Instability of Paddy Production and Regional Food Insecurity in Sri Lanka

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Abstract

Addressing food insecurity has become an important policy issue due to a host of factors such as climate change, export restraints, alternative uses of food, e.g., as bio-fuels and income-induced demand changes. The world has to find avenues to provide sufficient food to cater for the new developments in the food sector taking into consideration the risks of the changes these may effect on the environment. Paddy, the staple food crop of Sri Lankans, plays a significant role in stabilizing food security in the country. The production levels of paddy have been accompanied with wide regional variations due to irregularities in the rainfall patterns and cyclical effects of the production fluctuations. More thrust has been placed on irrigated paddy production in the areas of the dry zone, while traditional areas of the wet zone have been subjected to immense population pressure amidst various institutional arrangements. At present, more than half of the paddy output comes from the major irrigation schemes. The wide fluctuations in paddy production levels in these areas indicate the potential for regional vulnerability for food insecurity. This paper examines the growth of paddy production and evaluates the instability of paddy production in terms of the areas cultivated, productions and yields for the dry zone (DZ), intermediate zone (IZ) and wet zone (WZ) and districts in these climatic zones. The growth rates for different zones were estimated using a log linear function. The instability of area, production and yield was measured using a coefficient of the variation (CV). The CV of production, area and the yield for three major climatic zones and seasons are estimated. In addition, the indices for the risk of cultivation and amount of green vegetation on the island were used as indicators of instability. Paddy production has increased at the rate of around 2 % and 1 % per annum in the DZ and IZ, respectively; and has decreased in the WZ at the rate of 9 % per annum. The CVs for paddy production in the DZ, IZ and WZ in the *maha* and *yala* seasons are 18.15, 18.36, and 9.2 and 30.33, 25.38 and 19.22, respectively. The results indicate that instability of paddy production in the WZ is much lower than those

of the other two zones. The lowest levels of instability with respect to production (Matara), yield (Kegalle) and harvested extent (Ratnapura) were observed in the wet zone districts. The highest level of instability with respect to area, yield, production and harvested extent was observed in the Anuradhapura District. In the *maha* season, the IZ shows the lowest variation in the sown extent and highest variation in the harvested extent, and it indicates the higher risk of production at the later stage of the crop. The IZ shows the general risk in paddy production in the *yala* season, indicated by the highest instability in both sown and harvested extents. Similar observations for the IZ were observed in the sown to harvest and CV of vegetation index. The negative growth rate observed in the WZ was brought about by the reduction of the cultivated area. The higher stability in production could be utilized to augment regional food security as well as the supply of seed paddy for other regions. Thus the results highlight the importance of maintaining WZ as a buffer zone of production and investments in irrigation in the IZ to secure the availability of paddy.

Introduction

Food security exists when all people at all times have physical or economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life. It is often directly or indirectly dependent on agricultural and forest ecosystem services. Addressing food insecurity has become an important policy issue due to a number of factors such as climate change, export restraints, alternative uses of food such as bio-fuels, income-induced demand changes among many others. Impacts on the production of food will affect food supply at both global and local levels. Thus the world has to find avenues to provide sufficient amounts of food to cater to new developments in the food sector and at the same time be aware of the consequences that these changes in production may have on the environment. Today, countries in the world envisage increasing food production either by increasing the cultivatable extent or by increasing productivity through technology and the efficient use of resources. Paddy, the staple food crop of Sri Lankan, plays a significant role in food security in the country. There has been a steady increase in paddy production through time, leading to near self-sufficiency in feeding the population of 20 million. The paddy production in the *yala* season in 2008 showed a 51 % growth yielding 1.75 million metric tonnes, thus recording the second highest growth rate in any season after obtaining National Independence in 1948 (Central Bank Report 2009). This rise has been attributed to the following: a) increased area under cultivation; b) mass investment in irrigation development; c) improved seed varieties; d) increased fertilizer application; and e) favorable prices for rice.

