 1.5 m or more to ensure a healthy growing root system (Hurlston, 1991). As mentioned above the RBE is most suitable for banana cultivation (MASL, 1995). A well-drained soil is to prefer as standing water is destructive to the plant (Hurlston, 1991; Arvanitoyannis & Mavromatis, 2009). To find the soil that is most productively and economically profitable for banana cultivation, the soils are divided into three classes (Table 4:2) (Hurlston, 1991).

Table 4:2. The soils suitable for banana cultivation are divided into three classes.

	Characteristics of the soil class
Class I soil	Well drained, deep and highly fertile. Soils should form a flat surface and not contain any salt or stones.
Class II soil	Will require some maintenance since it might contain stones, have a sloping surface or have a slow drainage. The soil type is not saline and the fertility level is fairly good.
Class III soil	Have the same limiting characteristics as the second soil class but the problems are more significant. This means that more money is required to keep the soil in a good condition.

4.2.2 Plant characteristics

The banana crop is a perennial herb with a life cycle of about 4 to 10 years (Hurlston, 1991; Arvanitoyannis & Mavromatis, 2009). It consists of a rhizome (see figure 4:9), or a core, in which several meristems, or side buds, are located. The plant's vertical up-growing stalk is composed of leaves that are wrapped tightly together and is therefore called pseudostem. It emerges from the meristem. From the top of the pseudostem the fruits grow and develop in layers called hands. Each hand holds 10 to 20 bananas and up to 15 hands can grow on each stem (Arvanitoyannis & Mavromatis, 2009).

After harvest the pseudostem deceases but the rhizome continues to produce sprouts from its meristem, which is why the rhizome can be referred to as the banana's underground stem. The most mature sprout is named mother plant and each mother plant produces additional sprouts known as suckers (Weerasinghe, Ruwanpathirana & Pemachandra, 2002/2003). Three different kinds of suckers emerge from the mother plant's rhizome but all of them are not appropriate for producing bananas and therefore a selection is made (Hurlston, 1991).

- The sword sucker is the one chosen to continue the line of the fruit producing generation. It is recognized from its slender "sword-like" leaves and for being connected to the mother plant.
- The water sucker is not connected to the mother plant's rhizome, which causes it to be weak and develop badly with small bananas. Water suckers are recognized by their broad leaves.
- Regrowth suckers grow up again after a sucker has been removed and are therefore not suitable.

4.2.3 Planting material and tissue culture

Farmers in Sooriyawewa are mainly provided planting material from neighbouring farmers or from Mahaweli Authority (Farmer B, 2009; Farmer E, 2009). Insects, fungus, nematodes (group of small worms) and viruses are not uncommon problems affecting the planting material in this stage (Kudagamage, 2004; Arvanitoyannis & Mavromatis, 2009). When the suckers are removed from the mother plant it consequently damages the root system and rhizome to some extent, which in turn has a negative impact on the yield. Therefore a method called tissue culture has been developed and recently introduced in the study area. It improves the quality of the banana and its planting material and is advantageous to the production because a larger quantity of plants can be produced within a short period of time.

The tissue culture method is based on removing cells or tissues from healthy mother plants' rhizomes (Kudagamage, 2004; Arvanitoyannis & Mavromatis, 2009; Farmer B, 2009). These are subsequently treated and disinfected in a laboratory to reduce soil borne diseases and remove pests. The tissue culture plants grow separated and sprout before planted in the fields. However, the tissue culture plants do not always turn out prosperous according to Farmer B (2009) who mentions that tissue culture bananas were cultivated at the Mahaweli Development Centre with a bad result as the bananas developed poorly. Other farmers who purchased plants that originated from the same tissue experienced the same problem. Farmer B and Arvanitoyannis & Mavromatis (2009) state that the tissue culture method has many advantages and can supply disease-free material all year round. However, it is expensive to purchase the disease-free tissue plants.

4.2.4 How to cultivate bananas

In addition to literature studies the local methodology of banana cultivation was obtained from field work and the farmers interviewed. During the interview with Farmer E (2009) the basic process for banana cultivation was explained. As for paddy cultivation, the first step is to prepare the land by removing weeds, plough the soil and make the surface even by using a rake. Bounds or fences are created to prevent soil erosion. Thereafter holes with a diameter of 30 cm are dug to plant the suckers. The depth does, however, depend on the height of the rhizome, which should be buried just underneath the soil surface to prevent it from suffocating. The distance between each hole is measured to approximately 2.5 m (Hurlston, 1991) but can vary between 2.4 to 3.4 m depending on the banana type as well as on the soil fertility, irrigation system, pruning regime and whether machines are used or not (Arvanitoyannis & Mavromatis, 2009). A more fertile soil produces larger plants and requires a greater distance between the plants in the field. The holes are filled with manure, and around each hole, 200 g of chemical fertilisers are applied. After three days, when the fertilisers have percolated into the soil, it is soaked with water (see figure 4:10). Thereafter the suckers are planted.

Before being planted, the sucker is dipped in a liquid mix of the pesticide Carbofuran and water to clean it from insects and diseases (Nippon KOEI Co., n.d.). Subsequently the plant is left for approximately one week in the shadow before it can be planted in the soil. During the first months after planting, the farmer prepares the field for irrigation by digging shallow canals between the crops, which will help distributing the irrigation water when the field is flooded (Hurlston, 1991). Two months later chemical fertilisers are added around each hole. Thereafter fertilisers are added in a four month cycle for the remaining of the cultivation period. The application of fertilisers is most important during the three to four first months of the plant's life because this period determines the development of the banana fruits (Arvanitoyannis & Mavromatis, 2009).

Figure 4:10. Irrigation water is transported to the fields in channels dug by hand. Photo: Erica Perming, 2009.

When the banana is harvested, the pseudostem is cut at a location which causes it to bend over so the fruit bunch can be cut off (Hurlston, 1991). The plant can be left in the soil for about 1.0 to 1.5 months to supply the suckers and the new mother plant with nutrients but Farmer E (2009) removes it within a week to prevent worms from getting a grip of the stem. The plant is raked up from the soil carefully to prevent damages to the rhizome, cut into pieces and spread out in the field. When the life cycle of the banana plant has run out the field is cleared and all drainage systems are controlled and repaired. According to Farmer E (2009) this happens approximately five years after the banana cultivation initiated. The field is ploughed to prepare the soil for another crop. To benefit the soil and to prevent diseases from spreading, another crop has to be cultivated for at least six months before bananas can be cultivated again. According to the farmers it is common to rotate with for example papaya in Sooriyawewa.

4.2.5 Alternative cultivation methods

The farmers stand before a number of decisions before they are able to initiate a plantation. If economic reasons are the main purpose for the cultivation, market demands are important to follow (Arvanitoyannis & Mavromatis, 2009). The farmer also has to choose which type of pesticides, fertilisers, tools, and irrigation method that should be applied. Additionally, there are different methods to support the banana plantation. The general method for the farmers in Sooriyawewa is to cultivate in a perennial manner rather than annually (Farmer E), see below.

4.2.5.1 Perennial cropping method

With the perennial cropping method, water suckers, regrowth suckers and suckers that emerge before the mother plant has flowered are removed (Arvanitoyannis & Mavromatis, 2009). A sucker that emerges early is not left to grow because it will worsen the conditions for the plant, resulting in reduced fruit quality. According to one farmer the plants in the study area produce suitable suckers after about four months. One farmer implies that the unwanted suckers should be removed as early as possible to prevent them from taking up water and nutrients from the soil and the mother plant. Otherwise growing suckers reduce the mother plant's productivity (Weerasinghe 2000, Ruwanpathirana & Pemachandra, 2002/2003). When suckers are removed it is important to keep an equal spacing between every plant that still grows in the field to prolong the life of the cultivation. Ideally, three bananas grow from the same rhizome in a triangular setting at the age of four, eight and twelve months respectively. The banana farmers say that the cultivation will produce a regular income for five years with this method. Thereafter the bananas need to be cut down because of the occurred chemical changes in the soil, partly produced by the used chemical fertilisers and pesticides. Thereafter another crop is cultivated as described earlier.

4.2.5.2 Annual cropping method

The other method is called annual cropping and with this method all planted bananas are removed after harvest (Farmer E, 2009). All suckers that emerge during the growth are removed and, consequently, it is only one mother plant that manages to produce fruits. Weerasinghe and Weerasinghe (2005) conducted a research where a comparison was made for the annual cropping method and the perennial cropping method, both using the banana type Embul. The results showed that annual cropping produced a higher bunch weight, probably because suckers did not compete about the nutrition.

According to Farmer E, the annual cropping method is used when bananas are cultivated for "quick money". It is possible to time the harvest with peak market demands and the plants can be cultivated with less space between each other. Out of the banana varieties in Sooriyawewa, Kolikuttu is most suitable to cultivate with this method. First of all because the plant is smaller in size compared to the other varieties and is therefore less affected by shade from adjacent plants. Kolikuttu is also the banana that produces the fruit with the highest market price. The fact that the plant is susceptible to a bunch of different diseases is a reason to why it always has to be eliminated and replaced with another crop after harvest. Annual cropping simplifies the control of pests and diseases since crops that are immune to present diseases can be chosen for rotation. The method is, however, more labour demanding as the crops have to be replanted every year. Annual cropping fields have therefore got a tendency to be abandoned for a couple of years after harvest. Table 4:3 compares the differences between the annual and the perennial cropping method.

Table 4:3. The table summarises the advantages and disadvantages between annual and perennial cropping methods for bananas planted with the same distance between the plants.

Annual *Removing all suckers*	**Perennial** *Keeping suckers*
Has to be replanted but gives quick money and the harvest can be timed with the market demands by planting the crop approximately one year before harvest.	No need to replant which makes it less labour demanding. Gives a permanent income for five years.
Gives an increased bunch weight.	The nutrient is shared between the suckers and the mother plant which consequently yields a smaller bunch weight.
Can be planted with tighter distance, which allows more plants.	Requires larger distance between the plants because the suckers need more space to grow.
Better control of pests and diseases.	Poorer control of pests and diseases.

