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The Influence of Rainfall Variability on Paddy Production: A Case Study in Batticalloa District

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ABSTRACT

Climate change has become a major concern to human society because of its potentially deleterious impact worldwide. The degree to which rainfall amounts vary across an area or through time is an important characteristic of the climate of an area. This subject area in meteorology is called "rainfall variability". Changes in amount, intensity and frequency affect the environment and society. The annual rainfall varies from 864 mm to 3081 mm (146 years data) distribution, which has sight variation throughout the district. The study purposes to examine the relationship between rainfall and paddy production. Samplings from 100 households have been gathered by questionnaire survey as primary data and the secondary data has been collected Meteorological Department, Department of Agriculture and published research reports. 146 years rainfall data and 34 years paddy cultivation data has been utilized to analyse the result. Accurate statistical methods have been used to find the variability that includes correlation and trend analysis of 3, 5 years moving average of standard deviation. As the result, the study finds that through the 3, 5 years moving average had shown high drier seasons of the years. The paddy production was very high in Maha season but this was very low in Yala season because of the rainfall variability. By the correlation between rainfall and paddy production, the significant value is positive in Maha season and this is negative in Yala season. However, both are having the different significance each other. Thus, even the rainfall was highly influenced to the higher production, this is impossible in each time. Therefore, the development of irrigation tanks and channels, rainwater harvesting and proper management would be supported to more production in Yala season.

***Keywords*:** Agriculture; Meteorology; Paddy production; Rainfall variability

1. INTRODUCTION

Rainfall is the primary importance to the both physical and cultural landscape of any region. Of all the standard climatic parameters, rainfall is the most variable parameter in time and space (Mendelsohn, Dinar, Sanghi, 2001). The rainfall intensity varies markedly across the island. Based on rainfall, several agro climatic regions (wet zone, intermediate zone, dry zone, and arid zone) have recognized.

The degree to which rainfall amounts vary across an area or through time is an important characteristic of the climate of an area. Changes in amount, intensity and frequency affect the environment and society. The climate can be very different if the frequency and intensity of rainfall differ, highlight the fact to the characteristics of rainfall are just as vital as the amount, in terms of the effects on the soil moisture and stream flow (Chandrapala, 1966). Depending on the rainfall pattern, climatologists divide Sri Lanka's climatic year into four seasons: two Monsoon periods and two Inter-Monsoon periods. The Southwest Monsoon (Summer Monsoon) prevails from May to September while the Northeast Monsoon (Winter Monsoon) lasts from December to February. In between these two monsoon periods, two Inter-Monsoon periods exist: March to April - first Inter-Monsoon period and October and November - second Inter-Monsoon. Westerly winds prevail during the Southwest Monsoon and Northeasterly winds prevail during the Northeast Monsoon (Yoshino, Masatoshi, Suppiah, Ramasamy, 1984). The seasonal variations of wind direction and rainfall have a marked influence on human activities.

The annual rainfall varies from 864 mm to 3081 mm (146 years data) distribution, which has sight variation throughout the district. The most of the rain is being received during the month of October to February and it is both inter-monsoon and North East monsoon types. The mean annual rainfall values on the eastern slopes are less than 3,500 mm and the lowest are in the northwest (Chandrapala, 1966).

Climate change has become a major concern to human society because of its potentially deleterious impact worldwide. It poses especially significant threats to sustainable development in developing countries, which have fewer resources and are more vulnerable (Munasinghe, 2001).

Impacts on developing countries remain poorly understood because few studies have successfully measured the effects of climate on developing country economies. Nonetheless, it is likely that a developing country will be more vulnerable because a greater fraction of its economy is in climate sensitive sectors (for example, agriculture), it is already in a hot climatic zone, and the economy relies on labour-intensive technologies with fewer adaptation opportunities (Mendelsohn, 2001).

Rainfall is a key determinant of the growing seasons and the types of agriculture practiced. Rainfall plays an important role in agriculture as any shortages or excesses of rainfall gives way to a reduction in yields. For instance, rice is the main crop in Sri Lanka and is highly susceptible to rainfall variability (Yoshino, 1984).

Rice, the basic food of Sri Lanka, is the most important source of employment and income of the rural population. During 1940’s the country produced only 45 percent of the total requirement of rice with a population of only 7 million and the country is now at 90 percent self-sufficiency with 20 million population. During the past decade, this has varied between 85% - 98% (Thiruchelvam, 2005). Thus, there is growing concerns that the global warming would affect the productivity of paddy crops (Tao *et al*, 2008).