However, the growth of the paddy sector with stability has been a matter of concern in the strategy of ensuring food security. The production levels of paddy have been accompanied with wide regional variations due to irregularities in the rainfall pattern and cyclical effects of production fluctuations. In Sri Lanka paddy is cultivated in all the agro-ecological zones under three different water regimes namely, major irrigation, minor irrigation and rain-fed. The island has been divided into three principal agro–climatic zones, which have been demarcated based on hydrology, meteorology, soils and vegetation. The wet zone (WZ) receives an annual rainfall of more than 2,500 mm. The intermediate zone (IZ) receives between 1,750 and 2,500 mm of rainfall and the dry zone (DZ) receives less than 1,750 mm of rainfall annually. Thus, there is a considerable variation in production, yield and the area cultivated from region to region, mainly because of low rainfall, water scarcity and drought-prone districts. At present, more than half of the paddy output comes from major irrigation schemes. In 2008, the contributions to the island- wide paddy production from DZ, IZ and WZ were 64 %, 23 % and 13 %, respectively (Department of Census and Statistics 2009).

More trust has been placed on irrigated paddy production in the areas of the dry zone, while traditional areas of the wet zone have been subjected to immense population pressure amidst various institutional arrangements. The 'asweddumized' extent of paddy in WZ has decreased by around 21 %, while the 'asweddumized' extent of paddy in DZ and IZ has increased by around 11 % and 23 %, respectively, during the period of 1979 to 2006 (Department of Census and Statistics 2009). In the past two decades, more investment has gone into irrigation development, various subsidy schemes and to research and development, especially to increase the level of production in DZ and IZ. Hence, the variability in crop production increased by region to region, after the development of irrigation and implementation of many other promotional programs. However, this higher potential of production in DZ and IZ compared to WZ is alleged to be accompanied by considerable year to year fluctuation, thereby giving rise to increasing instability in the production of paddy. The wide fluctuations in paddy production levels in these areas indicate the potentials of regional vulnerability for food insecurity, but even though the potential of paddy production in WZ is stagnated due to urbanization and many other various institutional arrangements, fluctuations in production are not significant. It is, therefore, important to understand the causes of fluctuations in production, yield and extent cultivated within different agro-ecological zones. This study analyzes fluctuation in paddy production, yield and area to understand the nature of food security at the regional level.

In the light of the problem discussed above, this paper attempts to analyze interregional variation in the extent cultivated, yield and production of paddy using time series data for the period of 1979 to 2008. The study is specifically focused on the following objectives: a) present the overview of the extent cultivated, yield and production of paddy to identify the fluctuations around the trend line; b) estimate the instability in the extent cultivated, yield and production of paddy in different agro-climatic zones and districts; and c) estimate the growth rate of the extent cultivated, yield and production of paddy by season and its association with rainfall.

The paper is divided into five sections. The next section (Data and Method) presents the method and data used. In section three (Results and Discussion) the district and regional level analysis of the trend of paddy extent cultivated, yield, and production is presented. Next, the estimates of instability in yield, area and production, with respect to DZ, IZ and WZ and district level under the three different water regimes of major irrigation, minor irrigation and rain-fed are presented. Section four (Production Growth Rate) discusses the growth rate of production and area with respect to time, season and rainfall. The final section (Conclusion) presents conclusions and policy implications.

Data and Method

An analysis of fluctuations in major food crops is important for understanding the nature of food security and income stability at the regional level. Trend analysis using time series data of extent and yield and production of paddy in the major irrigation regime for the period of

1979 to 2008 is conducted in this study. Graphical methods are used to differentiate trends among agro-climatic zones and administrative districts.

The coefficient of variation (CV) can be used as a measure of instability of crop production. In general, the coefficient of variation measures the amount of variation of the response variable. This statistic is useful for comparing the degree of variation from one data series to another, even if the means are drastically different from each other. Studies in instability related to the food crop sector in Sri Lanka are very rare. However, some studies carried out in India have used CV as a measure of the instability in food grains. A study of growth and instability of agricultural production in Maharashtra (Mitra 1990) used CV as a measure of the instability in crop production in different regions. Mahendradev (1987) reviewed the trends in instability using a moving period approach with Standard Deviation (SD) as the measure of instability. Dhawan (1987) assessed and compared the instability of irrigated farming with the corresponding instability in rain-fed farming of the 11 states of India by using the CV.