4.2.5.3 Distance setting

Another decision the farmers face is the distance setting between the plants. Weerasinghe (2000) investigated whether it is possible to reduce production costs by cultivating with a closer plant density combined with the annual cropping method, against the perennial cropping method with normal distance. The test was performed with the varieties Alukehel and Embul planted with distances of 3.0x1.0 m for annual density, versus 3.0x3.0 m for perennial, and 2.5x1.0 m for annual density against 2.5x2.5 m for perennial for respective banana variety. The results showed higher yields for both banana varieties when they were cultivated in an annual dense manner and the bunch weight was similar for both cultivation methods. Arvanitoyannis and Mavromatis (2009) also mention a higher yield from annual dense cultivation, but a reduced bunch weight. An alternative for farmers who use the annual cropping method is to let the sucker grow until the stage when it can be removed together with a bit of its rhizome and sold as a "seed" to other farmers (Weerasinghe, 2000). The method reduces the productivity but may nevertheless be profitable for the farmer. One hectare of dense planted bananas could produce suckers to be transplanted to a five hectare plantation under the same circumstances. Another benefit with a dense plantation is that it controls weeds as it shades the ground more.

4.2.5.4 Additional methods

There are several methods and techniques that can be used to improve the quality of the banana and increase the yield. A method called bunch covering can be useful for the production of more healthy bananas that are prevented from being attacked by pests and insects (Weerasinghe & Ruwanpathirana, 2002). Bunch covering means that a clear plastic bag or a nylon rice sack, impregnated with chemicals and with holes in the bottom, is placed over the banana bunch. The gas, ethylene oxide, which is naturally released from the banana, will be trapped inside the bag and speed up the ripening of the fruit. The method is also proved to enhance the bunch weight and the quality of the bananas. The fruit development is best around 30°C and normally it takes around two to three months for the fruit to ripen. To put a bag around every bunch in the field demands a lot of labour and among the farmers in Sooriyawewa it was neither discussed nor seen. Another technique mentioned by Weerasinghe and Ruwanpathiram (2004), which is proved to increase the bunch weight is when bad developed hands of bad quality at the bottom of the bunch are trimmed just after bloom.

Figure 4:11. The figure shows a banana bunch and its flower. Photo: Erica Perming, 2009.

5 Irrigation

In the Dry Zone of Sooriyawewa, water scarcity is documented to be the main problem experienced by farmers (Shinkai et al., 2007) (see Table 6:1) and with an increasing population the problem requires attention. Natural water sources are limited to certain locations, such as rivers, streams, lakes, etc. During the last 2000 years artificial canals, dams and wells have therefore been used to locate the water to places secluded from natural water bodies (Molle & Renwick, 2005). The irrigation water in Sooriyawewa is supplied by the Uda Walawe irrigation scheme, situated in Walawe river basin (Farmer C).

5.1 Walawe river basin

Sri Lanka has 103 drainage basins out of which Walawe river basin is the largest. It intersperses both in the Wet and the Dry Zone and has a catchment area of 2442 km^2 (Molle & Jayakody, 2003). The upper part of the basin is situated at the southern foothills of the Central Highlands with the highest elevation reaching above 2000 m (Boelee & van der Hoek, 2002). Southwards the elevation decreases down to the Lowlands of the Dry Zone. The wide elevation range gives annual rainfall amounts that stretch from 1000 mm in the south-eastern parts to over 2500 mm in the upper reaches.

Walawe river originates in the northern part of the basin, 2395 m above sea level, and flows about 100 km southwards and out in the sea by Ambalantota (IMWI, 2007). The headwaters of Walawe River generally receive 4500 mm of rain annually (Ohtani, 1993). Approximately 50 % of the rainfall received in the basin reaches Walawe River through run-off (Weragala & Kaluarachchi, 2008). The other half is taken up by vegetation or dissolves into the air through evaporation.

5.2 Uda Walawe irrigation

Cutting across Walawe River, on the boundary between the Wet Zone of Ratnapura District and the Intermediate/Dry Zone of Moneragala District, is the Uda Walawe reservoir (Table 5:1). The reservoir is more affected by the Northeast Monsoon rather than the Southwest Monsoon and together with a number of smaller tanks Uda Walawe helps to provide the irrigated cultivations with water (MASL, 2008). The reservoir is also developed to produce hydropower.

Table 5:1. The capacity of Uda Walawe reservoir.

	Storage capacity (m^3)	**Annual rainfall** (mm)	**Length** (km)	**Depth** (m)
Uda Walawe reservoir	268 000 000	1500	4	37

Source: MASL, 2007

Two main irrigation canals are connected to the Uda Walawe reservoir, namely the Right Bank Main Canal (RBMC) and the Left Bank Main Canal (LBMC) (MASL, 2008). These canals pass a number of smaller tanks which are connected to the Walawe River and are all a part of the Uda Walawe irrigation scheme. Six blocks come under the scheme;

Chandrikawewa, Murawesihena and Angunakolapelessa are the three blocks of the RBMC with 12000 hectare of irrigable land, and Sevanagala, Kiriibbanwewa, Sooriyawewa and Mayurapura are within the LBMC. On the left bank 6744 hectare of irrigable land, up to Sooriyawewa, was developed from 1997 to 2003. The most southern part of the LBMC was commenced first in 1999 and scheduled to be finished in 2003 (Wijesiri, 2008). It was not finished until October 2008 and subsequently added an extra 5152 hectare of irrigable land to the scheme, making the LBMC irrigate a total area of approximately 12000 hectare (Wijesiri, 2008).

5.3 Irrigation scheme

When the schemes were designed, knowledge was taken from the ancient constructions (Wijesiri, 2008). A technique of re-using water has been used for centuries and is proven to capture as much as 50 % of the drainage water. The tanks are connected in a range which makes the downstream tanks collect drainage water from the tanks upstream. But because of the deficient rainfall in the area, the stored amount of water is not always sufficient, which affects the amount of water released in the canals. Buysse (2002) mentions that the storage was low between May 2000 and May 2001 due to drought, which resulted in reduced release of water during Maha 2000/2001. Additionally, the water is not always sufficient to reach the end of the canals but is lost along the way through "seepage, evaporation, leaks and illegal tapping".

Figure 5:1. The irrigation water supplied to farmers cultivating different crops is regulated by canals such as the one seen in the figure. In this picture a pipeline is connected to the canal, which leads the irrigation water to the field. In this figure the pipeline is connected to the canal just before the water is blocked. The water is regulated, according to a schedule, by the farmers themselves. Photo: Erica Perming, 2009.

When constructing the newly developed, or the so called extension area in the southern LBMC; Mayurapura and the southernmost part of Sooriyawewa, some improvements were made to increase the effectiveness of the water usage. First of all, between 1999 and 2001 the entire left bank scheme was lined with concrete to reduce water seepage (Shinkai et al., 2007). Secondly, a system called "mini tank dual canal system", claimed to be better adapted to the different soil types and take the conservation of the ecosystem in consideration, was installed in the extension area (Shinkai et al., 2007; Somaratne, 2007). Land consisting of LHG was allotted for paddy cultivation and land with RBE for cultivation of OFC, including banana. The mini tank dual canal system separates irrigation water for paddy from irrigation water for OFC by transporting the water in separate canals. Moreover, smaller tanks are distributed in the extension area, some of which are adapted to the topography by having their own smaller catchment areas. The other tanks draw water from the so called Distributor Canals or Branch Canals (Figure 5:2). With help of sluices it is possible to regulate the water distribution (see figure 5:1) and in this manner fields that cultivate paddy can receive water at all hours while banana fields are only supplied with water for 12 hours per day. During night time the tank is refilled.

5.4 The irrigation in Sooriyawewa

The canal system in Sooriyawewa is constructed as illustrated by figure 5:2 (Ranasinghe, 2009). The Main Canal is directly connected to the Uda Walawe Reservoir and is controlled by the Residential Project Manager. The Branch Canal, which leads water from the Main Canal, is controlled by the Block Manager. From the Branch Canals the water is transported through the Distributor Canals to the Field Canals which lead the water out to the fields. The Distributor Canals are controlled by the so called Farmer Organizations and the Field Canals are controlled by the farmers themselves. Every farmer is responsible for the control of when and how much water they should receive from the total amount of the irrigation water that is accessible. One Distributor Canal is normally connected to between 10 and 12 Field Canals but can sometimes even be connected to up to 20 Field Canals. One Field Canal supplies 12 to 15 farmers with water.

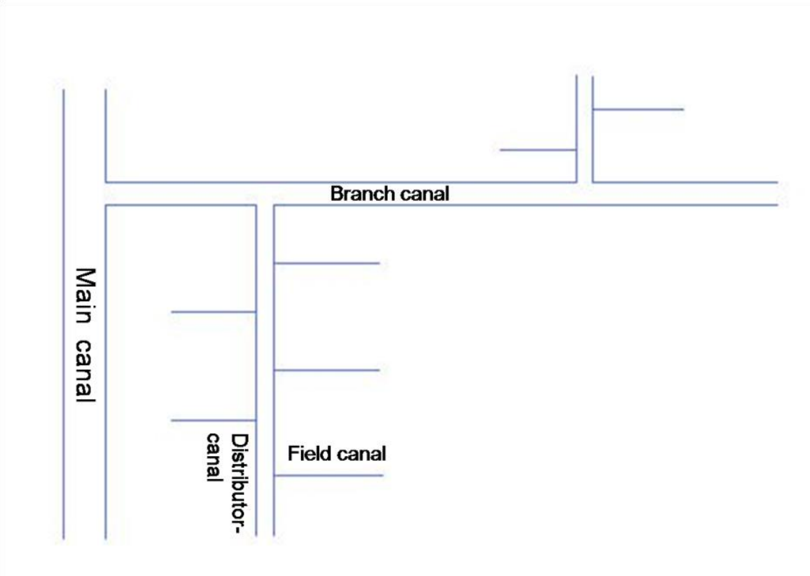

Figure 5:2. The construction of the canal system in Sooriyawewa. Source: Ranasinghe, 2009. Drawing: Erica Perming, 2009.