The two seasons for paddy cultivation are Maha and Yala. Maha is the seven month period from September – March and Yala, the five month period from April to August. As such, Yala gets its rainfall from the second half of the first inter-monsoon and most of the Southwest monsoon, whereas Maha depend mainly on the rainfall from the Northeast monsoon and the second inter-monsoon (Fernando, 2000).

It is the single most important crop occupying 34 percent (0.77 /million ha) of the total cultivated area in Sri Lanka. On average 560,000 ha are cultivated during Maha and 310,000 ha during Yala making the average annual extent sown with rice to about 870,000 ha. About 1.8 million farm families are engaged in paddy cultivation island-wide. Sri Lanka currently produces 2.7 million tons of rough rice annually and satisfies around 95% of the domestic requirement. Rice provides 45% total calorie and 40% total protein requirement of an average Sri Lankan (DOA, 2006).

Contributing the Maha season provides about 70 percentage of the country's annual rice production. These areas involves in Anuradhapura, Batticaloa, Hambantota, Polannaruwa, Vauniya, Ampara, Jaffna, Kurunegala, Galle, Kalutara, Gampaha and Colombo zone in Sri Lanka, which have been reserved and designated purposely for wetland paddy cultivation by the government in the National Agricultural Policy. Most of the government support programs and interventions on paddy cultivation sector are concentrated in these areas, which also makes it an important area for research and development activities.

Climate and agriculture both are highly interrelated. Agriculture is highly dependent on the climatic factors. The climatic factors as well as other factors that are determined by climate cause vulnerability of agriculture and agricultural production.

Batticaloa District has many agriculture activities such as Paddy cultivation, Vegetables, chilies and other crops. Paddy cultivation is the major plantation for farmers in this district. Their basic economy and food is mainly depending on rice production. Batticaloa District has good climate, well irrigation and soil structure for paddy production. The study area's paddy cultivation is also affected by the rainfall fluctuation and the other hand without enough irrigation water. Due to this, they leave the paddy cultivation in the middle of this period. There was lots of researches and publishing done about this issue. These problems lead to number of problems in paddy production and human life. It is a major problem in primary economic activities.

This study, therefore, attempts to determine the potential impacts of climate change, namely changes in rainfall, on the paddy production of the study area.

2. STUDY AREA

Batticaloa is in the eastern coast of Sri Lanka on a flat coastal plain boarded by the Indian Ocean in the east occupies the central part of the eastern Sri Lanka. The District of Batticaloa itself consists of several administrative divisions, which are:

- Manmunai North
- Manmunai West
- Manmunai South West
- Manmunai South & Eruvil Pattu
- Manmunai Pattu
- Koralai Pattu North

- Porativu Pattu
- Kattankudy
- Eravur Pattu
- Eravur Town
- Koralai Pattu
- Koralai Pattu West

It covers land area of approximately 2633.1 Km^2. and internal waterway of 229 Km^2. The District accounts for 3.8% of the Countries total Land area. The District has a population of 582,323. Density of population is 222 Persons per square Km. in Batticaloa District (District Secretariat).