Equation (1) represents the ratio of the standard deviation of a variable to its mean, and it

(1) $$CV = \frac{\sigma_{\hat{Y}}}{\hat{Y}}$$

Where, CV is the coefficient of variation, its mean and is the standard deviation of the variable concerned.

In addition, an index for risk of cultivation was derived as an indicator of instability in the area cultivated i.e., ratio of sown area to harvested area (Equation 2).

(2) $$\text{Production risk of cultivation} = \frac{\textit{harvested extent (ha)}}{\textit{sown extent (ha)}}$$

This index can be utilized to assess and compare the production risk in different regions and thereby the instability in the area cultivated. Value of this index varies from zero to unity. An index value closer to unity indicates higher stability.

The growth rate of production and area was carried out for the overall period of 29 years (1979 – 2008) with respect to the three different agro-ecological zones. The rates of growth for this period are estimated by using a log linear function of the time series data on paddy production and area of the DZ, IZ, and WZ as well as the island as a whole. The two estimated equations are as follows:

(3) $$In\ Q_t = \beta_0 \pm \beta_1 T + \varepsilon$$

(4) $$In\ Q_t = \beta_0 \pm \beta_1 T \pm \beta_2 S \pm \beta_3 W + \varepsilon$$

Where; Qt = Production (mt or /Area cultivated (ha), T = Time in years, S = Season dummy, W = Weather factor (rainfall) expressed in, and ε is the stochastic error term.

The coefficient b1 in equation (3) gives the unadjusted trend growth rate, while β_1 in equation (4) gives the growth rate adjusted for weather and seasonal effects. The coefficient β_2 represents the seasonal effect while b_3 provides the elasticity of production or area cultivated with respect to rainfall.

Zonal and district-wise time series data for 29 years i.e., 1979 to 2008, pertaining to area, yield and production under major irrigation, minor irrigation and rain-fed conditions were used in the study. Data used in the study were compiled publications from the Department of Census and Statistics, the Socio Economics and Planning Centre of Department of Agriculture, Natural Resource Management Centre of Department of Agriculture and Central Bank of Sri Lanka. Time series data on rainfall were collected from available weather stations in a way to represent selected districts for the analysis. Administrative districts in the country were categorized into three agro-climatic zones namely, the Dry Zone (DZ), the Wet Zone (WZ) and the Intermediate Zone (IZ). Districts included in the DZ category are, Puttalam, Anuradhapura, Ampara, Hambantota, Udawalawe and Mahaweli 'H'. Kurunegala, Matale, Badulla and Monaragala represent the IZ while Colombo, Kalutara, Gampaha, Galle, Matara, Rathnapura, Kegalle, Kandy and Nuwara Eliya represent the WZ. All districts in the Northern and Eastern provinces except Ampara were excluded due to unavailability of data for a part of the study period.