5.4.1 Irrigation Schedule

In 2009 paddy farmers in Sooriyawewa explained that during the first month of cultivation water is available in the canals every day. Thereafter there is a nine day water schedule, meaning that water is received from the canals for nine days continued by nine days without water. The days in the schedule varies between five to nine days depending on how much water that is available in the reservoir. During the period when paddy is not cultivated, OFC-farmers receive water on a 15 day-schedule.

5.5 Additional irrigation methods

When water is available the fields are flooded. For banana, which does not require as much water as paddy, the farmers mention other irrigation methods that are more suitable. A relatively simple method is when shallow ditches are dug between the plants in the field. Hurlston (1991) emphasises the importance of a suitable water flow to prevent soil erosion and damages to the plant.

Another more technical method is to place sprinklers and/or drip irrigation in the fields, which spray or drip water at the base of the plants (Hurlston, 1991). This method is more expensive than the other method but it does not require as much maintenance. Though farmers know about it, micro irrigation is not yet very widespread in Sooriyawewa. The only place where it could be seen was on the fields belonging to the Mahaweli Development Centre, where it was used to irrigate grapes. The other farmers often flooded the fields when water was available in the Field Canal because of the existing water rotation schedule and because bananas and paddy are often cultivated in the same fields.

6 Agricultural problems in Sooriyawewa

During the interviews with the paddy and banana farmers in Sooriyawewa it soon became evident that the water shortage was the number one problem striking the agriculture. The Farmers also mentioned the diseases and economic problems as obstacles during the cultivation. Shinkai et al. (2007) report the major problems understated by the farmers in Sooriyawewa and in irrigated and rain-fed lands in the Uda Walawe area (Table 6:1).

Table 6:1. The major reported problems that the farmers experience according to another study conducted by Shinkai, 2007. The figures are from the study area Sooriyawewa, which relies on irrigation water and figures are also presented from irrigated respective rain fed fields around Uda Walawe for comparison. The number of farmers that participated in the study is unknown.

Major reported agricultural problems (% of farmers)			
	Sooriyawewa	*Irrigated land*	*Rainfed land*
Water scarcity	71.52	60.19	79.77
Costly inputs	48.48	59.24	57.49
Damages from pests and diseases	36.84	43.95	41.87
Marketing problems	17.14	23.08	80.86

Source: Shinkai et al., 2007.

Following is a reasoning of the interviewed farmers' thoughts together with other sources about the main problems that occur when cultivating paddy and banana in the Dry Zone.

6.1 The water problem

Due to the spatially and seasonally unequal distribution of water in Sri Lanka, the drier regions are at times subjected to water shortages (Liyange, 2002). June, July and August, when rainfall is low and the evaporation is high, are the most troubled months in the Dry Zone. The occurring climate change has resulted in distorted weather patterns and the arrival of estimated rainfall has not come when expected (Punyawardena, 2002). The anomalies are a problem which will become larger due to the prevailing climate change combined with the increasing demand for food as the population increases (Punyawardena, 2002). Being a developing country, Sri Lanka has difficulties managing the agriculture as it is and the management of these aspects will therefore most likely have significant impact on the future (Liyange, 2002). The Sri Lankan Government is aware of this problem and has formulated policies on how to manage the water situation in the future. The policies emphasize on the value of using the water efficiently. The task might, however, not be very easy to implement. For example, although a lot of money has been invested in the restoration of the irrigation schemes, it does not prevent people from taking water without permission, a problem that the interviewed farmers in Sooriyawewa were concerned about. However, Mahinda Rajapaksa who has been the president of Sri Lanka since 2005 (Nationalencyklopedin, 2010) was born in Hambantota and grew up in a family that cultivated paddy (Rajapaksa, 2005). It is widely recognized that the president has an interest in developing the area and the farmers put their hopes on that the region will experience more attention and development.

6.1.1 Weather patterns and climate change

Several studies indicate that there is a general trend of a decline in precipitation rather than an increase in Sri Lanka (Droogers, 2004; Peiris 2006). Peiris suggests that the last decade's deforestation might be an explanation to the change, since the forest no longer regulate the hydrological cycle to the same extent. A similar idea is suggested by Keuneman and Anderson (1983) when discussing the changed monsoon patterns. Furthermore, Peiris (2006) raise concerns about how the agriculture that replaces the forests conduce biodiversity losses, soil salinity and erosion, to name a few hazards when irrigation and chemical substances are utilized. According to Somaratne (2007) it was not until the last extension project commenced in Uda Walawe Irrigation and Resettlement Project that the conservation of the ecosystem was considered.

An exception in the rainfall trend is seen in Walawe basin where a small positive change of precipitation has been observed (Droogers 2004). In a study, Droogers (2004) used models to project how the climate will change in the future in Walawe basin and what effect it will have on the food production. Results projected that the climate change in this region will increase the average food production due to the substantial carbon dioxide rise combined with the small precipitation and temperature increase. A weakness in the model is that the impact of the pathogens in the future was not accounted for. However, according to IPCC (Cruz et. al., 2007) the general climate trend in South Asia, including Sri Lanka, is an "increase in the occurrence of extreme weather events including heat wave and intense precipitation events". IPCC further projects that the pathogen growth rate will increase as a consequence of the increase in temperature. Hence, the crops will become more vulnerable and the food production is likely to be affected. In the end this will, in particular, affect the poor people that rely on agriculture (Cruz et. al., 2007).

6.1.2 The water's impact on socio-economy

The Dry and the Intermediate Zones, which are hit by the Northeast Monsoon, are especially affected by the more inconsistent weather patterns and it is also in these two Zones the majority of the crop cultivation occurs (Liyange 2002). Lack of water or a surplus of water leads to damaged crops, which limits the yield. The farmer is highly dependent on the yield since it provides an income and thus an opportunity to sustain a healthy livelihood (Hussain & Giordano, 2004). A linkage between water, health and poverty exist since bad health can lead to poverty and poverty may cause bad health. On the contrary, good health brings opportunities to a sustainable living standard. In the centre of this, water has a significant impact on the outcome. A loss of income can be enough to force a family into debts and then into the cycle of poverty. The farmers rely on water, either through rainfall or irrigation for their crop production. The irrigation schemes in Sri Lanka have created a better situation in terms of food security, employment opportunities and protection against severe droughts. Currently most water resources derived from the schemes are used for agriculture but there are extensive development plans that point towards a more industrialized expansion of the Uda Walawe irrigation scheme (Droogers, 2004). The demand for water is hence expected to rise with as much as 10 to 15 times in the future (Droogers, 2004).

When the access of safe drinking water was compared in 1998 between the urban areas and the rural areas it was found that 90 % of the population in the urban areas had a rather high access to safe drinking water while this was only true for 57 % of the rural population (Hussain & Giordano, 2004). The irrigated water can sometimes be used for other purposes such as recharging groundwater and this is the case in the Uda Walawe area. People use the irrigation schemes for washing and supplying water for livestock, which create water contamination (Somaratne, 2005). Contaminations can spread through the canals and give rise to several diseases such as diarrhoea, typhoid and dysentery.

6.1.3 The interviewed farmers' perspective on the water situation

According to the information the farmers gave at the time of the interviews during Yala season 2009, water shortage is of most concern (Table 6:2). Farmer A experienced the season as the worst out of his 35 years as a farmer in terms of water availability. The farmer also experienced that the periods with less rainfall became more frequent. According to the other farmers, 2009 was an unusually dry year and concerns regarding the harvest were expressed. The man in charge at the Mahaweli Development Centre (Farmer B) also confirmed that there had been a considerable water deficit that year but the centre has the advantage of being provided with additional water if necessary. According to Farmer C the climate is changing and the rainfall is becoming less abundant and because of that the farmers are more dependent on the irrigation schemes than before. Consequently, the farmer has to put a lot of effort into regulating the water in the fields. However, according to the same farmer the water situation has not affected the yield negatively due to the development of improved seeds that are more resistant to disturbances. Farmer D agreed to water shortage being the main problem but also said that his land was situated on a higher level, which made it more difficult to get enough water from the irrigation schemes. During 2.5 years the farmer's family had cultivated bananas instead of paddy because of the water shortage and also because the banana market was more successful. Due to the lack of water in the Yala season 2009 one of the steps taken to eliminate weeds did not succeed properly. This resulted in a denser growth of weeds in the paddy fields, which consequently will give a lower yield. Farmer E, who mainly relied on banana cultivation, described how the banana plants were not as prosperous as they could have been due to the lack of water. In addition, the banana plants can be difficult to cultivate since they easily contract diseases if maintained incorrectly.

Table 6:2. The table shows a summary of the main agricultural problems that were revealed by the interviewed farmers in Sooriyawewa 2009.

	Main problems
Farmer A	Water scarcity
Farmer B	Water scarcity
Farmer C	Water scarcity
Farmer D	Water scarcity which also is because the paddy field is situated on a higher elevation.
Farmer E	Water scarcity and banana being subjected to pests.

Farmer E experiences July and August as the driest months with no or very little rainfall. He also mentioned a gradual change in the rainfall pattern. According to him, September used to be the month with most rainfall but today both September and October have most rainfall. For the farmers who rely on irrigation the rain water pattern is crucial to make sure that the reservoir has got sufficient supplies of water during the beginning of the cropping season when a lot of water is required. To prepare for the Yala season Farmer E is executing water harvesting and has a small tank on the property adjacent to the fields. Farmer E was the only one of the farmers interviewed that executed water harvesting.

6.2 Costly inputs

Another problem the farmers experience is how to manage the economy. The agriculture is connected to many expenses (Table 6:3) and it is advantageous if a farmer can avoid taking loans. However, many farmers take loans from banks, especially during May and June (Shinkai et al., 2007). Approximately 50 % of the farmers were in debt in 2007.