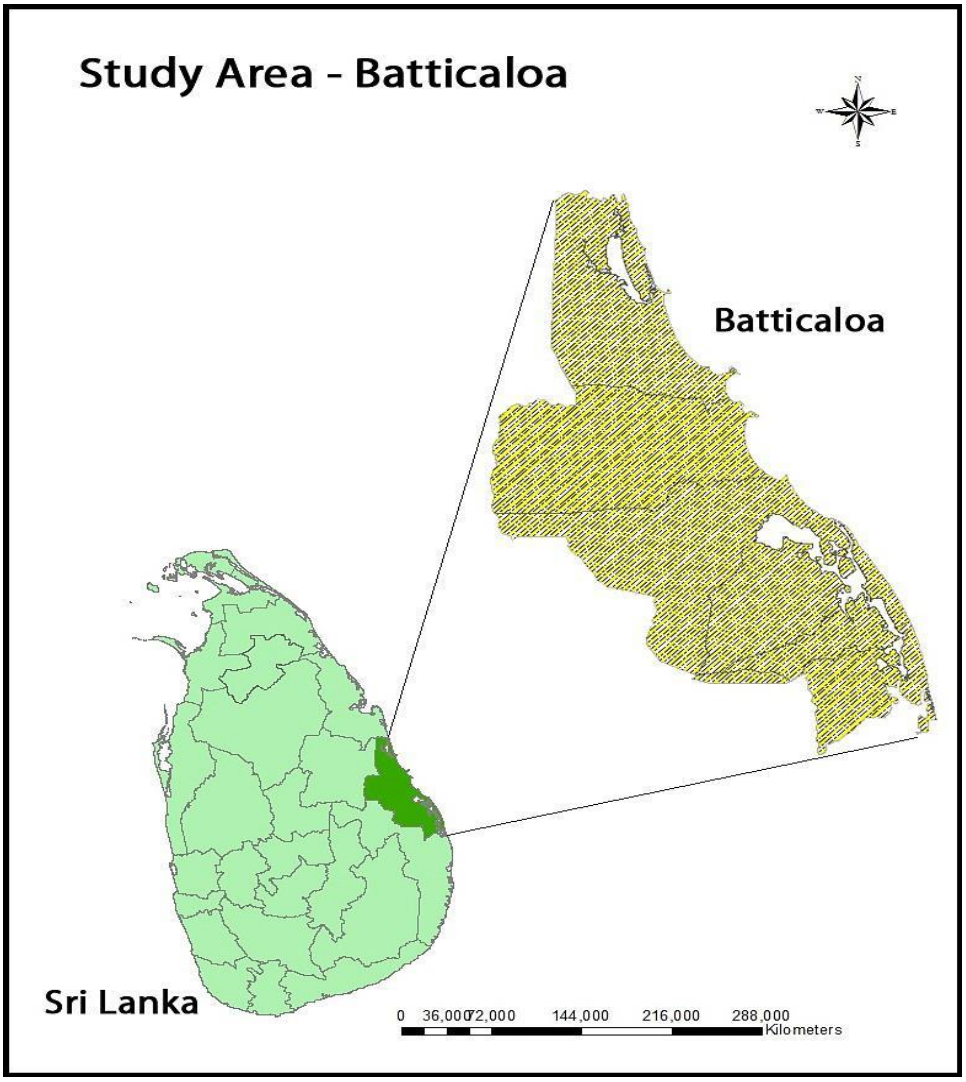

Figure 1. Study Area – Batticaloa (Source: Retrieved on Arc GIS 10.1, 2016)

3. OBJECTIVES

1. To identify the rainfall variability in Batticaloa District
2. To find out the production of paddy yield in Batticaloa District
3. To examine the relationship between rainfalls and paddy cultivation in Batticaloa District

4. METHODOLOGY

In the collection of necessary information and data for the study, the researcher depends on both qualitative and quantitative data from both the primary and secondary sources.

4. 1. Primary Data

Sampling method has been used to collect primary data. Hundred samples have been collected by Questionnaire survey. These 100 samples were distributed to different stakeholders as follows; Development Officer 20, Irrigation officials 15, Farmers 50, Public 15 and Field observation has been done in the paddy area. Direct interview; questions will be prepared and discussed with individuals and group of people based on the study focus. These informal direct interviews would be conducted with men and women from different group of people throughout the research process. The Direct interview methods will be used to gather primary information criteria for the selection of individual and group interviewee has been based on farmers, government officials and non-government officials.

4. 2. Secondary Data

The secondary data has been collected from several organization. Population data from Department of Census & Statistics of Sri Lanka, Rainfall and temperature data from Meteorological Department, Paddy production of Batticaloa District from Department of Agriculture, Irrigation Report, Annual performance report & accounts of Batticaloa, images, and published research reports were utilized to the study. The following sources of secondary data collection would be used in this study;

- Printed Maps
- Private (NGO's) sources
- Collection from the web

4. 3. Data Analysis

146 years rainfall data (1868 – 2013) from meteorological station of Batticaloa and 34 years paddy cultivation data (1980 – 2013) from Department of Agriculture has been utilized the analyze the result. Accurate statistical methods have been used to find the variability on rainfall trend and paddy production trend that includes trend analysis, 3, 5 years moving average of Standard deviation.

Correlation analysis is used to analyze the water level a statistical analysis method that statistically measures the extent and the nature of the relationship between two variables. Correlation is concerned with describing the strength of the relationship between two variables by measuring the degree of "scatter" of the data values. In this study, the correlation

co-efficient analysis is undertaken to find out the relationship between the rainfall and paddy production in the study area. MS Excel, SPSS, GIS software were used for the study.

