Growth and Instability Analysis for Selected Other Field Crops (OFC) in Sri Lanka

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Abstract

Sri Lanka government has initiated various production-oriented programmes time to time, which have exaggerated the intensifying level of production of domestic crop sector especially paddy and other field crops. However, still there has been a negative trend in OFC sector with wide fluctuations and extensive instability in regional level. Thus, the government has to depend on imports to meet the increasing domestic demand. This is mainly attributed to low growth in the agricultural sector and vulnerable for food security. Hence this study was undertaken to answer the question of what the nature and extent of growth and instability in area, production and average yield of selected other filed crops has been. The national and district level production and cultivation extent figures of black gram, green gram, cowpea and kurakkan were used for the analysis. Compound growth rate and Co- efficient of variation was used to measure the long term growth trend and instability. Based on the different levels of compound growth rates and instability indexes, a matrix was prepared to identify the most vulnerable regions. The results of this study reveal that, Yala season is highly susceptible to fluctuations of production and extent of cultivation. Cultivation of cowpea is more stable though it follows a negative trend. It was also revealed that increasing of the land area under cowpea cultivation in Hambantota district and Mahaweli H is suitable. Kurakkan cultivation is unstable and also pursues a negative trend. However, the prospects of kurakkan cultivation in Northern and Eastern Provinces are high. Black gram and green gram cultivation in the dry zone dose not entail production risk. With immense population pressure and urbanization, land area for crop cultivation in the wet zone would further decline. Proper irrigation support for intermediate zone, crop diversification in dry zone, developing new high yielding varieties and promoting cultivation in North and Eastern provinces would be timely.

1. Introduction

Other Field Crops (OFC) in Sri Lanka mostly include condiments (chili, big onion, red onion), coarse grain (maize and kurakkan), pulses (green gram, cowpea, soybean, black gram) and oil crops (groundnuts and gingerly). Average monthly consumption of OFC s is given below.

Table 1: Average Monthly Consumption of OFC

Crop	Average monthly consumption per person (grams)
Green gram	50.40
Cowpea	24.36
Kurakkan flour	21.39
Black gram	5.78
Maize	12
Soybean	9.08
Other pulses	16.09

Source: Household Income and Expenditure Survey, 2009/2010

Consumption of pulses and legumes enhances the level of protein intake and plays a significant role in Sri Lankans' dietary requirement. In Sri Lanka, the expansion of the production of pulses such as green gram, cowpea, soybean and groundnut has to be considered to supplement protein requirements (Jayawardena, ND).

Currently, OFCs are cultivated in 73,721 hectares in *Maha* season and about 35,448 hectares in *Yala* season in Sri Lanka. Around 63 percent of the total cultivation extent of OFC comes from dry zone areas with irrigation facilities, while 30 percent and 7 percent of the area is distributed in intermediate and wet zone respectively. With the development of *Mahaweli* scheme, irrigated land became right of way in dry zone area and more desirable new varieties of OFC were introduced for cultivation.

However, the level of production of these crops does not fulfil the domestic requirement. As a consequence, the country depends heavily on imports, to fulfill the short fall of domestic production of OFCs. Chili (dry) of which the annual import is around 82 percent of the total availability and big onion, green gram and black gram, the annual imports are around 65%, 50%, and 55% of the total availability respectively (External trade Statistics, 2011). These figures make clear that there is a production deficit of the necessary food commodities and Sri

Lanka is mainly dependent on the imports of several field crops, irrespective of their feasibility for cultivation in the island.

In order to increase the production of agricultural crops, the Sri Lankan government initiated various production-oriented programmes from time to time, which have exaggerated the level of production of domestic crop sector especially paddy and OFCs. However, agricultural growth and its stability have been subjected to much distress when formulating strategies for agricultural development in the country in recent years. In the last two decades, a decreasing trend in production and cultivation extent of OFCs could be observed. These are alleged to be accompanied by considerable annual fluctuations and instability in production, cultivation extent and average yield. These fluctuations in output continued to be a matter of concern. This leads to serious implications in terms of aggregate supply management, price shocks and farm income. Consequently, it destabilizes the viability of OFC sector and lessens its potential to contribute to economic growth as well as food and nutritional security.

Further, the climate of the island has undergone a change that the expected rainfall does not come at the correct time, severely handicapping farmers during the growing season. Water scarcity and excess water have become recurrent problems faced by the crop production in Sri Lanka. Meanwhile, the increasing ambient temperature has also caused several direct and indirect negative impacts on crop growth (Punyawardena, 2012). This has also been accompanied with wide regional variations and cyclical effects of the production fluctuation.

Thus, this study was undertaken to answer the question of what the nature and extent of growth and instability in area, production and average yield of selected OFCs in national level over and above districts level has been. Such information will help decision makers and policy planners for formulating a suitable action plan towards manipulating the area, production and yield of these crops in Sri Lanka.

2. Objectives

To address the above concern, this paper aims to estimate the seasonal and year- round instability and growth rates in area, production and average yield with respect to national level, major agro climatic zones and district level for the selected OFCs. The specific objectives of this study were (i) To review the trend of area, production and average yield during the period of 1979 to 2011, (ii) To estimate the instability in area, production and average yield, (iii) To estimate the growth rates for area, production and average yield based on the Logistic

Growth Model, (iv) Identify the relationship between growth rate and instability and (v) Identify the most vulnerable regions of cultivating of these crops and to provide necessary information and recommendation to policy makers.

This paper is split into five sections. The first section presents the data used in the study and methodology which has been applied to analyze the data. The section analyzes the time series trend with respect to production, area and average yield concerning seasonal, annual and regional variability of selected OFCs. Next, instability in area, production and average yield for considered crops will be estimated. Estimated growth rates for above disciplines and developed matrix for instability and growth rates in each district is given in section four. The final section provides conclusion and recommendations.

3. Material and Methods

The analysis covers the time series secondary data pertaining to production, extent and average yield with respect to district and national level as well as three different agro climatic zones for the period of 1979 to 2011. Mainly, data were compiled from Department of Census and Statistics and import data were gathered from Sri Lanka Custom.

This analysis is limited to four OFCs. Three crops i.e. green gram, black gram and cowpea from pulses were selected concerning vulnerability for higher variation and high import bill. Kurakkan was selected from the coarse grain category due to rapid increase in consumption and dramatic production decline over the past three decades as well as owing high indigenous value among Sri Lankans.

To have an overview of the production, cultivation extent and average yield of these crops, the graphical analysis was employed and examined the change in production patterns over the years. Further, to observe the dynamics of OFC production and extent of cultivation, district and agro climatic zone wise analysis was undertaken. Districts which represent Dry Zone (DZ) are Puttalam, Anuradhapura, Ampara, Hambantota, Udawalawe , Mahaweli 'H'area , Jaffna, Vavuniya, Mulaitivu, Mannar, Trincomalee, Batticaloa and Kilinochchi, Kurunegala, Matale, Badulla and Monaragala represent Intermediate Zone (IZ) and Colombo, Kalutara, Gampaha, Galle, Matara, Ratnapura, Kegalle, Kandy and Nuwara Eliya represent Wet Zone (WZ).

