# A statistical study on agricultural factors related to paddy cultivation in Sri Lanka

by

Satkunasingam Suthananthan

Thesis submitted to the University of Sri Jayewardenepura for the award of the Degree of Master of Science in Applied Statistics in 2006.

## DECLARATION

The work described in this thesis was carried out by me under the supervision of Dr.B.M.S.G. Banneheka and a report on this has not been submitted in whole or in part to any university or any other institution for another Degree/Diploma.

To be the best of my knowledge the above particulars are correct.

.....

Signature of candidate.

S.Suthananthan.

Reg.No: GS/PS/1773/2002.

Index No: PGD/PS/0062.

## DECLARATION

I/We certify that the above statement made by the candidate is true and that this thesis is suitable for submission to the University for the purpose of evaluation.

.....

Dr.B.M.S.G. Banneheka.(Supervisor)

Senior Lecturer.

Department of Statistics and Computer Science,

University of Sri Jayewardenepura,

Sri Lanka.

# Table of Contents

## ACKNOWLEDGMENTS

I am grateful to the faculty of post graduate studies of the University of Sri Jayewardenepura Sri Lanka for granting me this opportunity. Special thanks are due to Dr. B.M. Sarath Gamini Banneheka, for his continuous assistance, guidance, supervision and fruitful discussions given throughout the study. Also I am thankful to Mr.P.Dias for his insightful reviews and comments. I appreciate the cooperation provided to me by the officials of the Department of Census and Statistics, Sri Lanka in obtaining the data.

I would also like to thank all other members of the academic staff of the Department of Statistics and Computer Science for their direct and indirect assistance.

Finally I must thank once again Director General, Director of Agriculture and other staff of the Department of Census and Statistics, Sri Lanka for the kind support and corporation given me to carry out this project.

S. Suthananthan.

## ABSTRACT

Rice has been the staple food of Sri Lanka for centuries. The continuously increasing nation's population increases the demand for rice. Recent statistical evidence shows that in year 2004 nation's paddy yield has declined compared to year 2003. Therefore, increasing production of paddy is vital for the social-economic development of the nation.

I have undertaken this research on the yield of paddy production as my dissertation for my M.Sc Degree in Applied Statistics where I attempt to suggest ways and means of increasing the yield of paddy production by changing the factors, such as type of irrigation, methods of land preparation, ...etc, used in paddy production.

In order to actualize the objectives described above, I have obtained the data from the Department of Census and Statistics. The data belong to the Maha and Yala season from years 1976 to 2004 were used for identifying trend in the paddy production. The other set of data belong to year 2002/2003 Maha season and 2003 Yala season were used to identify the influential factors in the paddy production.

One crucial aspect treated in this dissertation is forecasting yearly yield in terms of Maha and Yala season. In order to achieve this objective a statistical analysis was carried out, using Iterative Time Series Modelling (ITSM) computer software package where the minimum AICC technique was applied in the ARIMA model.

The forecasting yields of paddy production obtained from the study were checked with years 2003 - 2004 data. These outcomes were within the 95% confidence interval. Finally, the forecasting value derived for year 2005, with respect to both Maha

and Yala seasons were 78.71 bushels per acre, 77.51 bushels per acre; 79.85 bushels per acre, 78.75 bushels per acre for year 2006; 81.03 bushels per acre and 79.97 bushels per acre for year 2007. It is clear that the above production per acre in the Maha and Yala season is not enough to feed to the entire nation. So, I decided to identify the influential factors to increase yield of paddy production.

Therefore, the second set of data belong to year 2002/2003 Maha season and 2003 Yala season were used in the Gamma model for the purpose of determining influential factors of the paddy production. I have found some influential factors in this analytical study. These influential factors are major irrigation, minor irrigation, use of tractor, use of buffaloes, hand weeding and impounding water, use of weedecides, insecticides, chemical fertilizer, organic fertilizer, season, broadcast sowing method and districts. Out of these influential factors broadcast sowing method and certain districts are negative influential factors.

The above statistical analysis indicates that yield could be increased subject to variation of the controllable factors in paddy cultivation process. The controllable factors are method of land preparation, application of chemical fertilizer, application of organic fertilizer, application of insecticides and use of weedicides.