Table 6:3. An example of how the expenses can be apportioned when cultivating paddy. The table describes the seasonal costs for one acre (0.4 ha) of paddy when the fertilizers are subsidised. The total price for one acre is thus 38400 rupees.

	Price (Sri Lankan Rupees)	**Approximate share** (%)
Purchasing the paddy seeds and planting costs	4000	10.4
Preparing the paddy field	6000	15.6
Labourer	4000	10.4
Other labour cost	8000	20.8
Labourer and machines necessary for the harvest	10000	26.0
Herbicides	3200	8.4
Fertilisers	1600	4.2
Pesticides	1600	4.2

Source: Widusara Science Magazine, 2003 and Farmer C, 2009.

According to Somaratne et al. (2005) it is rare that farmers in Sri Lanka exclude the use of chemical fertilisers even though different options of manure can be obtained. The use of manure is a more economical and natural solution of returning the nutrients to the soil, (NIIR Board (2004) remark that fertilisers generally stand for 20 to 30 % of the production cost for banana) but it is still not used among many farmers. To enhance the use of manure the Mahaweli Development Centre in Sooriyawewa is attempting to spread the knowledge among the farmers in how to prepare and use manure in the cultivation. The Department of Census and Statistics (2011) reports the statistics of the share of fertilisers used (Appendix 1).

Manure of Potassium (MOP), Triple Super Phosphate (TSP) and urea, which consists of nitrogen, are the chemical fertilizers used to a great extent by the farmers in Sooriyawewa. The quantities used for the paddy crop are displayed in table 6:4. Calculations in the table are based on a paddy field where 1 ha of paddy is sown with the Combined Broadcasting method.

Table 6:4. Based on the amount of fertiliser that is applied to paddy on a regular basis, the table gives the amount of fertilisers that are used for maintaining a one hectare field during one year.

	Urea (kg)	**MOP** (kg)	**TSP** (kg)
Banana	99	206	66

Sources: Widusara Science Magazine, 2003.

Paddy cultivation is mostly carried out by smallholders in Sri Lanka and to support this group and the production of paddy several procedures have been carried out to maintain its self-reliance (FAO, n.d.). Because the Sri Lankan government has decided to make Sri Lanka self-sufficient on rice, the paddy farmers are offered fertilisers, seeds and other materials that are subsidised for the cultivation.

The paddy farmers that were asked did not question the amounts of fertilisers recommended and did not think about using more or less of these substances. Because the fertilisers are subsidised the farmers only have to pay 10 % of the total cost of the fertilisers and are not given more than the recommended amounts. The total cost of a 50 kg package of the three substances is 350 rupees when subsidised, which makes the market price 3500 rupees. For the banana farmers, fertilisers can thus be a costly expense. Farmer A expressed concerns regarding all the fertilisers used because of the effects it has on the soil and the crop. The farmer mentioned that the fertilisers increase the bananas' size and improved its appearance but on the cost of the fruits nutrient content.

Farmer C said that he cultivates only paddy and answered that he is pleased with it because of the subsidised fertilisers, when asked if he has ever considered cultivating another crop, for instance banana like many of his neighbours do. Other supports the paddy farmers are given is the free irrigation water and low interest credit.

To attain desired results from the fertilisers, consideration has to be taken to the actual soil type, present amount and distribution of minerals, as well as to the growth nature and characteristics of the previous and future cultivated crop (Chandrasekaran et al., 2007). A paddy cell and protoplasm consists mainly of nitrogen, meaning that the growth increases when nitrogen is applied on the paddy field. Over-fertilisation causes thinner cell walls, which decreases the stability of the crop so it wilts. Too little nitrogen will on the contrary affect the growth rate of the crop negatively. In a critical stage the leaves will fall off and eventually the paddy crop will die. Right amount of fertiliser is hence vital to achieve a fertile soil and a healthy growth. The Widusara Science Magazine was distributed to the farmers in Hambantota District and the recommended levels of fertilisers, in the Magazine, were developed with consideration to the soil types in the region.

6.3 Pests and diseases

During the cultivation of paddy and banana the reduction and prevention of natural hazards such as pests and diseases is essential. During the interviews, it was understood that bananas, unlike paddy, were more vulnerable to diseases. If the farmer manages to prevent the banana from get infected by diseases, the crop was said to be the easier to cultivate. The removing of brown leaves and leaves that can damage the fruits is essentially the only extra work necessary. There are, however, a number of natural hazards that can reduce the production and hence the control of diseases, pests and insects is an important task. High-quality bananas free from brown stripes are preferred and provide a higher market price, which is why destructive menaces should be treated. A disease that is mentioned during the interviews with the farmers is primarily the Panama disease, which is a type of the Fusarium Wilt (see Table 6:5), caused by the soil fungus *Fusarium oxysporum f.sp. cubense* (Rajapakse et al., 2005). A couple of years ago, Hambantota District and the area around Uda Walawe experienced a plague of Fusarium Wilt (Kudagamage, 2004). The susceptible banana variety Kolikuttu was cultivated in the area which caused the fungus to spread. Kudagamage (2004) states that perennial cultivation of susceptible plants increase the density of the fungus in the soil, which is why Kolikuttu is recommended to be cultivated with the annual cropping method.

According to Kudagamage (2004) and farmers in Sooriyawewa an effective method to prevent the spread of diseases is to cultivate different banana varieties mixed together. This is typically performed with banana varieties Embul and Seenikehel. Embul is generally a tolerant plant that can handle bad conditions like drought and poor soils and it is not attacked by pests as, for example, Kolikuttu is. Preventive treatment must also be used after harvest since post-harvest diseases exist. Applied for both paddy and banana is the significance to use clean tools since dirty tools can cause fungus to develop (Hurlston, 1991). A sharp and clean knife is therefore vital as well as a clean environment. Another threat is the insects, feeding on the bananas' rhizome, flowers, fruits, as well as on the paddy seeds (Arvanitoyannis & Mavromatis, 2009). But since natural predators usually terminate the insects, the problem is not severe and insecticides are not necessary. Fungicides and pesticides have lately been used to some extent to eliminate diseases and pests but are primarily used by those cultivating for economic gain (Somaratne et al., 2005).

Table 6:5. Fusarium wilt and other diseases present in Hambantota District.

	Fusarium Wilt *1	**Banana Bract Mosaic Virus** *2	**Banana Streak Virus** *2	**Banana Bunchy Top Virus** *2
Symptoms	Yellow leaves, badly developed fruits and plant death.	Deformed fruits and bunch, disrupted pseudostem and yield losses.	Disrupted pseudostem, broken leaves and yield losses. Can lead to plant death.	Reduced leaf size and bad to no development of fruits.
Susceptibility	*High*: Ambon, Kolikuttu *Moderate*: Alukehel *Low*: Seenikehel *No*: Embul	*High*: Alukehel, Embul, Seenikehel *Moderate*: Anamalu, Kolikuttu *Low*: Ambon	*High*: Anamalu, Embul *Moderate*: Ambon, Alukehel, Kolikuttu *No*: Ambon, Seenikehel	*High*: Kolikuttu *Moderate*: Alukehel *Low*: Ambon, Anamalu, Embul, Seenikehel
Recommendations	Remove all infected crops, change plant variety to a resistant type and make sure the drainage is good.	Remove and destroy the diseased plants before they spread to other plants.	Good management and fertilising might prevent the virus to affect the yield.	The rhizome has to be removed to make sure the virus disappears as there is no cure.
Other	Becomes more severe the longer the fungus prevails in the soil.	Presence decline with elevation.	Presence decline with elevation.	A serious banana disease.

*Sources: *1: Rajapakse et al., 2005. *2: Ariyaratne & Liyanage., 2002.*

6.3.1 Weeds

The definition of weed is a plant that grows where it is not wanted (Chandrasekaran et al., 2007). With poor or no weed management the consequence will be losses in yield since the weed competes with the crops for water, space, sunlight and the nutrients in the soil. Weed also increases the presence of pests and diseases (Arvanitoyannis & Mavromatis, 2009). Good weed control routines are particularly essential in the beginning of the cultivation period, before the cultivated crops have grown big enough to shade the weed. Weed grows very fast in the early stage and for the paddy crop, chances are that the weed overgrow the paddy and consequently limit the photosynthesis and the quality of the crop (Chandrasekaran et al., 2007). Weed can also accumulate and hinder the irrigation and drainage canals. Weeds are generally a problem for the farmers and take a lot of time and effort to control. Hurlston (1991) suggest that all weed should be sprayed with herbicides when preparing the field to prevent it from spreading, since weed reduces productivity. But if too much herbicide is used it will damage the crops and cause a reduced crop growth (Arvanitoyannis & Mavromatis, 2007). However, weed also has a few advantages. The leguminous weed can fix nitrogen from the atmosphere to the soil and in the upland areas the weed holds the soil and prevents it from being afflicted by erosion. Therefore it is necessary to manage the weed in the right manner. The paddy farmers did not describe any extensive problems when controlling the pests and diseases with pesticides. Considerable effort was instead used to eliminate the weed in the paddy fields.

6.4 Political impacts

The fourth major problem reported by the farmers concerns the marketing, partly affected by political decisions and market demands according to table 6:1. The farmers explained that for banana, which has a fluctuating price on the market, the harvest is preferably matched with the months with the highest market prices. Between April and June it is the fruit season in Sri Lanka which means that the banana experiences competition on the market and is hence sold to a lower price. Consequently, when the production is low, the price on the market increases. At the time when the interviews were conducted paddy had a fixed minimum price but that had not always been the case.

Figure 6:1. Figure showing the banana market in Sooriyawewa. Since a lot of bananas are cultivated in Sooriyawewa buyers come from other parts of the country with their trucks to trade bananas. Photo: Erica Perming, 2009.