5. RESULT AND FINDINGS

5. 1. Annual Rainfall Changes

The annual changes of rainfall are shown below on Figure 2.

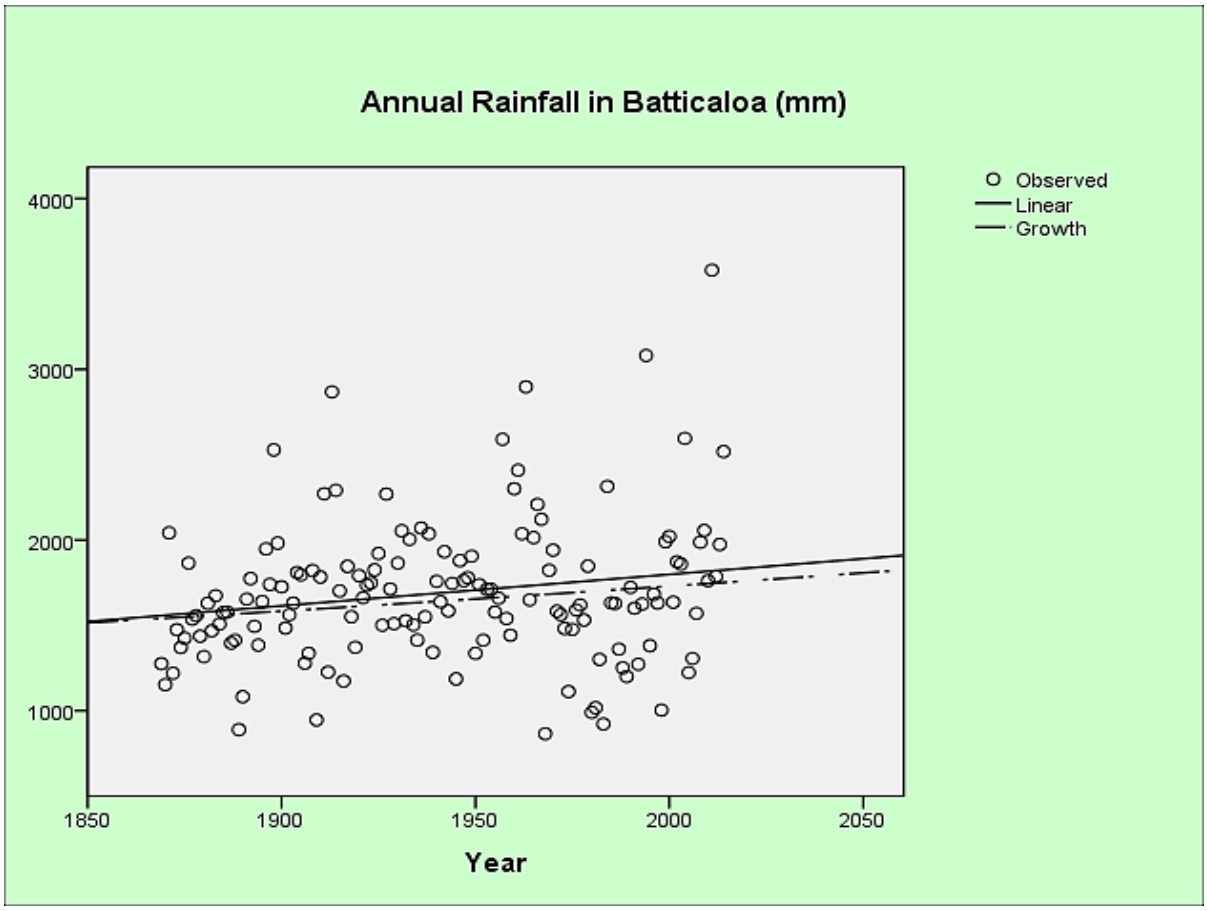

Figure 2. Annual Rainfall in Batticaloa

The trends of annual rainfall was deviated in this area, 2011 had being 3581mm as a high rainfall of the years and 1968 had being 865mm as a low rainfall of the years. However, the rainfall was not being below 800mm in between these period. The rainfall was from 2000mm to 3000mm in the years 1871, 1898, 1911, 1913, 1914, 1927, 1931, 1933, 1936, 1957, 1965, 1966, 1984, 2000, 2004, 2009 and 2014 and above 3000mm of rainfall was obtained in 1994 and 2011, we have faced heavy flood during this period. Some period was obtained below 1000mm of rainfall in 1889, 1909, 1968, 1980. This was caused to the drought in the study area. In other periods, the rainfall was in between 1000mm to 2000mm, many years were obtained.