# CHAPTER- 1

# INTRODUCTION

## 1.1. Background of the study

Sri Lanka, like other countries in the Asian region has an agricultural economy and the agricultural sector plays an important role in the social-economic development of the country. Rice has been the staple food of Sri Lanka, for centuries and during the pre-independence era, great emphasis was placed upon the cultivation of paddy and other crops. But the development of the domestic agricultural sector received due attention only after independence in 1948. Since independence, successive governments have given priority to the development of paddy cultivation. And in due course, paddy has regained its position as the major domestic food crop of the highest importance in the economy of Sri Lanka.

As it is the case with all other countries, the population of Sri Lanka has also continued to increase. This directly influences the increase in the demand for rice in the country. According to the trends and performance, paddy production has indicated a negative growth rate of 14.3 per cent in 2004 as against a growth rate of 7.4 per cent in 2003.[11]

Examination of previous data shows that, the total production of paddy and the total land area under paddy cultivation have increased. The average yield in paddy (per cultivated area) has also increased with time. This might be attributed to different cultivation practices that are being subject to study in this research. Due to the significant influence of the paddy in the Sri Lankan economy, previous and present government have taken efforts on promoting rice production in order to achieve self-sufficiency in this commodity. Large-scale irrigation projects, land development and

settlement schemes have been undertaken while the government also provides free irrigated water, fertilizer subsidies and guaranteed prices to farmers. In the 1930s and 1940s policies were directed at developing the dry zone for the cultivation of rice. However, the main problem associated with paddy was the low yield due to the large numbers of smallholder farmers.

It is claimed that the yield per unit of land area is very low in Sri Lanka. Some even advocated the abandoning of paddy cultivation because of poor productivity compared to other countries. However, a comparison of the yields in comparable countries in the region shows that the average yield in Sri Lanka is much higher than in most of these countries. For instance, yield in Sri Lanka is higher than that of several major rice exporting countries like Thailand, Myanmar and Pakistan. Sri Lanka's paddy yield cannot be compared with the yield in countries like Japan or Korea because they have a temperate climate and longer day lengths, which result in greater photosynthetic activity and higher yields. [3]

| Country | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|
| India | 3,236.1 | 2,852.3 | 2,131.5 | 2,839.5 |
| Indonesia | 4,251.9 | 4,400.7 | 4,387.9 | 4,473.2 |
| Madagascar | 2,128.4 | 2,050.8 | 2,195.2 | 2,196.2 |
| Myanmar | 3,240.5 | 3,383.4 | 3,417.4 | 3,674.2 |
| Pakistan | 3,074.4 | 3,031.2 | 2,745.2 | 3,017.9 |
| Philippines | 2,946.8 | 3,068.1 | 3,186.6 | 3,279.7 |
| Sri Lanka | 3,672.0 | 3,856.4 | 3,954.3 | 3,895.2 |
| Thailand | 2,424.5 | 2,612.8 | 2,618.6 | 2,564.1 |

Table 1.1: Yield in major rice producing countries in the tropical region in Kg/hectare. (Source: Central bank annual report 2003.)

The Table 1.1 gives the average yield per year per hectare from 1999 to 2002 in major rice producing countries in the tropical region. It does not show any radical changes in average yield in paddy for the countries listed above. Certain areas in

Indonesia belong to temperate zones and have longer days, resulting in higher yields. Further, Indonesian soil is more fertile because of volcanic activity.

The sowing extent under paddy cultivation during 2002-2003 Maha and Yala were 1,486,553 acres and 941,555 acres respectively. There is a 18 and 10 percentage increase when compared with the previous Maha and Yala seasons. The average yield of paddy estimated for 2002-2003 Maha and Yala were 73.58 and 71.94 bushels per acre respectively. Compared with the previous Maha and Yala season there is a decrease of 3.8 and 0.6 bushels per net acre, respectively. [1]

A significant role is played by the farmer in the paddy / rice industry and without his commitment and involvement; it is difficult to improve this industry. Therefore, it is essential to investigate the present paddy production system and identify the causes for the drawbacks and difficulties faced by farmers in order to reach a viable solution to the problem and thereby ensure the yield of the paddy is increased and thereby transforming paddy cultivation into a viable means of self-employment.

Therefore, there is need for research on the development of these paddy production sectors. The change in the paddy yield and the influence of cultivation methods on the average yield are the main focus of this study.

**1.2 Literature review**

1. A.G.W.Nanayakkara, 1987, [10] in his report under the title 'Progress in paddy cultivation and production in Sri Lanka and forecasts for the future'. In this study, the average yield in paddy and the year were used as the response variable and the explanatory variable respectively. These data were collected over the period 1952 to 1986. He has fitted polynomial linear regression models for Maha season and Yala seasons separately. According to A.G.W.Nanayakkara there are a number of factors,

which could influence the production levels of paddy. Some of the important factors influencing production are rainfall, use of fertilizer (quantities used depend on price, availability and proper distribution), availability of irrigation facilities, and price of paddy, areas sown and harvested. In the opinion of the author, far more accurate results can be obtained by including these factors in this study.