Studies of instability and growth rate related to OFC sector in Sri Lanka are rare. A study carried out by Fernando *et al* (2009) has examined the instability and growth rates of paddy in different agro climatic zones. They have used coefficient of variation and production risk of cultivation index to estimate instability. Based on the log linear function, growth rates have been estimated. Their results reveal that the highest production stability recorded in wet zone while higher risk in production of paddy involved in intermediate zone. However, some studies carried out in India have used different measurements to find out the instability and growth performance in food grain sector in India.

Sharma and Dhakre (2009) have used semi log exponential function to compute compound growth rates. The coefficient of variation index has been used to study the instability in ginger production in North- East region in India. In order to measure the percentage contribution of area, productivity and their interaction, the technique of decomposition has been adopted.

Growth and instability of major oilseeds in India (Kachroo *et al*, 2010) was estimated using Logistic and Coppock's model for computing close approximation of the average year percent variation adjusted for trend. Prasad *et. al* (2009) has used exponential function to derive the compound growth rate and also co efficient of variation was used to measure the magnitude of instability in area, production and productivity of different crops. Singh and Kaviarasan (2010) have employed exponential function for analyzing growth in area, production and productivity of flowers and they have applied Cuddy – Della Value Index (adjusted coefficient of variation) to assess the instability of time series economic variable affects on flower production.

In this study growth rates are computed by using log linear functions (Gujarati and Sangeetha, 2009). Time series data on production, area and yield with respect to these crops in regional level as well as for the country were used. The equation fitted to analyze the growth rate is semi log exponential form.

$Y_t = Y_o (1+r)^t$ ....(i)

Where; Y_t is extent/production/average yield of selected OFCs in t^{th} time period and r is the compound rate of growth of Y, Y_o is intercept and t = time in years.
Compound Growth Rate (CGR) (%) = {Antilog (log β_2) – 1}*100 (Gujarati, 2009) ....(ii)

The growth performance in production, extent cultivation and average yield is carried out for the period of 1979 to 2011 on the selected crops and this estimation was carried out at national level and districts level, under different agro climatic zones representing seasonal variations.

Co- efficient of variation (CV) was used to measure the magnitude of instability in extent, production and average yield of selected four OFCs. In general, the CV measures the amount of variation of the response variable. The index is as follows;

$$CV = (\text{Standard deviation}/\text{Mean})*100 \quad \text{.................. (iii)}$$

Where; X_t = extent/production/average yield in the year t and $\bar{X}$ = mean of extent/production/average yield.

Further, for better understanding of district level growth and instability scenario based on the different levels of compound growth rates and instability indexes, a matrix was prepared for extent/production /average yield.

Thus, four levels of growth i.e. high, moderate, low and negative and three levels of instability: low, moderate and high instability were considered for the preparation of the matrix. The levels were derived by taking the mean and standard deviation as a measure of check. The grouping ranges as follows;

Category
High > ($\bar{X}$ + ½ SD)
Moderate = ($\bar{X}$ ± ½ SD)
Low < ($\bar{X}$ – ½ SD)

Where; $\bar{X}$ - mean and SD – Standard deviation
Source: Krishnamurthy & Veerabhadraiah, (1999)