5. 2. Standard Deviation for Rainfall

The annual rainfall varies from 864 mm to 3081 mm (146 years data) distribution, which has sight variation throughout the district. The most of the rainfall is being received during the month of October to February and it is both inter-monsoon and North East monsoon types.

The Figure 3 clearly illustrates the changes of rainfall variability. There were 14 dry season and 14 wet season. The long term of dry season were occurred from 1870 to 1895 for 16 years and the long term of wet season were occurred from 1956 to 1967 for 12 years. The first wet season was being from 1896 to 1900 for 5 years and the first dry season was being from 1870 to 1895 for 16 years.

The seasons are flaxible in each other. Nonetheless, the long term was experienced the dry season in between the years.

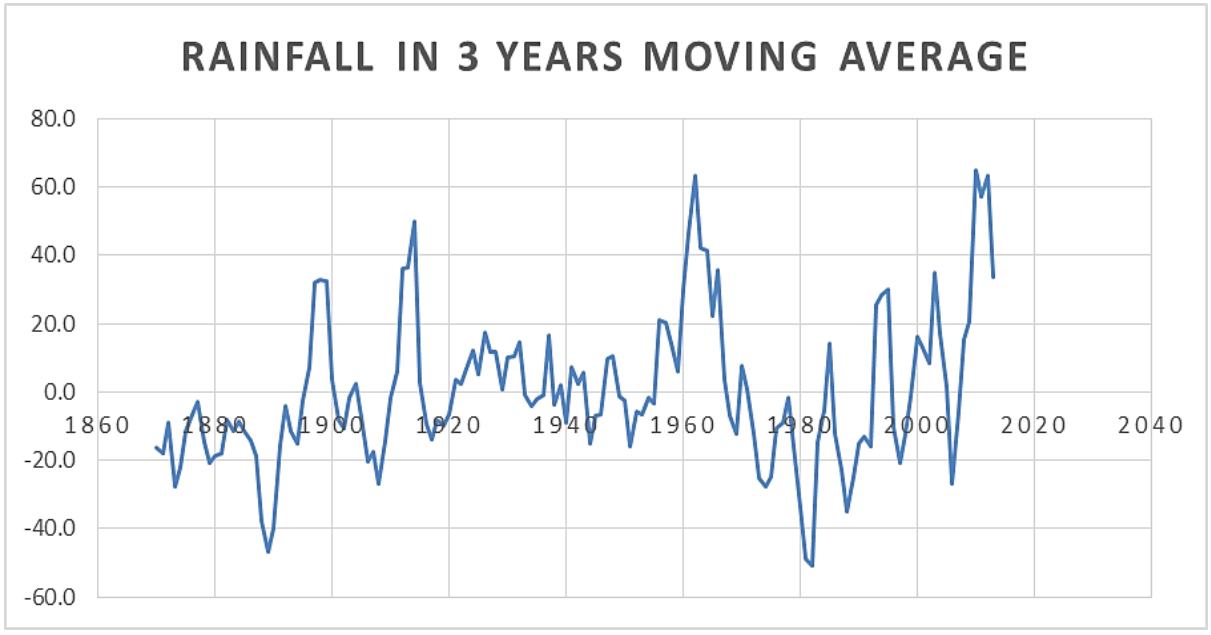

Figure 3. Rainfall in 3 years Moving Average

The Figure 4 shows that the selected 146 years rainfall, there were 11 dry season and 11 wet season. The long term of dry season were occurred from 1871 to 1895 for 25 years and the long term of wet season were occurred from 1922 to 1936 for 15 years. The first wet season was being from 1871 to 1895 for 25 years and the first dry season was being from 1922 to 1936 for 15 years.

The rainfall seasons are imbalanced in each other. Nonetheless, we had experienced the long term of dry season in between the years.