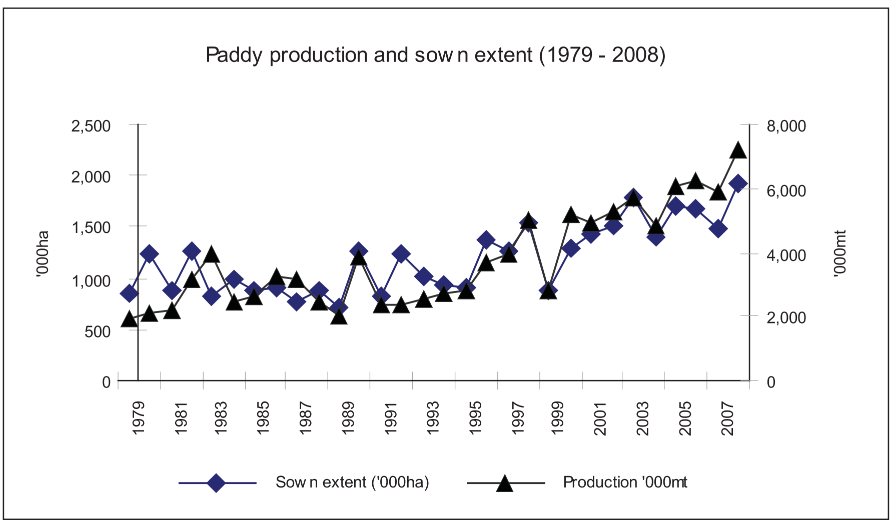
Results and Discussion

Long-term Trend in Production, Extent and Yield

Trends in paddy production and sown extent are shown in Figures 1 to 3. These trends indicate that the performance of the paddy sector has improved. This increment was mainly brought about by the increase in the area of cultivation and partly by yield improvement.

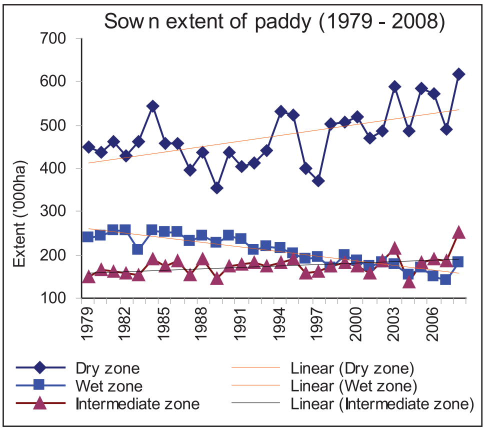
Both sown extent and paddy production have increased in DZ (Figure 2). This increase could be due to rapid irrigation developments whereas, a decreasing trend was observed in WZ. The general neglect of paddy land, changes in cropping system and utilizing paddy lands for other uses would be the main attributable factors in this regard. Production and extent is

Figure 1. Island paddy production ('000 mt) and sown extent ('000 ha).



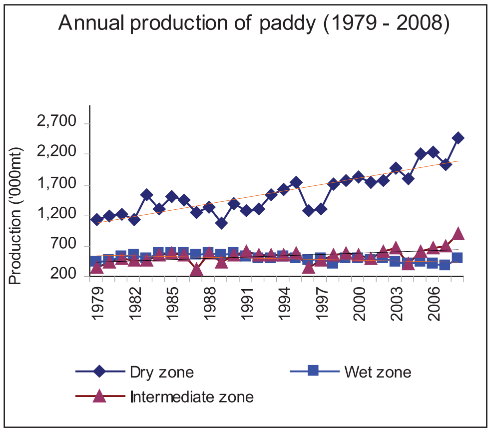
Source: Paddy Statistics, Department of Census and Statistics 2009

Figure 2. Sown extent of paddy ('000 ha) in three major agro-climatic zones.



Source: Paddy Statistics, Department of Census and Statistics 2009

Figure 3. Production of paddy ('000 mt) in three major agro-climatic zones.

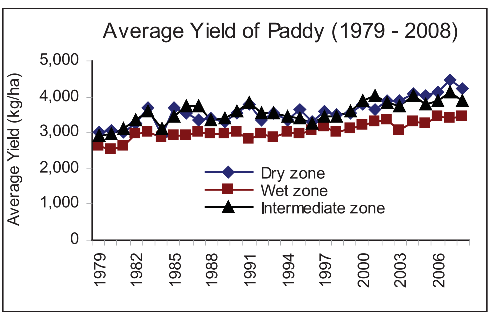


Source: Paddy Statistics, Department of Census and Statistics 2009

being stagnated in IZ because paddy is mainly cultivated under rain-fed and traditional seasonal tanks, and there were no significant irrigation infrastructure development programs that were implemented.