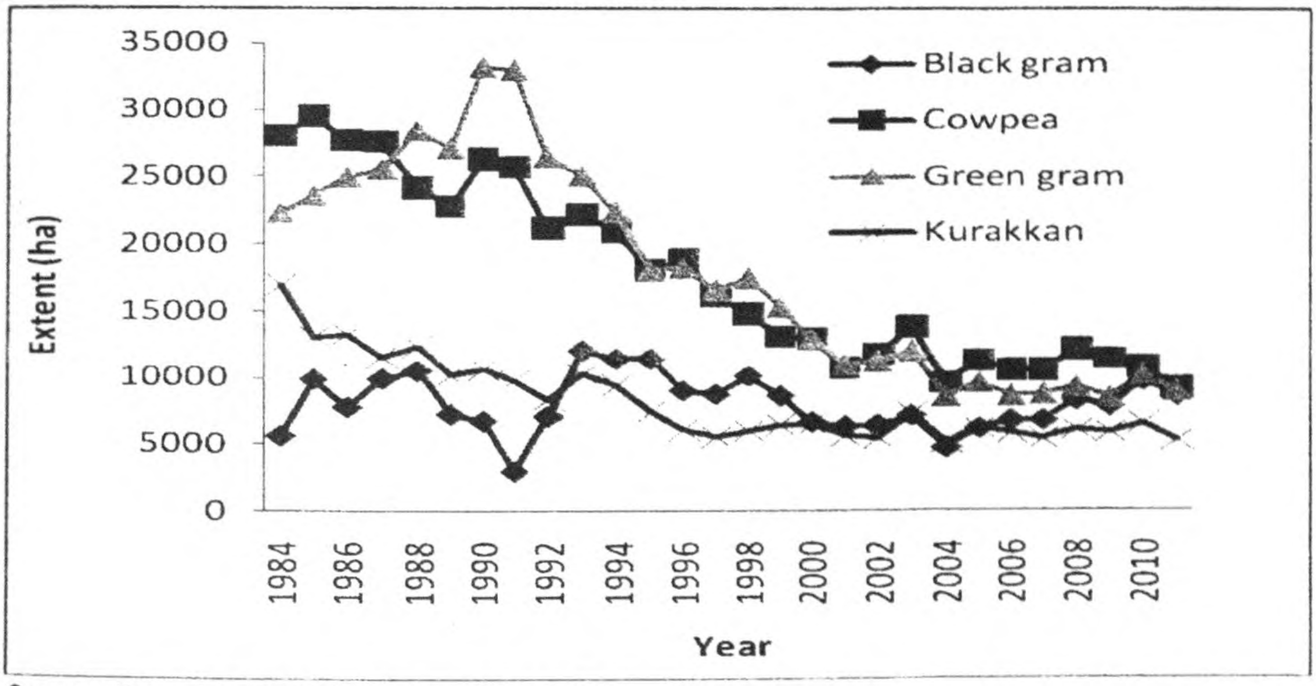
4. Results and Discussion

4.1 Trend Analysis in Production, Extent and Average Yield (black gram, green gram, cowpea and kurakkan)

4.1.2 Graphical Analysis

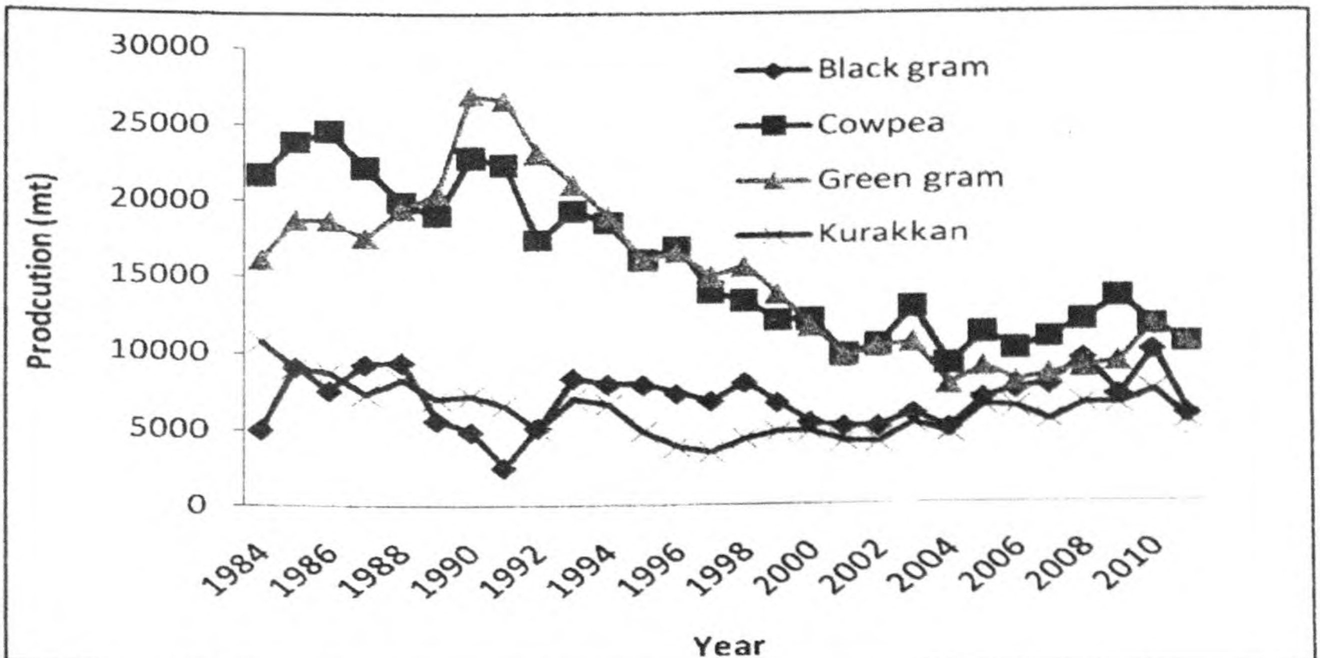
Production and cultivation extent of these crops followed a volatile and drastically declining trend in the last two decades (Figure 1 and 2). During the period of 1985 to 2011, production has dropped by 37%, 56%, 44% and 40% while there was a 13%, 69%, 62% and 60% decline in cultivation extent in black gram, Cowpea, green gram and kurakkan respectively (Figure 1 and 2). Comparably percentage change in production was slightly smaller than the percentage change in extent cultivation due to slight yield improvement except black gram where 33 percent yield drop could be observed (Figure 3, 4, 5 and 6).

Figure 1: Cultivation Extent of Black gram, Green gram, Cowpea and Kurakkan



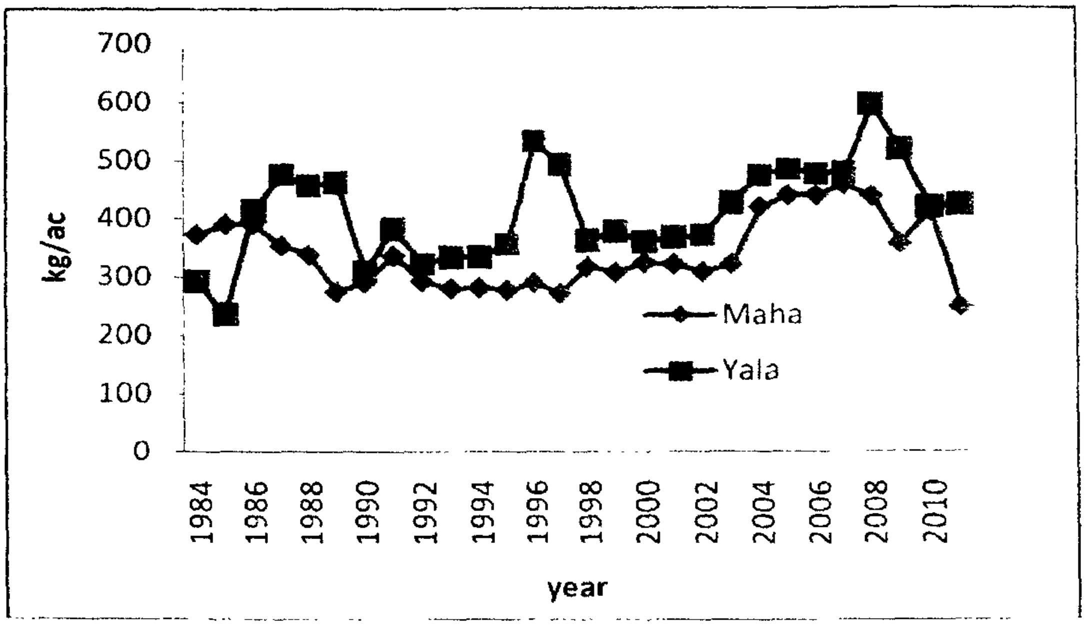
Source: Department of Census and Statistics

Figure 2: Long Term Trend in Production of Black gram, Green gram, Cowpea and Kurakkan



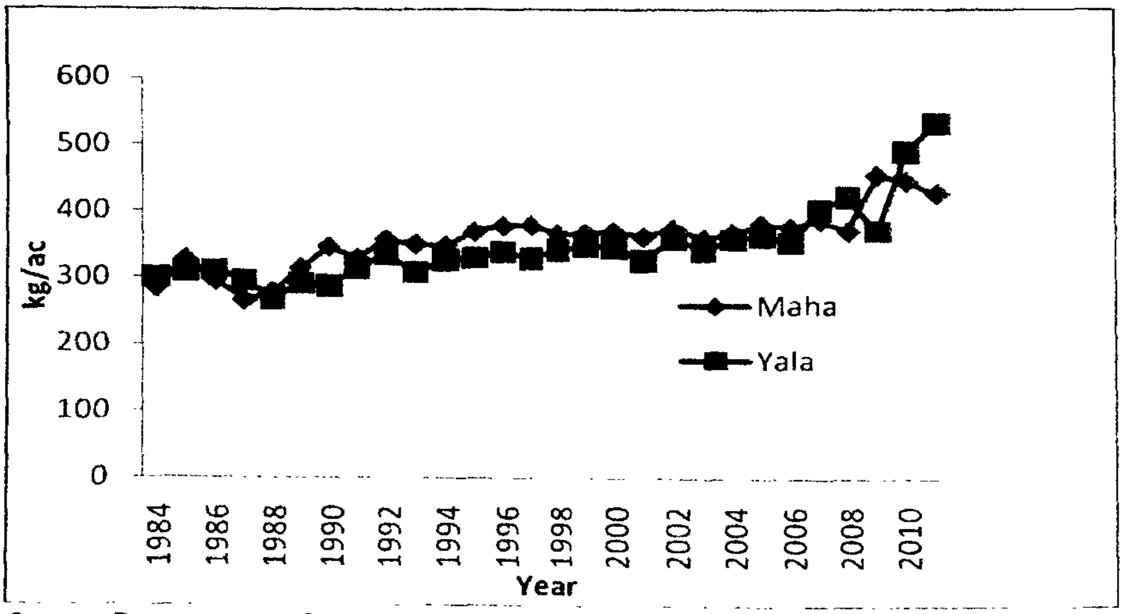
Source: Department of Census and Statistics