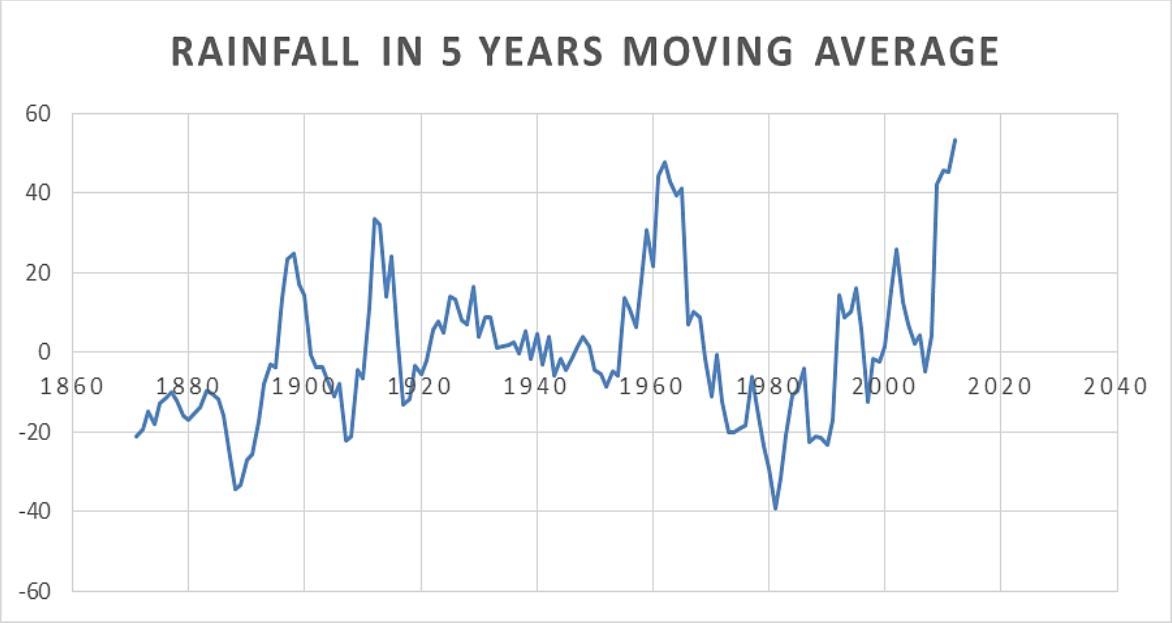

Figure 4. Rainfall in 5 years Moving Average

5. 3. Paddy Production in Batticaloa

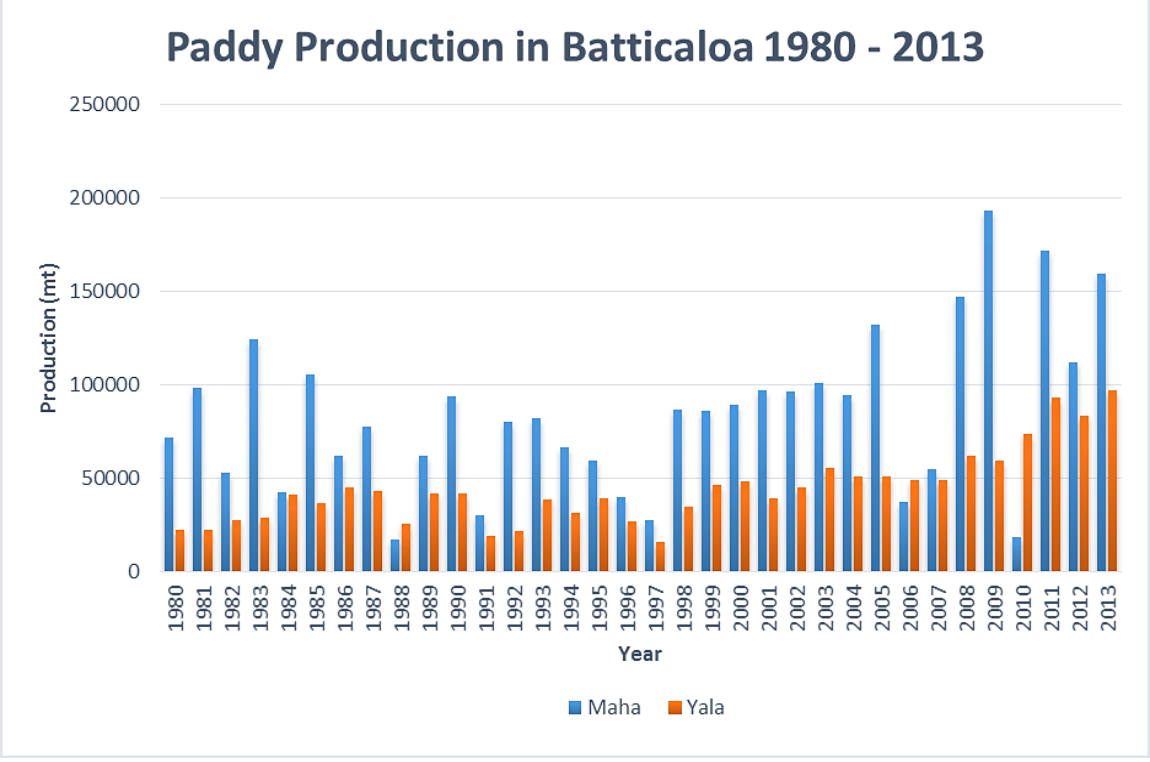

Figure 5. Paddy production (mt) in Batticaloa 1980 – 2013 (Source: Department of Census and Statistics, 2015)

According to the Figure 5, the paddy production was very high in Maha season when compare with Yala season. The yield was very high above 100,000mt in 1983, 1985, 2003, 2005, 2008, 2009, 2011, 2012, and 2013. During the period of 1988, 1991, 1997 and 2010 were very less yield produced in Maha season. The main reason for this, it got very less rainfall in in these periods and even the pre and post-civil war is another reason for the less production. Whatever the rainfall is high in this area, 2005, 2008, 2009, 2011 and 2013 were got high production.

In the Yala season, less amount of production had produced by the farmers because, they could not get the sufficient water for the cultivation. The major reason for this, the less rainfall was registered during this period. The highest production is 96,780mt in 2013 and others are less than 2013. The good development was started after 2008 when compare with past years.

5. 4. Correlation Analysis

Table 1. Maha season Paddy production (mt) and Rainfall in Batticaloa 1980 – 2013.

Correlations			
		Rainfall	Maha Season
Rainfall	Pearson Correlation	1	.510**
	Sig. (2-tailed)		.002
	N	34	34
Maha Season	Pearson Correlation	.510**	1
	Sig. (2-tailed)	.002	
	N	34	34
**. Correlation is significant at the 0.01 level (2-tailed).			

The Table 1 shows, the relationship between Rainfall and Maha season paddy production. From the table it can be observed that there is a strong positive relationship between Rainfall and Maha season paddy production. The correlation value is 0.510 and which is significant at the level of 1% because the p value (0.002) is less than the significant level of 0.01.

Table 2. Yala season Paddy production (mt) and Rainfall in Batticaloa 1980 – 2013.

Correlations			
		Yala	Rainfall
Yala	Pearson Correlation	1	.335