6.4.1 The paddy crisis

During the interviews with the farmers it was understood that the farmers depended on many external influences which had an impact on the financial outcome of their cultivation. The market situation along with the minimum price for a unit of rice and subsidised fertilizers were frequently mentioned influences. In addition the loan condition was also mentioned by a farmer as an obstacle. The farmers emphasised on the importance of a minimum price for a unit rice as well as the the subsidized fertilizers and told that these policies have not always been consistent in the past.

The production of domestic food is almost entirely done by smallholders in Sri Lanka (MONLAR, 2005). Since 1930 the governments have had policies to protect and preserve the smallholding farmers in order to maintain a self-sufficient food production. The policies included regeneration of the earliest irrigation schemes and reservoir, especially in the Dry Zone areas. In addition, subsidised fertilisers were introduced and the government was influential when supporting the market for paddy and other crops. The farmers were supplied with quality seeds, generous credit systems and import restrictions on locally cultivated crops were also a part of the policy plan. These policies did not only help the farmers, it also pushed down the crop prices which helped the poorer population to afford nutritious food.

In 1977 the policies were altered, by recommendations of the World Bank, which more or less reversed the previous policies (MONLAR, 2005). This was not to the farmers' advantage and meant that the farmers from now on would face severe economic problems. The changes in policies in short meant that the politicians invested and prioritised the development of the infrastructure instead of the smallholders. In addition, the trade was liberalised in hope of increasing the export and to attract investors from overseas. Liberalisation also promoted the private sector, which in turn reduced subsidies, tariffs and other protections the farmers had (Weerahewa, 2004). Farmers protested for the policies to change and one alteration that would have facilitated the situation was to set a minimum price for one kg of paddy, high enough for the farmers to profit from their harvest and subsequently prevent a competition in the markets. The reversal of the policies became a very serious problem since almost half of the population in Sri Lanka is included in the agrarian sector (MONLAR, 2005). To shortly describe the consequences; a lot of smallholders became indebted because the expenses of production increased ten times, within a decade, while the domestic food prices did not follow. The trade liberalisation also made it easier to import domestic products, which increased the competition among the farmers. Consequently the health of the population, especially in the rural areas, declined and poverty, hunger, anaemia and malnutrition together led to increased suicide rate in Sri Lanka and became one of the highest in the world. Within four months in the Polonnaruwa district, in 1994, 28 farmers committed suicide because they were not able to pay their debts. This had a significant influence on the election later that year when a new Governmental party was elected which promised changes in the policies in order to obtain a sustainable food production (MONLAR, 2005).

With the new Governmental party in 1995 all loans taken by farmers were written off when 25 % of the loan had been paid off (Epaarachchi et al., 2002). The subsidised fertilisers were re-introduced in 1994 and included urea, sulphate of ammonia, MOP and TSP (Epaarachchi et al., 2002). In 1997 the subsidy was only applied for urea. According to the farmers the subsidised fertilisers now include MOP, urea and TSP. To further support the paddy production in Sri Lanka machines and equipment used during the harvest could be imported free of duty from 1998. However, the fixed price of paddy was never implemented and the farmers were not satisfied. It was not until 2000, after the price of paddy and OFCs had dropped to new low levels, the policies were changed according to the farmers' petition. The changes were implemented after almost a hundred farmer organisations launched a massive protest where many farmers went on a hunger strike and collectively demanded a number of changes (MONLAR, 2005).These questions have been a recurrent theme in election campaigns to attract the farmers' votes (Epaarachchi et al., 2002). Two farmers were asked during the interview about their view of the politicians and both farmers had very low opinions of the politicians. Although, one farmer expressed that he was satisfied with the president because he ended the war.

The rice-trade system is today handled by the private sector to 80 % (Weerahewa, 2004). Before 1977 the government played a prominent role in the rice-trade system but this has declined since then resulting in that the private sector has gained a lot of power when purchasing paddy compared to the smallholders, with the private sector as the main buyer. Consequently the purchaser has the advantage to set a lower price because the farmer depends on the purchaser and often needs to sell the paddy quickly to get money for paying the debts. Hence the ability to bargain is very limited for the farmer in this situation and consequently the price will be lower than what the farmer wishes for. The liberalisation of rice trade worked towards lowering the price of rice in Sri Lanka but the consequences for the farmers were severe. Thus there is prominent linkage between poverty and the rice industry in Sri Lanka. One of the farmers confirmed that it currently is a fixed price for one kg of paddy which has eliminated the power of the buyer over the farmer. The price of paddy is 28 to 30 rupees per kg depending on the type and 60 rupees per kg of rice according to Farmer C (2009). Note that it takes one and a half kg of paddy to produce one kg of rice. The price can still vary depending on the situation on the market. The miller has the ability to store paddy and wait for the best time to come and then sell it when the demand for rice is larger. The Government spent 2 % of the total recurrent expenditure in 2007 for paying the subsidised fertiliser which has a prominent impact on a large part of the families in the country (Epaarachchi et al., 2002). The poorer part of the population is more sensitive to a change in rice price than the more wealthy part of the population. This is because the poor people depend more on rice than the wealthy part of the population, the rice consumption among non-wealthy is higher and it is also the group that cultivates paddy for a living.

7 Statistics

It is difficult and time consuming to collect statistics in Sri Lanka due to that the data has not always been collected consistently and because the data is sometimes documented on paper in Sinhalese and not electronically in English. Therefore no statistics specific for Sooriyawewa D.S. division has been found. However, rainfall statistics could be obtained for Embilipitiya D.S. division situated in Hambantota District and Udawalawe situated adjacent to Hambantota District. Paddy and banana statistics could be obtained for Hambantota District.

7.1 Rainfall statistics

It is difficult to find rainfall statistics with sufficient quality in Sri Lanka, as mentioned earlier, and therefore only statistics for Udawalawe and Embilipitiya are presented. The rainfall statistics for Udawalawe is of interest since the location is included in the catchment area for the Udawalawe irrigation scheme from where farmers in Sooriyawewa receive water. Embilipitiya is, like Udawalawe, located in close proximity to Sooriyawewa with the Euclidean distance of 19 km.

Udawalawe has recorded monthly rainfall data from 1985 to 2008 and in the analysis, a seasonal monthly average for Maha respective Yala was calculated, see figure 7:1. Beginning in Yala 1985 respective Maha 1985/1986, and going on until Maha 2007/2008 respective Yala 2008. Maha 1985/1986 is thus shown as Maha 1985 in the graph. In this analyse the months October to March represents the Maha season and the remaining six months (April to September) represents the Yala season.

The results in figure 7:1 show the average monthly rainfall in Udawalawe for Maha respective Yala season. The rainfall pattern has changed between 1985 and 2008 with an increase in rainfall during Maha season and a decrease during Yala season. The change in rainfall pattern is most apparent during the last decade. However, the result of the total amount of rainfall in Udawalawe, during the same time period, shows an increase (see Appendix 2).

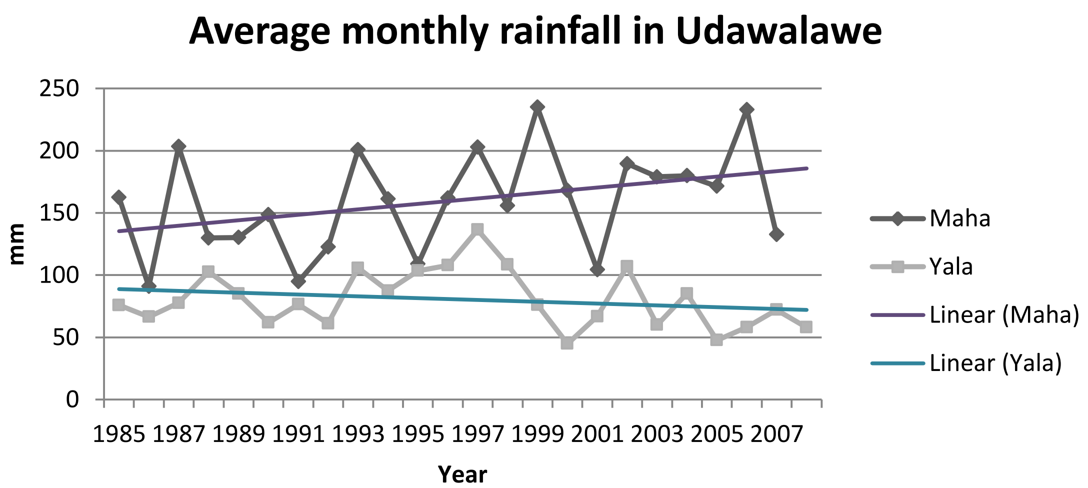

Figure 7:1. Graph showing the distribution of monthly average rainfall during Maha and Yala for the years 1985 to 2008 in Udawalawe. Source: Unknown.

Figure 7:2 shows the monthly average rainfall during Yala and Maha during the period of 1985 to 2008 in Embilipitiya. The same trend is seen for Embilipitiya, as for Udawalawe, with an increase in rainfall during the Maha season and a decrease during the Yala season. This trend is also notably for the last decade. When looking at the trend of the total rainfall during the same period an increase is also seen for Embilipitiya (see Appendix 3).