Figure 3: Average Yield of Black gram



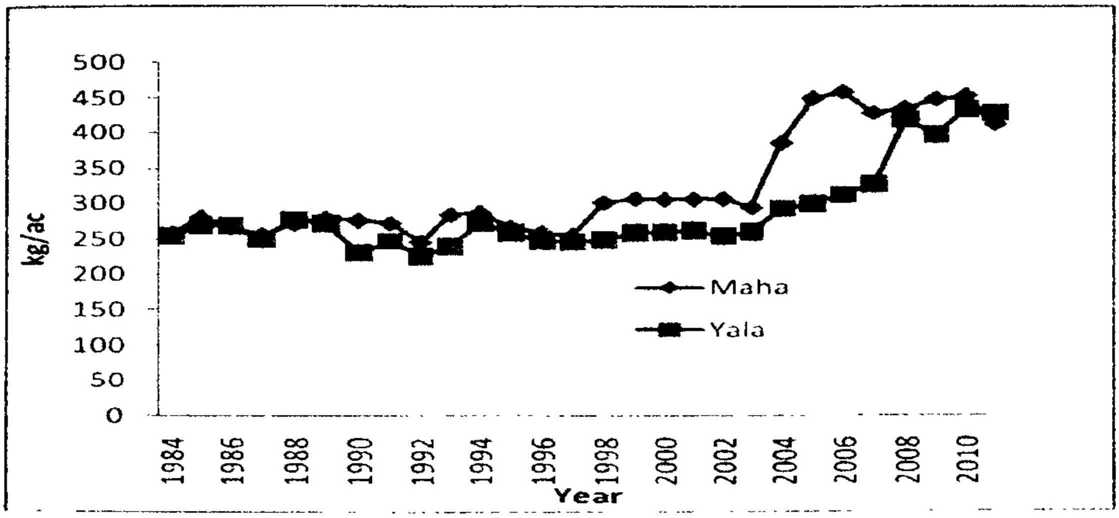
Source: Department of Census and Statistics

Figure 4: Average Yield of Green gram



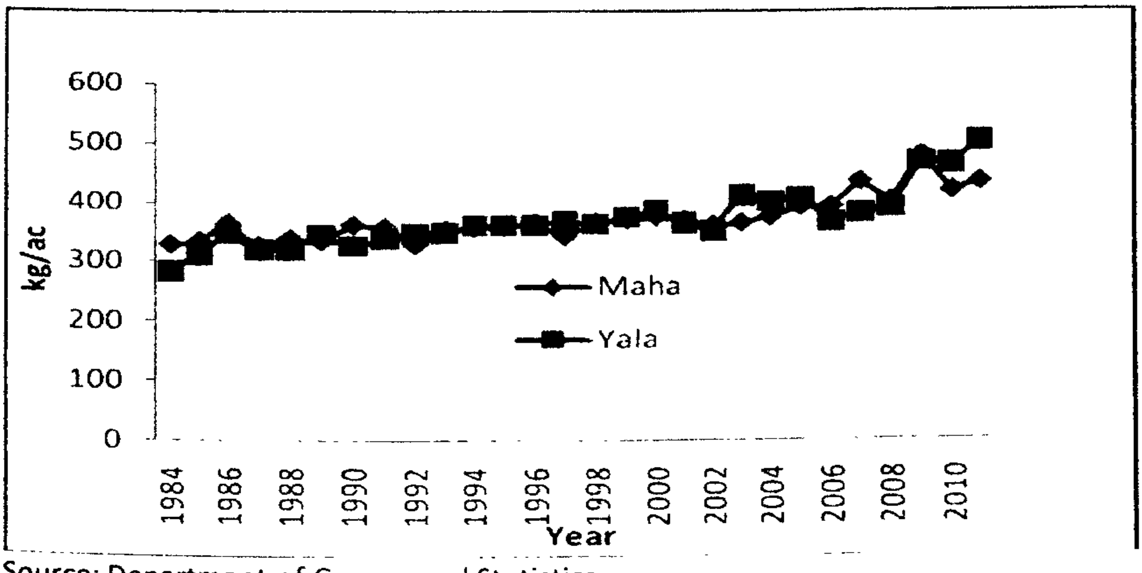
Source: Department of Census and Statistics

Figure 5: Average Yield of Kurakkan



Source: Department of Census and Statistics

Figure 6: Average Yield of Cowpea

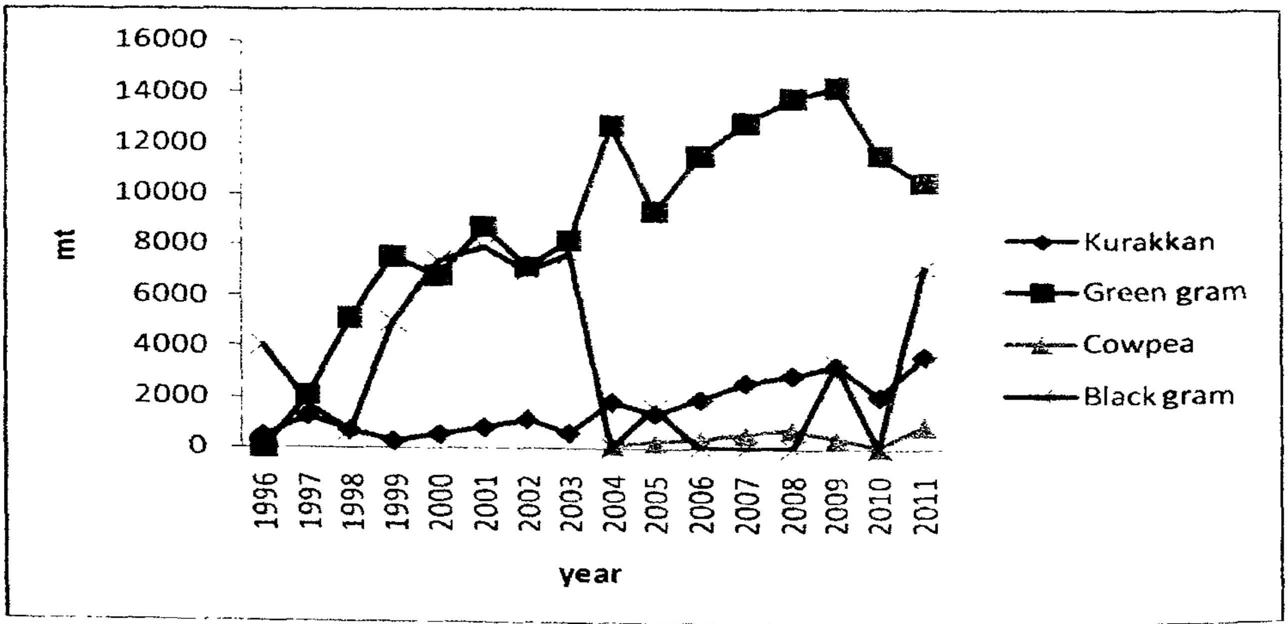


Source: Department of Census and Statistics

The dramatic shift in extent cultivation of these crops into paddy cultivation in dry zone areas after implementation of Mahaweli project, primarily contributed to this production decline. Another reason was the much bigger focus of policies and support measures on self-sufficiency in rice and the neglecting of the OFC generally (Karunagoda, et *al*, ND)·

Further, irregularities in rainfall also caused fluctuation of production over the years. However, it is observed that such a sharp fall in subsidiary food production was not due to drought and rainfall irregularities but to the free trade policies pursued by the government under which cheap/subsidized imports of subsidiary foods undermined domestic agriculture.