**2.** A.M. Razmy, 1998 [5] has studied 'trends in paddy production in Sri Lanka' for his M.Sc degree in applied statistics at the University of Peradeniya. In this study, the average yield of paddy and year were used as the response variable and the explanatory variable respectively. He has fitted general linear regression and the classical time series model for Maha season and Yala season for each district, separately. The author has concluded that, high yield can be obtained by resorting to improved cultivation practise and in particular, use of good seed, fertilizer and weed control of weeding, which latter practice is greatly facilitated by trans planting or row sowing.

### 1.3. Objectives

The objectives of this dissertation are to;

1. Study the trend of average paddy yield in the country.
2. Identify a model that explains the relationship between yields per perch in bushels with respect to cultivation processes.

## 1.4. Outline of dissertation

In the second Chapter, the secondary data with respect to paddy yield in 25 districts are presented. These data are explained according to districts, season, type of irrigation, method of land preparation, method of cultivation, weeding method, adverse weather condition, insecticides, fungicides, fertilizer and data profile.

In Chapter 3, the stochastic model has been used to analyse the data in terms of year, season and average paddy yield. In order to verify the outcome, I found that ARIMA was the most suitable. For this purpose ITSM package was used.

In Chapter 4, the data above have been analysed using the General Linear model and the Gamma model in Generalized Linear model. For this purpose application packages SAS, SPSS, MINITAB and excel were used.

In Chapter 5, conclusion with respect to Chapter 3 and Chapter 4 have been presented with explanations. Suggestions relevant to present and future paddy yields have been presented.

# CHAPTER- 2

# DESCRIPTION OF DATA

## 2.1. INTRODUCTION

The data on paddy were collected as secondary data from the agriculture division of the Department of Census and Statistics. The statistics on paddy presented here are in terms of the yield. The data for the compilation of these statistics are taken from the bi-annual crop cutting survey conducted by the Department of Census and Statistics throughout the country. The sampling design adopted for the survey is a stratified three stage random sampling method with mode of irrigation namely; Major, Minor, Rainfed as strata. From each stratum sample villages are selected using simple random sampling method where the number of samples per stratum depends on the sown are for first stage. In second stage, from each selected village, sample parcels are selected using simple random sampling method. From each selected parcel, sample Liyeddas are selected using simple random sampling method in third stage. Crop cutting experiments conducted in about 2500 villages in the Maha season and about 2000 villages in the Yala season. The standard experimental plot size is 16 1/2ft x 16 ½ ft (5 meters x 5 meters)[3]. This survey is the main source of quantitative information on paddy cultivation in Sri Lanka.

## 2.2 Description of Variables

The yield from 1976 to 2003 is used for the study of the pattern of paddy yield over the period. Also, yields for year 2002/3 Maha and 2003 Yala are used to identify the influence of cultivation processes on the average yield of paddy. The variables used are described in the following section.

**Seasons (SE)**

Agro-climatically, the year is divided into two distinct seasons, Maha coinciding with the North-East monsoon and Yala, with South-West monsoon. The Maha season is distributed all over the island from late September to February, the major cultivation season. The Yala season is from early April to early September, the minor cultivation season.

| Label | Name | Level | Number of observations | Percentage |
|---|---|---|---|---|
| SE | Season | 1-Maha | 3870 | 57.5 |
| | | 2-Yala | 2865 | 42.5 |
| | | Total | 6735 | 100% |

Table 2.2.1: Number of observation and percentages under Maha and Yala.

The Table 2.2.1 shows the major cultivation season Maha has a higher number of observations than the other season.

**Type of irrigation (IR)**

Irrigation is an important factor for the growth of paddy. There are three main forms of irrigation.

1. Major irrigation schemes: here the water supply is either from a major tank or a river.
2. Minor irrigation schemes: these are natural or man made reservoirs. A large portion of the rural population depends on village tanks for their livelihood.
3. Rain-fed cultivation: here paddy is grown either directly or indirectly based on natural rainfall. If the rainfall is light at the beginning and at the end of both monsoons, it is of little value to most seasonal crops, because it does not wet the soil deep. Heavy rainfall, on the other hand, will be mostly lost as runoff.