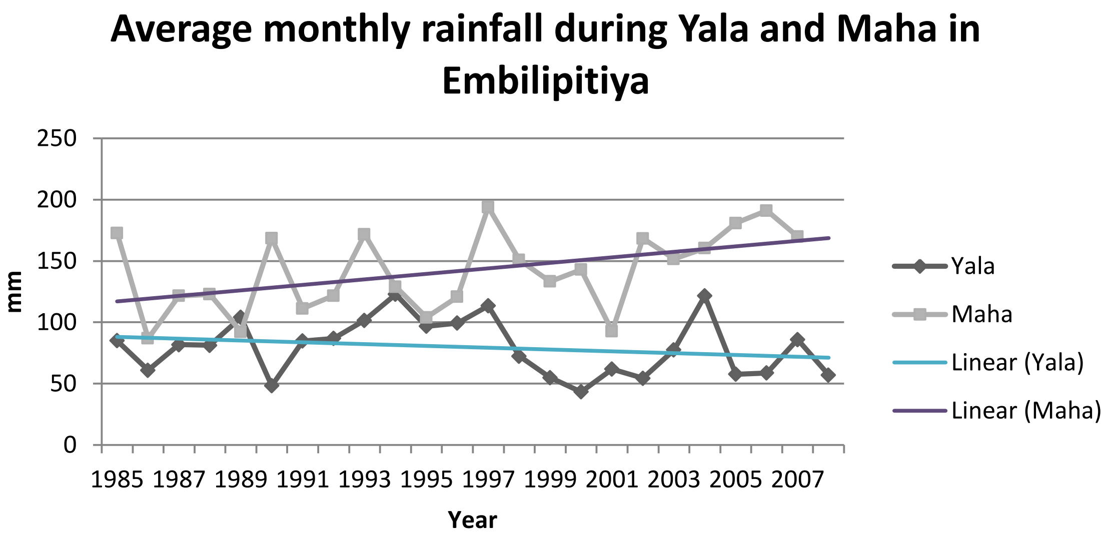

Figure 7:2. Graph showing the distribution of monthly average rainfall during Maha and Yala for the years 1985 to 2008 in Embilipitiya. The Maha season is getting wetter while the Yala season is getting drier. Source: Unknown.

7.2 *Paddy statistics*

The extent of paddy harvested in Hambantota District during the Maha season used to be significantly larger than for the Yala season (see figure 7:3). However, the last decade has witnessed a smaller difference in the areal cultivated by paddy during the Yala and Maha season, which means that the farmers cultivates paddy during both seasons. The extent of paddy cultivated experienced a dip around year 2001 but has recovered since then and year 2008 reached one of the highest notations.

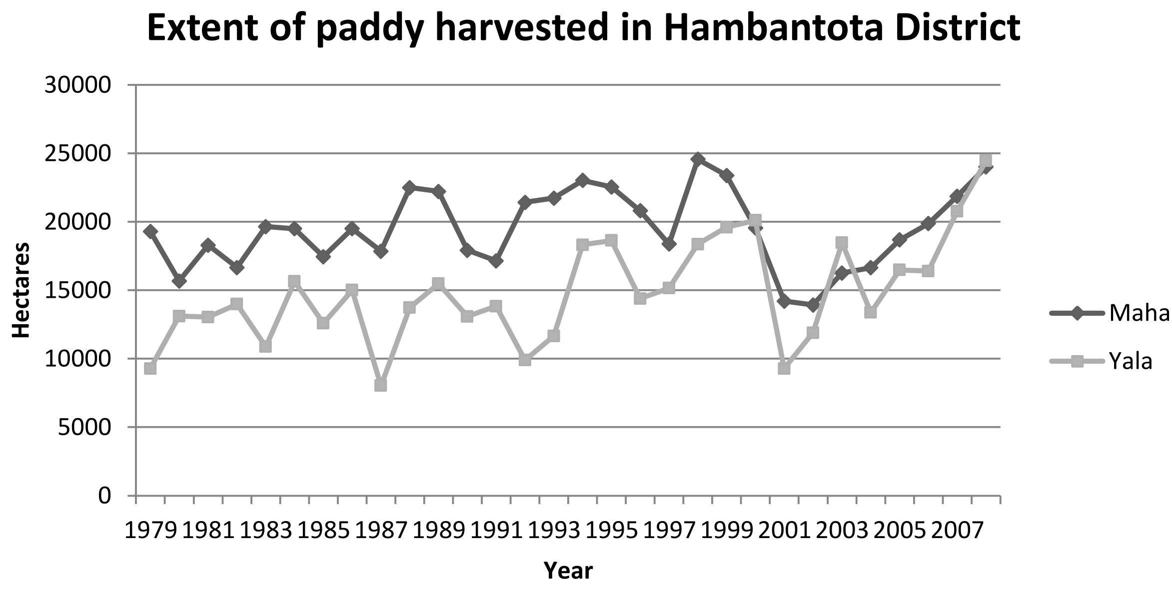

Figure 7:3. The extent of paddy harvested in Hambantota District during Maha and Yala during the period 1979 to 2008. Source: Department of Census and Statistics Sri Lanka, n.d.

The paddy yield per hectare has increased since 1979 from 3480 kilograms per hectare in 1979 to 4760 kilograms per hectare in 2008 during Maha in Hambantota District, see figure 7:4. During the same time period the yield per hectare also increased during Yala from 3760 kilograms per hectare to 4730 kilograms per hectare. As seen in figure 7:4 the yield is larger during Maha than during Yala in general although the difference is not always that substantial. However, when comparing the yield per hectare seen during Maha compared to Yala since 1999 it becomes evident that the difference in yield during the two seasons are quite substantial, with the exception of year 2004. The low yield during Yala in comparison to Maha in 1984 and 1991 cannot be explained by droughts.

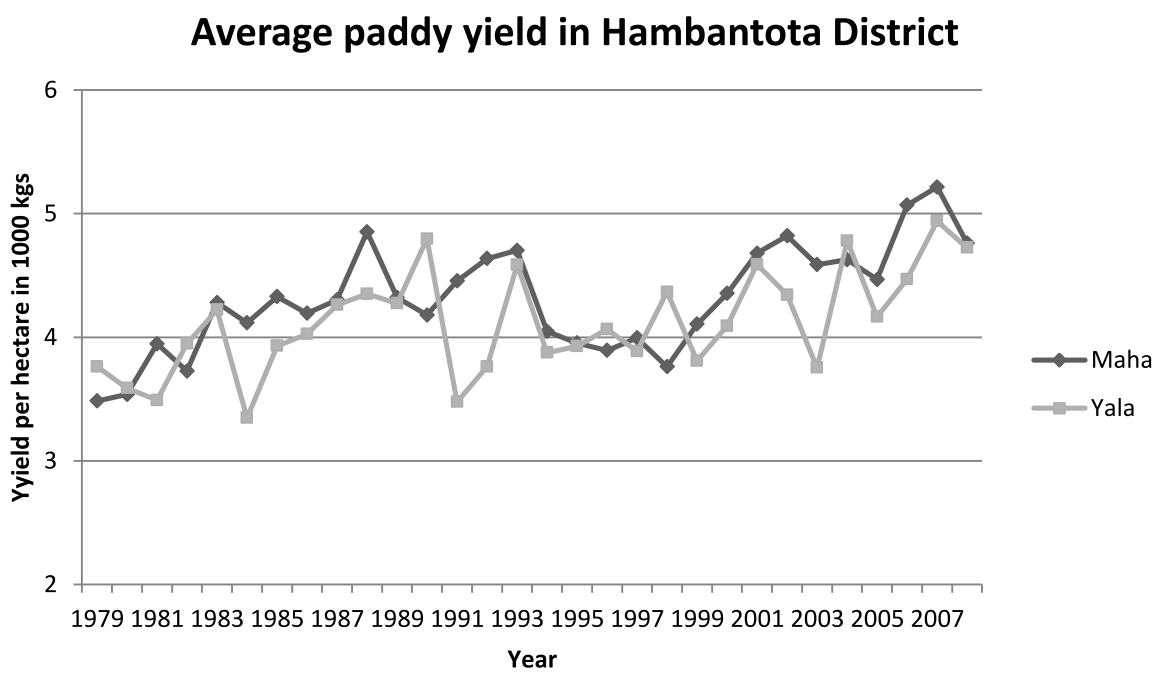

Figure 7:4. The graph shows the average paddy yield per hectare in Hambantota District during the Maha and Yala season between 1979 and 2008. Source: Department of Census and Statistics Sri Lanka, n.d.

7.3 *Banana statistics*

Since statistics is only available for the extent of banana cultivated between the short period between 1995 and 2008 in Hambantota District it is difficult to make an extensive analysis of the cultivation patterns and trends. From the statistics shown in graph 7:5 it is shown that the trend during the first five years (1995 to 2000) was more or less constant. In 2001 a small decrease in banana cultivation was seen before it increased substantially and reached a peak in 2004. After 2004 the extent of banana cultivated decreased, reaching approximately the same level as seen before 2000.

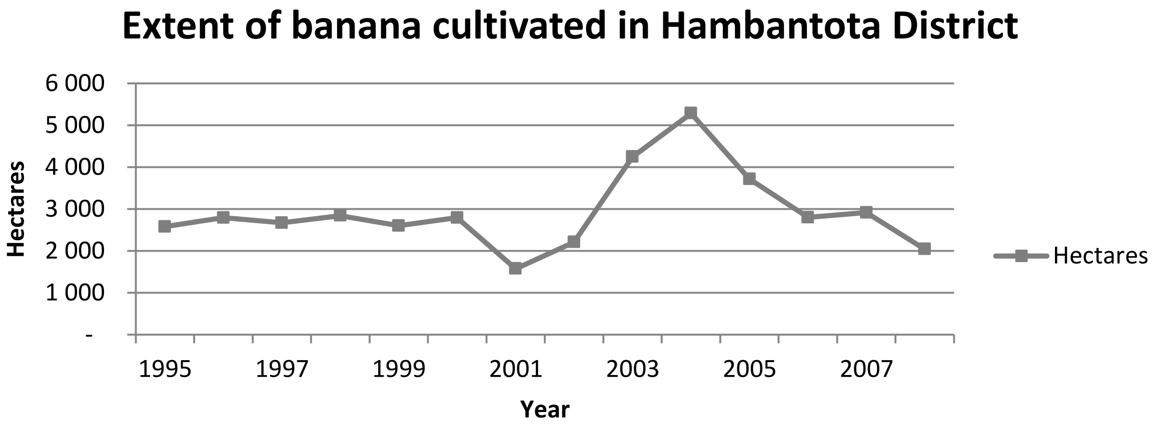

Figure 7:5. The extent of banana cultivated in Hambantota District between year 1995 and 2008. Source: Ministry of Agriculture in Colombo, 2009.