Figure 7: Annual Import Quantity of Kurakkan, Green gram, Cowpea and Black gram after 1996



Source: Sri Lanka Custom

Following the implementation of the WTO agricultural agreement in 1995, a major policy change took place in 1996 and the external trade was more liberalized with the replacement of quantitative import restrictions into *ad valorem* tariff system. Hence, imports of OFCs tend to increase after 1996 (Figure7). Local farmers could not compete with the imported food as they were comparatively cheaper partly owing to higher productivity resulting from advanced technology and partly due to subsidies in the supplying countries (Kelegama, 2002).

4.1.3 Compound Growth Rate and Instability in Extent, Production and Average Yield

Growth rates are extensively used in the agricultural field as they have important policy implications. Hence, this study is focused on evaluating the long term growth performance and the instability during the overall period in case of selected OFCs with regard to extent, production and average yield in *Yala, Maha* and annual, separately using compound growth rate and co- efficient of variation (CV). The results were presented in Table1. According to that, the overall growth trend for extent, production decreased significantly while average yield shows a positive growth in both *Yala* and *Maha* seasons in all considered crops except black gram which compounds growth rates which were not significant (Table 1).

Table 2: Instability Index (CV) and Compound Growth Rates in Selected Other Field Crops

Extent	Blackgram		Cowpea		Greengram		Kurakkan	
	GR	CV	GR	CV	GR	CV	GR	CV
Annual	**-0.1**NS *(0.014)*	26.39	**-3.54*** *(0.004)*	39.20	**-3.05*** *(0.006)*	42.75	**-2.47*** *(0.006)*	57.42
Maha	-0.3NS *(0.014)*	29.96	**-3.34*** *(0.004)*	37.64	**-2.47*** *(0.006)*	41.67	**-4.40*** *(0.008)*	50.08
Yala	**-0.1** *NS* *(0.014)*	**52.80**	-3.92* *(0.004)*	**46.83**	**-4.30*** *(0.006)*	**52.68**	**-4.40*** *(0.008)*	73.00
Production								
Annual	**0.3** *NS* *(0.007)*	26.00	**-2.57*** *(0.004)*	33.35	**-1.69**** *(0.006)*	37.67	**-2.57*** *(0.005)*	39.56
Maha	**0.3** *NS* *(0.007)*	28.18	**-2.47*** *(0.004)*	34.49	- **1.19***** *(0.007)*	39.11	**-3.25**** *(0.010)*	37.29
Yala	**1.21** *NS* *(0.016)*	**65.14**	**-2.57*** *(0.004)*	**35.54**	**-2.86*** *(0.007)*	**45.37**	**-2.47*** *(0.006)*	66.70
Average Yield								
Annual	**0.6** *NS* *(0.004)*	16.52	**1.11*** *(0.001)*	11.88	**1.41*** *(0.001)*	15.03	**1.92*** *(0.002)*	22.26
Maha	**0.5** *NS* *(0.004)*	17.89	**0.90*** *(0.001)*	11.51	**1.31*** *(0.013)*	14.00	**2.02*** *(0.002)*	23.49
Yala	**1.31** *NS* *(0.004)*	**19.90**	**1.41*** *(0.001)*	**15.32**	**1.51*** *(0.015)*	**18.15**	**0.003*** *(0.003)*	20.07

Note: This is based on the author's estimations

Figures in parentheses indicated the standard error for their respective coefficients,

* Denote coefficients are significant at 1 % level

** Denote coefficients are significant at 5 % level

*** Denote coefficients are significant at 10 % level

NS – Denote not significant

The results of CV show that relatively higher instability in extent, production and average yield recorded in *Yala* season in each crop (Table 2). It further illustrates the range of differences in degree in instability among production, extent and average yield.

In case of cowpea, the instability index was low compared to other three crops ranging from 48 percent in extent cultivation in *Yala* season to 11 percent in average yield in *Maha* season, though a high negative growth trend was implied. It reveals that even though cultivation extent and production of cowpea is stable compared to other crops with the other factors like cheap imports, high labour cost and farmer motivation for paddy cultivation with government subsidies possibly forced farmers to shift away from the cowpea cultivation. On the other hand, the highest instability in cultivation extent and production of kurakkan was observed with 73 percent in cultivation extent and 66 percent in production variation in *Yala* season. Kurakkan production has been declining by 3.2 percent in *Maha* and 2. 5 percent in *Yala* season (Table 2). The data further indicated that yield instability index was below 20 percent for all crops except kurakkan which ranges around 23 percent in *Yala* and *Maha* season. This implied that much risk was not involved in average yield variable, yet area variability has more influence on production fluctuations and poor growth performance.

4.2 Instability and Growth Rates under Three Major Agro Climatic Zones

More than 85 percent of total extent of black gram cultivation reported in Maha season and low instability accounted in this season compared to Yala accompanied high production risk. Production instability varies around 125 percent in wet zone, 84 percent in intermediate zone and 68 percent in dry zone in *Yala* season and each agro ecological zones performs a negative growth trend (Table 3). This would be due to uneven rainfall and inadequate irrigation.

However, dry zone is more stable for black gram cultivation and instability varies around 30 percent in area and production and nearly 12 percent in yield in *Maha* season. Yet, intermediate and wet zone engage high risk for cultivating black gram. In *Yala* season, wet zone cultivation extent and production is decreasing in low rate compared to *Maha.* On the other hand, in intermediate zone, both extent and production decrease in low rate in *Maha* compared to *Yala*.

At present, around 95 percent of the black gram cultivation extent is distributed within dry zone region, hence, it reveals that there is no risk in cultivation of this crop. However, if needed to increase the area cultivation of black gram, Maha season in intermediate zone with strong irrigation support and Yala season in wet zone can be utilized to minimize the risk of cultivation and to achieve comparably high growth. Growth rates of yield are high in intermediate zone than in dry zone. Therefore, further yield improvement in dry zone would be successful because cultivation is more stable in dry zone.