	Sig. (2-tailed)		.053
	N	34	34
Rainfall	Pearson Correlation	.335	1
	Sig. (2-tailed)	.053	
	N	34	34

At 95%, confident level the Table 2 illustrates that there is negative correlation between Rainfall and Yala season paddy production, according to the Table 2 the correlation value is 0.335 and which is significant at the level of 5% because the p value (0.053) is greater than the significant level of 0.05. According to the correlation for rainfall helps to test the production here the significant P value is less than the 0.05 significant levels therefore the alternative or null process can be accepted.

6. CONCLUSIONS

The contribution of rainfall for paddy production takes a major role in the world. Rainfall differs in every area of Sri Lanka. It varied from 864mm to 3081mm distribution which has sight variation throughout the district. According to the 3 years standard deviation moving average, there were 14 dry seasons and 14 wet seasons, the first wet season was being for 5 years from 1896 to 1900 and by the 5 years standard deviation moving average, the first wet season was being for 25 years from 1871 to 1895.

The paddy production was very high during the Maha season because of the high rainfall and this is low in Yala season by the less rainfall. The yield was very high in 2008, 2009, 2011 and 2013. According to the correlation analysis, both positive and negative impacts were identified. There is a strong positive relationship between rainfall and Maha season production, the correlation p value is 0.002 is less than significant level of 0.01. There is a negative relationship between rainfall and Yala season production, the correlation p value 0.053 is greater than the significant level of 0.05. As a result, rainwater harvesting, making the proper irrigation system, improving the traditional agricultural practices are the suggestion to get more yield from Yala season. Overall analysis, there are strong and negative relationship between paddy production and rainfall.

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