8 Discussion

8.1 The water situation

Water shortage is the largest problem the farmers experience in Sooriyawewa D.S. division. According to the interviewed farmers the climate has changed and a decrease in rainfall has been experienced. However, the farmers are only partially correct in their observation. When looking at the results of total amount of rainfall in Udawalawe and Embilipitiya between 1986 and 2008 the trends show an increase for both locations, but when looking at the trends during the Yala season the trends show a decrease in rainfall for both locations, while the opposite is true for Maha. This observation is also consistent with the results of IPCC (2007), which projects that wetter areas will become wetter while drier areas will become drier. The fact that the difference in the amount of rainfall, when the two seasons are compared, is increasing can also have the effect that the farmers experience the Yala season as much drier because the Maha season is simultaneously getting much wetter. It is also possible that the rainfall pattern is changing on a much smaller scale, which the statistics do not manage to capture. For example, the rainfall pattern may have changed on a diurnal basis, which in turn affects the farmers' perception of the weather. The change in rainfall can also be a shift in the onset and termination of the Northeast monsoon, which also would affect the farmers' perception. These are speculations that would be interesting to look into more in depth.

It is also during the Yala season when the farmers experience the water shortage the most. The analysis conducted by Droogers (2004) is consistent with our analysis if only the total rainfall is considered but not if the rainfall during Maha and Yala is separated. There may still be additional explanations to the water shortage experienced by the farmers. The area is going through a demographic expansion, which means that the same irrigation system has to supply a greater community and an expanding cultivation. This development will most likely continue as the Sri Lankan government invests in expanding the Walawe basin industrially.

The irrigation system, in which the farmers are distributed water for about nine days and then are left without water for about nine days, appears inefficient. If the farmers instead were to be given water every second day, or with a shorter time interval, the water would have time to percolate into the soil and less water would evaporate. An evaluation, of the system and of the farmers' water consumption, is welcomed.

8.2 Economy

It becomes evident when looking at the history that the government in Sri Lanka and its politics has a great influence on the smallholders' economy. The government can facilitate the farmers' financial situation, the paddy farmers in particular, by providing subsidised fertilisers and maintaining a lowest fixed price for paddy. In addition, the farmers depend on other investments that the government ensures and its management of loans. Although, Hambantota District has been given extra attention because the president is from the region, there is still more that can be done to facilitate the situation for the farmers and their financial situation. Measures need to be developed to secure the farmers vulnerability during years with low yield in order to prevent farmers to be forced to take loans and become indebted. Additional measures are also needed in order to raise the living conditions of the farmers in Sri Lanka.

The fact that the war is over may possibly open up for more investments in the agriculture and in the farmers.

The paddy farmers have received more support in terms of subsidized fertilizer and a fixed minimum price than the farmers cultivating bananas and OFC. Nevertheless, many farmers prefer to cultivate bananas instead of paddy because of its other advantages. Furthermore, the banana fruit also improves the health of the population since it is nutritious and cheap.

The decisions made by the farmers, as well as the physical environment, affect the prosperity of the cultivated crop and thus the economy. Therefore, before converting paddy to banana consideration should be taken to the dominant soil type. In this manner the water resources are used more efficiently. Additionally, the market situation should also be considered before making the decision of shifting from paddy to banana cultivation to ensure that the economy of the farmer is not jeopardised.

8.3 Agricultural Methodology

Not only the physical environment and the usage of fertilizers affect the yield during paddy and banana cultivation but also the methods used. Therefore it is of value to consider and develop techniques in order to sustain the increment of yield per area. The bunch covering (see page 29) method for banana cultivation was for example a method that was not seen in Sooriyawewa D.S. division. The reason can be that this method is very labour demanding, but it could also be as simple that no farmer has tried the method and is therefore unaware of its benefits.

It is obvious that the Parachute method (see page 20) is the most advantageous method to utilize if possible. However, it is unclear why the Combined Broadcasting method is not used more frequently instead of the regular Broadcasting method. One explanation could be that it is a relatively new method and that the farmers are unaware of the benefits of the method. The Combined Broadcasting method could be one approach to cut down some of the cultivation costs and improve the harvest.

The question whether the method of standing water for paddy should be applied or not remains debatable but it seems to be the only option the farmers have to successfully eliminate the weed even if it does not improve the water situation. According to the farmers standing water is the best technique to eliminate the weeds in the early stage of cultivation. On the contrary, other sources claim that it is sufficient to keep the soil soaked throughout the whole cultivation and then use other methods such as herbicides to reduce the weed. However, with the existing regulating system with which the water from the canals is distributed, the option of keeping the soil soaked during the whole cultivation does not exist for the farmers. Besides, the amount of herbicides are limited since it is subsidised and to purchase more substances would be costly and is not recommended. A hazard with using chemical substances in combination with the standing water method is that some amount dissolves in the drainage water, which becomes polluted and has a damaging effect once it reaches the environment. Since the alternative of practising the standing water method during the first critical month exists, and all other farmers are implementing the method, it is not surprising that the farmer still utilize it when alternative options are lacking.

8.4 Fertilizers

Since the fertilizers constitute a greater cost for the banana farmers than for the paddy farmers the banana farmers are more prone to investigate in alternative methods that can cut down on the cost of fertilizers. The banana cultivators are, for example, aware of the benefits produced by remaining the cut down harvested herb on the field. To additionally reduce the costs of production the paddy farmers should also emphasize on developing their knowledge in how to prepare manure instead of only relying on the fertilizers. It is not only an economical gain but also a more sustainable and environmental friendly method of cultivation. A problem with the subsidised fertilisers is that the farmer consequently uses it instead of developing their own manure.

8.5 Statistics

The farmers emphasize that the water shortage is their largest problem. However, the statistics do not reveal that the water shortage has an effect on the average yield per hectare when comparing the years with low rainfall and the years with low yield. Even though the rainfall is decreasing during the Yala season the yield per hectare continues to increase, which means that the development of cultivating more efficiently is not hindered. However, when comparing the average yield per hectare during Maha and Yala it becomes evident that it is more prosperous to cultivate paddy during Maha. Since paddy cultivation in this region depends on irrigation, the recharge of the tanks is crucial. Therefore the rainfall that takes place upstream greatly affects the amount of water that the tanks will be recharged with and thus the yield. The change in weather patterns seen in this region is alarming since it is becoming more extreme, with a wetter Maha season and a drier Yala season. This development brings concerns for the future and will most likely result in further droughts and difficulties when the farmers manage their agriculture. An increase in droughts in the future is also supported by Droogers's (2004) and IPCC's (2007) projections, which predicts more frequent weather extremes.

The explanation of the decrease in hectares of paddy cultivated seen around year 2001 can partially be explained by a shift from paddy cultivation to banana cultivation, since an increase of banana cultivation is seen around the same period. However, the peak of the extent of banana cultivated does not completely correspond with the low of paddy cultivated. Since this study has not included an analysis of the trend of OFC cultivated, during the same time period, the impact it has on the banana and paddy cultivation is therefore unknown. It is also possible that the region has experienced a demographic increase since a greater areal is being cultivated by paddy. In addition, the difference in the extent of paddy cultivated during Maha and Yala season has decreased the last decade, which means that the majority of the farmers practice paddy cultivation twice a year.

9 Conclusion

The agriculture in Sooriyawewa D.S. division is heavily depending on irrigation but water shortage is still an occurring problem for the farmers. The water shortage constitutes a greater problem for the paddy farmers compared to the banana farmers, since the paddy requires more water when it is cultivated. The farmers have observed a change in the rainfall pattern. The statistics support the farmers' observation during the Yala season and gives a more comprehensive description of the rainfall patterns, which show a development of a wetter Maha season and a drier Yala season. However, despite the declining rainfall trend during the Yala season, the paddy agriculture has acquired a greater yield per hectares cultivated, which is true for both seasons.

Other problems experienced by the farmers are pest and weed management, which is essentially a problem for the banana farmers. In addition, the market situation also determines the banana farmers' success and thus their economy. The competition among the paddy farmers has in the past pushed down the price of paddy to unsustainable levels for the farmers. However, the situation has improved greatly since a minimum fixed price was set. It is important that the government continues to invest in the farmers and make sustainable cultivation feasible. In addition, if Sri Lanka wants to be self-sufficient in its rice production it is necessary to keep paddy cultivation profitable in order to motivate the farmers to continue cultivating the crop.

The following points summarize the observations from this study and suggest some measures that can be done to improve the situation for the farmers and in particular the farmers in Sooriyawewa D.S. division:

- Improve the loan conditions for the farmers.
- Prepare for extreme weather events, such as droughts.
- Maintain the minimum fixed price for paddy.
- Continue to subsidise the fertilisers for the paddy farmers.
- Educate the farmers in how to make their own manure. It will be cheaper and safer to use sustainable and natural substances.
- Evaluate the efficiency of the irrigation scheme and the system in which it is distributing water.
- Investigate the leakage of fertilisers and pesticides into the drainage water in order to maintain a good quality of the water and thus the environment.