Table 3: Instability Index (CV) and Compound Growth Rates of Blackgram in Major Agro Climatic Zones

Blackgram	Wet Zone		Intermediate Zone			Dry Zone
	GR	CV	GR	CV	GR	CV
Extent						
Annual	**-9.43*** (0.018)	96.91	**-4.69*** (0.001)	74.64	**-0.10 NS** (0.007)	26.92
Maha	**-8.24*** (0.020)	98.62	**-4.30*** (0.013)	72.19	**0.00 NS** (0.008)	30.70
Yala	**-6.29*** (0.013)	150.98	**-5.82*** (0.016)	88.99	**0.90** (0.015)	55.17
Production						
Annual	**-7.04*** (0.016)	79.72	**-3.82*** (0.014)	72.81	**0.50 NS** (0.008)	27.79
Maha	**-5.92*** (0.018)	81.29	**-3.54**** (0.015)	74.06	**0.40 NS** (0.007)	28.48
Yala	**-2.37**** (0.009)	124.58	**-4.97**** (0.016)	83.67	**2.02 NS** (0.017)	68.41
Average Yield						
Annual	**1.01 NS** (0.044)	38.91	**1.21*** (0.003)	17.31	**0.60*** (0.002)	9.40
Maha	**-1.00 NS** (0.053)	33.93	**1.11*** (0.003)	17.75	**0.80*** (0.002)	12.05
Yala	**- 11.66***** (0.065)	30.79	**1.82*** (0.004)	24.24	**0.70**** (0.003)	12.33

Note: This is based on the author's estimations
Figures in parentheses indicated the standard error for their respective coefficients,
* Denote coefficients are significant at 1 % level
** Denote coefficients are significant at 5 % level
*** Denote coefficients are significant at 10 % level
NS – Denote not significant

Green gram cultivation is mainly carried out in *Maha* season (60 percent). According to the results presented in Table 4, green gram cultivation in *Yala* season in intermediate zone is highly vulnerable to production risk due to high fluctuation in extent cultivation. Instability index for extent cultivation is around 73 percent and production instability around 71 percent in intermediate zone.

However, nearly one percent positive growth rate in yield can be observed in both intermediate and dry zone. On the other hand, it shows a negative trend in production and extent cultivation. Data further reveals that dry zone is more stable for green gram cultivation. Further, expanding extent cultivation of green gram in dry zone could be effective. Due to relative positive growth in yield performance, intermediate zone also can be utilized. However, proper irrigation should be developed. Immense population pressure and urbanization would further decline the land area for green gram in wet zone.

Table 4: Instability Index (CV) and Compound Growth Rates of Green gram in Major Agro Climatic Zones

Green gram	Wet Zone		Intermediate Zone		Dry Zone	
	GR	CV	GR	CV	GR	CV
Extent						
Annual	**-4.4*** *(0.018)*	52.29	***-4.01**** *(0.013)*	55.35	**-1.68**NS *(0.007)*	28.26
Maha	***-4.69**** *(0.02)*	50.45	-3.15* *(0.044)*	58.76	**-1.39** NS *(0.008)*	31.13
Yala	**-4.4*** *(0.013)*	52.33	**-5.73*** *(0.016)*	73.46	**-2.76** NS *(0.015)*	35.44
Production						
Annual	**-4.01*** *(0.016)*	53.96	**-2.66*** *(0.014)*	55.63	**1.5** NS *(0.044)*	29.16
Maha	**-4.3*** *(0.018)*	55.02	***-1.78**** *(0.005)*	55.62	**0** NS *(0.007)*	27.07
Yala	**-3.82*** *(0.009)*	59.31	***-4.49**** *(0.016)*	71.03	**1.9**** *(0.065)*	38.59
Average Yield						
Annual	**1.5** NS *(0.044)*	29.16	***1.3**** *(0.003)*	16.44	**1.00*** *(0.002)*	13.36
Maha	**1.1**NS *(0.053)*	27.07	***1.2**** *(0.003)*	16.80	**0.9*** *(0.002)*	12.20
Yala	**1.9**** *(0.065)*	38.59	***1.4**** *(0.004)*	17.21	**1.00**** *(0.003)*	15.28

Note: This is based on the author's estimations
Figures in parentheses indicated the standard error for their respective coefficients,
* Denote coefficients are significant at 1 % level
** Denote coefficients are significant at 5 % level
NS – Denote not significant

Extent cultivation and production of cowpea is falling significantly in all three regions (table 5) and higher instability also could be observed in wet and intermediate zones. Dry zone is comparably stable in production of cowpea and average yield performs positively, with an upward trend in each region. This reveals that the negative trend in production is due to sharp drop in cultivation extent over the years and yield improvement could not conquer this. Instability in yield is comparable in both dry and intermediate zones. It demonstrates around 10 percent variation (Table 5). Therefore, strategies should be developed to prevent the sharp decline in cowpea cultivation in intermediate zone in order to increase the domestic production.

Table 5: Instability Index (CV) and Compound Growth Rates of Cowpea in Major Agro Climatic Zones

Cowpea	Wet Zone		Intermediate Zone		Dry Zone	
	GR	CV	GR	CV	GR	CV
Extent						
Annual	**-5.07*** *(0.004)*	52.24	***-7.78**** *(0.008)*	55.35	**-1.98*** *(0.006)*	30.91
Maha	***-4.97**** *(0.006)*	55.59	**-4.97*** *(0.006)*	49.06	**-1.98*** *(0.007)*	33.04
Yala	**-5.07*** *(0.006)*	59.10	**-7.78*** *(0.008)*	55.35	**-1.98*** *(0.007)*	30.91
Production						
Annual	**-3.44*** *(0.004)*	52.01	**-4.30*** *(0.006)*	52.23	**-1.09**** *(0.005)*	25.67
Maha	**-4.02*** *(0.005)*	59.14	***-3.63**** *(0.005)*	46.74	**-1.49*** *(0.005)*	31.13
Yala	**-2.57*** *(0.006)*	54.35	***-5.64**** *(0.007)*	66.70	**-0.30**NS *(0.005)*	25.06
Average Yield						
Annual	**1.41*** *(0.004)*	24.12	***0.60**** *(0.002)*	9.51	**0.60*** *(0.001)*	8.86
Maha	**0.70** NS *(0.005)*	30.01	***0.60**** *(0.002)*	10.94	**0.70*** *(0.001)*	9.67
Yala	**2.02*** *(0.002)*	28.20	***0.60****** *(0.003)*	8.26	**0.60***** *(0.003)*	8.86

Note: This is based on the author's estimations

Figures in parentheses indicated the standard error for their respective coefficients,

* Denote coefficients are significant at 1 % level

** Denote coefficients are significant at 5 % level

*** Denote coefficients are significant at 10 % level

NS – Denote not significant

Dry zone is more susceptible to production risk of kurakkan in *Maha* compared to wet and intermediate zones (Table 6). However, extent cultivation is somewhat stabilized in dry zone and higher production instability is due to high instability in yield. Results presented in Table 6 further reveals that in intermediate zone, the kurakkan extent is decreasing by around 6 percent annually though production is declining by around 2 percent in *Maha* season owing to positive yield growth rates. Comparably all three regions show significantly a negative trend over the years and a positive trend in average yield could be examined. Yield improvement in *Maha* season both in dry and intermediate zones is vital and remedies should be taken to expand the land area for cultivating kurakkan in wet zone.

Table 6: Instability Index (CV) and Compound Growth Rates of Kurakkan in Major Agro Climatic Zones

Kurakkan	Wet Zone		Intermediate Zone		Dry Zone	
	GR	CV	GR	CV	GR	CV
Extent						
Annual	**-4.97*** *(0.004)*	60.67	***-4.01**** *(0.013)*	55.35	**-1.68** NS *(0.007)*	28.26
Maha	**-4.97*** *(0.04)*	55.63	**-5.82*** *(0.004)*	64.23	**-1.39** NS *(0.008)*	31.13
Yala	**-4.59*** *(0.009)*	89.98	**-2.66**** *(0.014)*	138.02	**-2.76** NS *(0.015)*	35.44
Production						
Annual	**-4.01*** *(0.016)*	53.96	**-2.66*** *(0.014)*	55.63	**-4.7*** *(0.004)*	60.67
Maha	**-4.3*** *(0.018)*	55.02	***-1.78**** *(0.005)*	55.62	**-5.63*** *(0.004)*	67.04
Yala	**-3.82*** *(0.009)*	59.31	***-4.49**** *(0.016)*	71.03	**-2.95*** *(0.04)*	35.96
Average Yield						
Annual	**1.00*** *(0.003)*	18.99	***0.7***** *(0.003)*	20.54	**1.9*** *(0.004)*	30.26
Maha	**2.12*** *(0.004)*	31.72	***1.71**** *(0.004)*	31.20	**2.8*** *(0.003)*	32.46
Yala	**2.9*** *(0.003)*	34.05	***2.32**** *(0.003)*	32.15	**0.9*** *(0.003)*	17.08

Note: This is based on the author's estimations

Figures in parentheses indicated the standard error for their respective coefficients,

* Denote coefficients are significant at 1 % level

** Denote coefficients are significant at 5 % level

NS – Denote not significant

4.3 District Level Dynamics

To examine the dynamics of growth and instability, compound growth rates and co efficient of variations were computed for each district in Sri Lanka, considering available regular time series data. Therefore, a few districts were avoided due to not having regular time series data. In addition to that, a few districts were dropped due to insignificant compound growth rates.

4.3.1 Growth Rates and Instability Index for Cowpea Cultivation

The major cowpea cultivation districts are Ampara (29%), Monaragala (21%), Kurunegala (13%), Anuradhapura (8%), Badulla (4%) and Ratnapura (4%). Ampara district recorded a positive growth where extent cultivation is increased by 4 percent in *Maha* and 6 percent in *Yala* while production is increased by 5 percent in *Maha* and 7 percent in *Yala* due to slight improvement in yield though extent and production is unstable over the years. Other five districts recorded a negative growth. Instability in extent ranges from a lower rate of 37 percent in Monaragala district to a higher rate of 73 percent in Kurunegala, in *Maha* and 50 percent to 88 percent in *Yala* season respectively.

Table 7: Growth and Instability Matrix for Cowpea Cultivation

Instability / Growth rate	Extent - *Maha*			Average yield		
	High	**Moderate**	**Low**	**High**	**Moderate**	**Low**
High	Kilinochchi	xx	xx	xx	Killinochchi Mahaweli H	Hamban- tota
Moderate	xx	xx	Ampara	Batticaloa Ampara	Xx	xx
Low	xx	xx	xx	xx	Badulla Polonnaruwa	Matale Mannar Anuradhap ura
Negative	Kegalle, Puttlam Matale, Kurunegala Batticaloa Jaffna Ratnapura	xx	Badulla Anuradhapura Nuwara Eliya Pollonnaruwa	Puttlam, Ratnapura	Xx	Kurunegala

Instability Growth rate	Extent - *Yala*			Average yield		
	High	Moderate	Low	High	Moderate	Low
High	xx	xx	Mahaweli H Killinochchi	xx	Thrincom-alee kilinochchi	Mahaweli H
Moderate	Mulathiv	xx	Ampara	Puttlam	Nuwara-eliya Anuradha-pura	xx
Low	xx	Thrincom-alee	Badulla	Kandy	Ampara Matale	Kurunegala Ratnapura
Negative	Kegalle Puttalam Vavuniya Mannar	Kurunegala Batticaloa Hamban-tota Jaffna Anuradha-pura	Pollonn-aruwa Ratnapura Monaragala	xx	Batticaloa	

Based on the author's estimation
XX - denote district(s) not related to the cell

According to the instability matrix presented in Table 7, the Hamabantota district in *Maha* season and in Mahaweli H area in *Yala* season shows high growth trend in yield. It is more stable for cowpea cultivation. However, at present, cultivating cowpea in these two districts are not much popularized and contributes to around 5 percent in total production in each district. Thus, further increasing of land area for cowpea cultivation in Hambantota district and Mahaweli H area would be successful. Ampara, which is the major cowpea cultivating district, is having a moderate long term growth trend with massive variation in extent cultivation (Table 7). Kurunegala and Ratnapura districts are more vulnerable for production of cowpea due to the declining trend and high instability. Monaragala and Pollonnaruwa districts in *Yala* season are more stable, however, continuous declining trend is recorded.

4.3.2 Growth Rates and Instability Index for Black gram Cultivation

Around 60 percent of the land area of black gram cultivation is in Anuradhapura district. The other main black gram cultivating districts are Vavuniya (12 %), Kilinochchi (9%) and Mahaweli H area (7%). Monaragala district performs a high growth rate i.e. extent has been increased by 15 percent while production has been increased by 17 percent.

Table 8: Growth and Instability Matrix for Black gram Cultivation

Instability / Growth rate	Extent - *Yala*			Average yield - *Yala*		
	High	Moderate	Low	High	Moderate	Low
High	Vavuniya	xx	xx	xx	Badulla	Vavuniya
Moderate	Muathiw	Mahaweli H	xx	xx	Monaragala	Xx
Low	xx	xx	Monaragala	xx	Puttlam	Xx
Negative	xx	Puttlam, Killinochchi Kurunegala	Nuwara Eliya Jaffna	xx	Kilinochchi	Nuwara-Eliya Badulla
Instability / Growth rate	**Extent - *Maha***			**Average yield - *Maha***		
	High	**Moderate**	**Low**	**High**	**Moderate**	**Low**
High	Monaragala	xx	xx	Puttlam	xx	xx
Moderate	xx	xx	xx	xx	xx	xx
Low	xx	Kilinochchi	xx	xx	xx	Matale
Negative	xx	Puttlam, Kurunegala Mannar	Nuwara Eliya Mahaweli H	Nuwara-Eliya	Batticaloa	Kilino-chchi

Based on the author's estimation
XX - denote district(s) not related to the cell

Production is increased by higher rate than extent cultivation in both seasons due to yield improvement over the years. However, in the Monaragala district, cultivation of black gram fluctuates over time, hence, the production is susceptible for high instability. Some districts in the Northern Province and Polonnaruwa district also show a positive trend in production and area cultivating. On the other hand, in Mahaweli H area, black gram cultivation extent, production and average yield is declining in *Maha* season and in *Yala* season around a 5 percent growth rate could be observed. However, around 54 percent of the total cultivation extent of black gram is in *Yala* season, in Mahaweli H area. According to the matrix presented in Table 8, in *Maha* season no district performs low instability and high growth rate. Mahaweli H area recorded low instability though it has a negative trend over time in *Maha* season, and *Yala* season is having a moderate growth and moderate instability. In order to promote further black gram cultivation in *Yala* season, yield improvement should take place. Paddy cultivation in *Maha* season in this area is the main reason for poor performance in black gram cultivation.

4.3.3 Growth Rates and Instability Index for Green gram Cultivation

Green gram is mainly cultivated in the Hambantota district with around 43 percent in *Yala* and 19 percent in *Maha*. Though there are negative growth rates in terms of extent and production, comparatively high instability also occurs in each season. Instability in extent cultivation is mainly attributed to the production risk and yield growth rate shows a positive movement and an increase of around one percent annually.