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11 Appendix

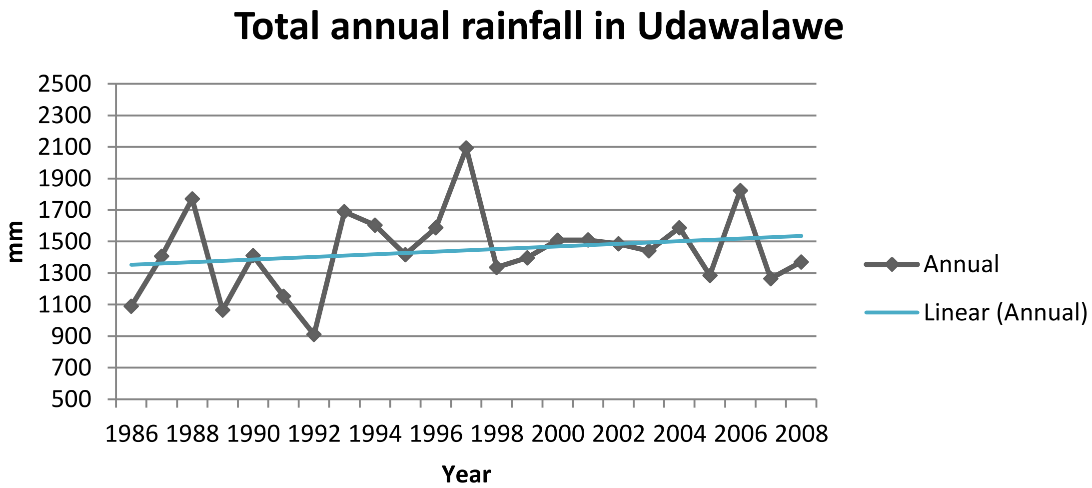
List of abbreviations and glossary:

Anicut	A small dam in the irrigation canal which regulates the water flow.
Chena cultivation	Slash and burn.
DOASL	Department of Agriculture in Sri Lanka
D.S.	Divisional Secretariat
ITCZ	Intertropical Convergence Zone
IWMI	International Water Management Institute
LBMC	Left Bank Main Canal
LHG	Low Humic Gley Soil
Maha season	The cultivation season with most rainfall, from October to March.
Mamoty	A device similar to a spade used for preparing the soil.
MASL	Mahaweli Authority of Sri Lanka
MOP	Muriate of Potash
OFC	Other Field Crops
RBE	Reddish Brown Earth
RBMC	Right Bank Main Canal
TSP	Triple Super Phosphate
Yala season	The cultivation season with less rainfall, from April to September.

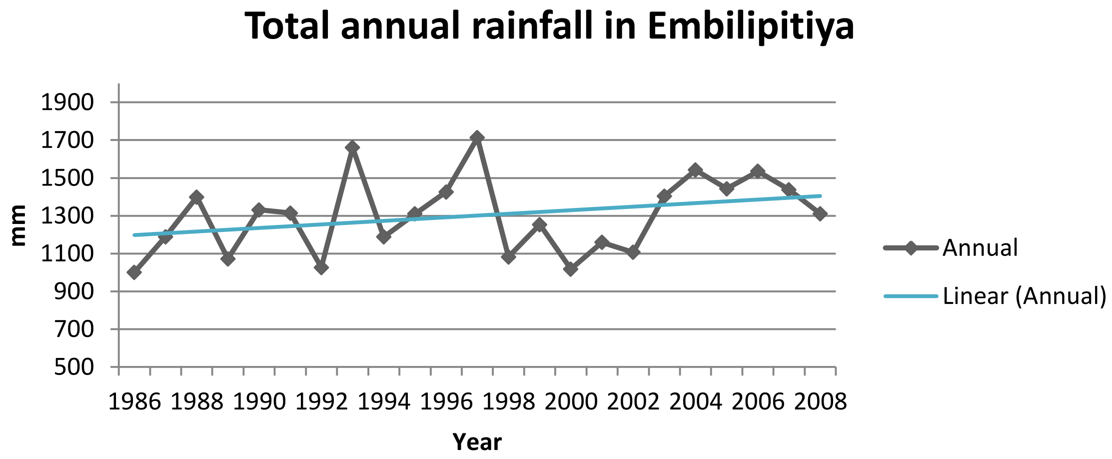
1 Share of the cultivated paddy land in Uda Walawe and Hambantota district that is cultivated with either chemical fertilisers, organic fertilisers, both chemical and organic fertilisers or no fertilisers at all during Maha and Yala. Source: Department of census and statistics Sri Lanka, n.d.

	Uda Walawe (% of used fertiliser)				**Hambantota** (% of used fertiliser)			
	Chemical	*Organic*	*Both*	*None*	*Chemical*	*Organic*	*Both*	*None*
2006/2007	42	2	56	-	55	0.4	35	9
2007	41	-	55	5	56	-	39	5
2007/2008	52	-	48	-	40	2	57	0.8
2008	58	1	40	-	44	0.1	55	1
2008/2009	45	0.7	54	-	42	-	57	1
2009	40	-	60	-	48	0.2	52	0.4
2009/2010	48	-	52	-	56	-	44	-
2010	41	-	58	-	75	-	23	2

2 The figure shows the total rainfall (mm) in Udawalawe from 1986 to 2008. Source: Unknown.



3 The figure shows the total annual rainfall (mm) in Embilipitiya from 1986 to 2008. Source: Unknow.



4 Table showing the monthly rainfall statistics (mm) in Udawalawe from 1985 to 2008. Source: Unknown.

	1985	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**
January		121	46	66	34	95	142	46
February	55	93	9	162	18	132	0	12
Mars	156	140	153	258	59	111	47	5
April	135	258	198	324	212	127	140	130
May	111	30	53	26	96	168	72	115
June	121	11	45	77	40	22	99	5
July	0	4	0	22	84	30	27	28
August	9	26	127	46	27	3	48	32
September	79	69	44	121	52	21	73	57
October	278	191	325	158	197	248	241	171
November	176	99	183	313	203	333	156	246
December	167	48	225	197	43	122	108	63
	1993	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
January	19	78	206	47	45	67	137	109
February	79	127	49	100	54	36	72	260
Mars	157	202	40	6	86	25	170	480
April	262	257	307	408	297	176	195	37
May	189	67	162	8	223	201	79	68
June	99	7	50	40	24	48	44	42
July	52	28	38	35	26	87	2	7
August	3	77	30	53	17	115	41	90
September	29	88	34	103	231	23	97	26
October	325	340	201	201	444	39	137	107
November	236	262	256	376	511	219	287	186
December	237	71	45	211	134	298	138	99
	2001	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
January	392	8	33	86	50	74	88	25
February	190	71	25	184	23	202	92	111
Mars	36	56	371	152	351	178	198	206
April	195	382	151	237	95	132	303	220
May	18	194	124	72	78	93	5	28
June	4	0	4	22	16	68	25	14
July	14	22	55	10	18	5	20	39
August	0	6	5	0	9	30	43	46
September	169	37	21	170	70	21	38	1
October	132	277	220	308	54	383	75	306
November	253	388	340	161	323	454	255	254
December	106	44	92	186	197	183	124	121

5 Table showing the monthly rainfall statistics (mm) in Embilipitiya from 1985 to 2008. Source: Unknown.

	1985	1986	1987	1988	1989	1990	1991	1992
January		143	67	58	52	103	107	20
February	71	97	1	78	8	17	18	31
Mars	254	129	187	150	53	98	64	0
April	44	137	238	177	127	73	213	55
May	154	49	29	83	102	119	74	150
June	152	19	11	64	60	31	86	20
July	5	7	0	50	211	24	44	56
August	21	54	111	37	50	21	38	25
September	135	99	101	78	76	22	55	142
October	265	165	265	187	109	333	172	140
November	224	57	123	315	178	303	269	286
December	179	44	55	123	48	187	175	104
	1993	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
January	23	86	191	79	20	120	81	58
February	54	33	54	115	12	50	156	75
Mars	124	61	63	8	65	57	249	228
April	186	147	222	329	89	127	154	40
May	233	136	220	5	293	143	84	5
June	113	25	52	44	15	41	45	58
July	60	78	18	27	25	49	0	6
August	0	50	23	80	6	39	6	135
September	18	106	46	111	254	37	41	18
October	348	231	236	119	303	29	120	43
November	262	194	137	277	486	161	195	230
December	239	41	49	232	146	230	124	124
	2001	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
January	148	8	100	39	51	70	146	46
February	146	36	64	255	35	76	79	171
Mars	168	185	295	135	260	187	71	178
April	207	152	170	195	128	120	297	243
May	11	82	137	100	64	0	21	4
June	8	18	22	36	17	66	28	15
July	14	29	43	9	24	16	4	28
August	1	20	0	17	55	75	51	45
September	130	26	93	137	58	76	114	7
October	143	154	160	226	160	366	189	145
November	122	275	317	226	455	297	359	248
December	62	122	4	166	139	187	77	181

6 Table showing the extent of banana cultivated in hectares in Hambantota District from 1995 to 2008. Source: Department of Census and Statistics Sri Lanka, prepared by Statistics Division, Ministry of Agricultural Development, 2009.

Year	1995	1996	1997	1998	1999	2000	2001
Hectares	2 581	2 792	2 670	2 844	2 602	2 795	1 576
Year	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Hectares	2 210	4 248	5 286	3 716	2 803	2 915	2 041

7 The area of paddy harvested in hectares during Yala and Maha in Hambantota and Udawalawe Districts during 1979 to 2008. Source: Department of Census and Statistics Sri Lanka, n.d.

	Hambantota (ha)		Udawalawe (ha)	
	Maha	Yala	Maha	Yala
1979	19302	9280	6264	5972
1980	15680	13117	7242	7410
1981	18303	13043	7792	9540
1982	16662	13991	9887	10457
1983	19648	10884	11118	10375
1984	19498	15650	11163	10973
1985	17460	12580	10560	11152
1986	19502	15012	11434	11459
1987	17848	8029	11465	10513
1988	22499	13741	10320	10379
1989	22227	15488	10574	10381
1990	17922	13087	10823	10488
1991	17151	13839	10595	10103
1992	21427	9900	10673	1328
1993	21731	11667	10483	9602
1994	23024	18321	10424	9880
1995	22545	18634	10102	9712
1996	20804	14400	9713	8002
1997	18383	15155	8884	9023
1998	24573	18366	9766	7210
1999	23395	19608	9024	9625
2000	19553	20109	9726	8804
2001	14212	9279	653	8638
2002	13930	11899	8766	8321
2003	16264	18470	8901	8132
2004	16646	13383	8461	8606
2005	18677	16492	8884	9160
2006	19873	16406	9904	9294
2007	21875	20771	9460	9381
2008	24007	24451	9527	10503

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