However, extent cultivation and production is declining over time around 5 percent in *Yala* and 7 percent in *Maha*. Around 19 percent of the total cultivated land area of green gram is in the Monaragala district in *Maha* season. It shows 1.3 percent in extent and 2.4 percent in production growth in *Maha*. However, in *Yala* season green gram is cultivated in around 4 percent of the total land area and it shows a declining trend. It reveals that *Yala* season is more vulnerable for green gram cultivation in this area due to lack of rainfall.

According to Table 9, Kilinochchi district in *Maha* season and Mahaweli H area in *Yala* season are evidence for competent districts for green gram cultivation. With this positive growth trend in extent cultivation and yield, further promotion of green gram would be vital. Poor irrigation facilities in Kurunegala and Puttlam districts and farmers shifting into Maize and Soybean cultivation in the Anuradhapura district would be the foremost reasons for the decreasing trend in green gram cultivation and high variability (Table 9).

Table 9: Growth and Instability Matrix for Green Gram Cultivation

Instability / Growth rate	Extent - *Maha*			Average yield - *Maha*		
	High	**Moderate**	**Low**	**High**	**Moderate**	**Low**
High	xx	Kilinochchi	xx	xx	Mahaweli H	xx
Moderate	xx	xx	xx	Batticaloa Hambantota	Anuradhapura	Pollonnaruwa Kilinochchi
Low	xx	xx	Baticaloa	Jaffna	Monaragala	Kegalle Nuwara Eliya Badulla
Negative	Matara Mathale Badulla	Puttlam Kurunegala Kegalle Ratnapura Kandy Nuwara Eliya	Jaffna Vavuniya Anuradha- pura Pollonn- aruwa	Matara	xx	Puttlam
Instability / Growth rate	**Extent - *Yala***			**Average yield - *Yala***		
	High	**Moderate**	**Low**	**High**	**Moderate**	**Low**
High	xx	Mahaweli H	xx	xx	Kilinochchi Mahaweli H	xx
Moderate	xx	xx	xx	Puttlam Kandy	Matale Polonnaruwa	Trincomalee
Low	xx	xx	Kilinochchi	xx	Anuradha- pura Ampara	Badulla Monaragala Hambantota
Negative	Matara Ratnapura Puttlam Kurunegala Anuradh- pura	Matale Ampara Kegalle	Kandy, Monragala Polonnaruwa Hambantota	xx	xx	xx

Based on the author's estimation
XX - denote district(s) not related to the cell

4.3.4 Growth Rates and Instability Index for Kurakkan Cultivation

According to the Annex IV, in *Maha* season, the kurakkan cultivation extent is decreasing during the last three decades in all districts except Badulla, Kilinochchi and Mahaweli H area where recorded a positive growth of 8 percent, 5 percent and 4 percent recorded respectively.

Table 10: Growth and Instability Matrix for Kurakkan Cultivation

Instability / Growth rate	Extent - *Maha*			Average yield - *Maha*		
	High	Moderate	Low	High	Moderate	Low
High	Mahaweli H	xx	xx	Matara Puttlam Badulla Mahaweli H	xx	xx
Moderate	xx	xx	Kilinochchi	Matale Anuradhapura	Kandy Pollonnaruwa	Monaragala
Low	xx	Hambantota	xx	xx	Hambantota	Ratnapura Jaffna Batticaloa Ampara
Negative	Matara Puttlam Matale Badulla Monaragala Vavuniya	Kurunegala Ratnapura Kandy Nuwara Eliya Anuradhapura Pollonnaruwa	Jaffna Mannar Trincomalee Batticaloa Ampara	xx	xx	xx

Instability / Growth rate	Extent - *Yala*			Average yield - *Yala*		
	High	Moderate	Low	High	Moderate	Low
High	xx	xx	Kilinochchi	Mahaweli H	Pollonnaru-wa Ampara Hambantota	Trincomalee Batticaloa
Moderate	xx	xx	xx	Monaragala Anuradha-pura	xx	Xx
Low	xx	Moderate	xx	Nuwara Eliya	Kandy Matale Badulla	Kurunegala Ratnapura
Negative	Kandy Anuradha-pura Monaragala	Matara Badulla Ratnapura Moderate Kurunegala Trincomalee Nuwara Eliya Puttlam	Pollonnaruwa Batticaloa Vavuniya Jaffna Hambantota Ampara	Xx	xx	Puttlam

Based on the author,s estimation

XX - denote district(s) not related to the cell

In *Yala* season, high instability was recorded with negative growth except in Kilinochchi (5 percent increasing trend) and Mahaweli H area (4 percent positive growth). However, in some districts, production is not declining as area cultivation, due to yield improvement. In *Maha* season, Anuradhapura, Pollonnaruwa, Batticaloa and Ampara show improvement in level of production with high yield. That is, 8%, 5%, 8%, and 9% respectively. New improved varieties, and continuous irrigation supply and increasing domestic demand would be the main reasons. In *Yala* season, high instability in extent cultivation and production were recorded than other OFCs. Table 10 illustrated that Trincomalee and Batticaloa in *Yala* season and Kilinochchi in *Maha* season are more stable for kurakkan cultivation. This reveals that encouraging of the kurakkan cultivation in Northern and Eastern Provinces is essential.

Conclusion and Policy Implications

OFCs production has been declining overtime, accompanied with year to year fluctuations with wide regional variations due to change in climate as well as other economic and social phenomena. This mainly vulnerable food security. After 1985, there was a drastic decline in extent cultivation of these crops and imports have been increasing to cater to the domestic demand. The results of this study reveal that, *Yala* season is highly susceptible for production fluctuation and instability in area cultivation. The results further indicate that high risk was not involved in average yield. Instability in extent cultivation affects production fluctuations and growth performance.

Black gram and green gram cultivation in dry zone does not entail production risk. According to the derived results, if black gram production further increases, yield improvement and expanding land area with strong irrigation support in *Maha* season in intermediate zone would be decisive. Further expanding extent cultivation of green gram in intermediate zone also can be utilized, however, proper irrigation should be developed. Extent of cultivation and production of cowpea is falling significantly in all three regions. However, results reveal that further increase of land area of the cowpea cultivation in Hambantota in *Maha* season and Mahaweli H in *Yala* season would be key to promote cowpea cultivation to prevent the sharp declining trend.

The Monaragala district has a potential to promote black gram cultivation. Further, in *Yala* season, promoting black gram cultivation in the Pollonnaruwa district and the Northern Province can be vital. However, extension should be given for yield improvement. The Monaragala district is more vulnerable for green gram cultivation in *Yala* season. The Kilinochchi district in *Maha* season and Mahaweli H area in *Yala* season are evidence for prospective districts for green gram cultivation. According to the results, encouraging of the kurakkan cultivation in Northern and Eastern provinces is essential.

To mitigate high instability, proper water management methods should be adopted. Popularizing micro irrigation systems such as drip irrigation and sprinklers, rainwater harvesting and reconstructing small tanks and cannels especially in intermediate zone is important for the maximum utilization of lands for OFCs. Encouraging crop diversification in dry zone and developing new high yielding varieties which are more tolerant to drought is timely. Farmers need to be educated on crop cultivation based on different agro climatic zones. Promoting of cultivation in the North and Eastern provinces also would be timely.

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