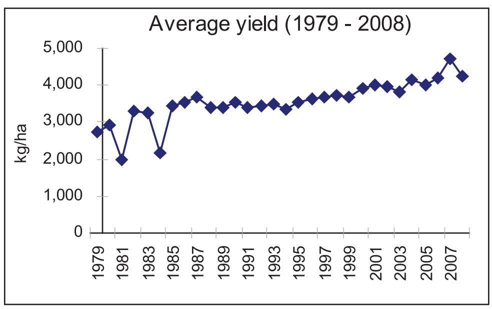
Average yield of paddy also shows an increasing trend but at a lower rate in all three zones as well as in the island as a whole (Figures 4 and 5). This highlights the improvement of technology and this increment also contributed to the increase in production.

Figure 4. Average yield of paddy (kg/ha) in three major agro-climatic zones.



Source: Paddy Statistics, Department of Census and Statistics 2009

Figure 5. Island average yield of paddy (kg/ha).



Source: Paddy Statistics, Department of Census and Statistics 2009

Instability in Paddy Production

Two methods, coefficient of variation (CV) and index of production risk of cultivation were used in measuring instability. The results of CV analysis show that the range of differences in the magnitude of instability of production within agro-climatic zones varied from 18.15 % in the DZ to 9.2 % in the WZ for *maha* season. Relatively higher instability in production can be shown in *yala* for all three zones (Table 1). On average in *yala*, instability in production is 63 % higher than *in maha*. This would be a result of water scarcity and low abandoned rainfall during *yala*.

Compared to the DZ and IZ, the instability of production and yield are lower in the WZ both in the *maha* and *yala* seasons (50 % lower in production instability and 25 % lower in yield instability) — (Tables 1 and 2). The IZ shows the highest instability in average yield under all three major irrigation schemes and the CV of yield in DZ comparable with WZ showing stable productivity of paddy in the *maha* season (Table 2).

Table 1. Zone–wise coefficient of variation of net harvested extent and production for *maha* and *yala* seasons.

Agro-climatic zone	Net harvested extent		Production	
	Maha	*Yala*	*Maha*	*Yala*
Dry	12.65	23.78	18.15	30.33
Intermediate	16.30	32.01	18.36	25.38
Wet	12.75	24.83	9.20	19.22

Note: This is based on the author's estimation of CV

Table 2. Zone–wise coefficient of variation of net harvested extent and production in different agro-climatic zones by season and by water regime.

Agro-climatic Zone	Water Regime							
	Major Irrigation		Minor Irrigation		Rain-fed		All Regimes	
	Maha	*Yala*	*Maha*	*Yala*	*Maha*	*Yala*	*Maha*	*Yala*
Dry	9.41	39	12.03	56.08	12.94	42.22	10.14	23.45
Intermediate	51.03	39.49	48.19	24.47	47.50	62.73	49.19	30.86
Wet	9.05	8.85	8.35	19.19	8.53	31.18	7.52	24.66

As regards the extent cultivated, DZ indicated the highest value of CV for the area sown compared to the other two zones. However, under the major irrigation and rain-fed condition, IZ shows the highest variation in the *yala* season and comparably the lowest value of CV for the area sown could be observed in WZ (Table 3).

Inter-zonal differences in CV of harvested extent also show a similar pattern (Table 4). In the *yala* season under the major irrigation and rain-fed conditions, the highest instability was recorded in IZ and the stability of harvested area could be observed in WZ. With respect to the sown extent, the lowest instability was recorded from the IZ, conversely it receives the highest instability in harvested extent in the *maha* season. In the *yala* season, the highest instability was recorded in both sown and harvested extents for the IZ. It reveals that during the *maha* season, IZ also receives a fairly large amount of rainfall, giving farmers an incentive

Table 3. Agro-climatic zone-wise CV of sown extent in the *maha* and *yala* seasons.

Agro-climatic Zone	Water Regime							
	Major Irrigation		Minor Irrigation		Rain-fed		All Regimes	
	Maha	*Yala*	*Maha*	*Yala*	*Maha*	*Yala*	*Maha*	*Yala*
Dry	11.27	24.39	30.44	56.08	35.46	42.22	11.25	23.45
Intermediate	11.35	39.49	12.16	24.47	7.13	62.73	8.90	30.86
Wet	4.00	8.85	10.18	19.19	15.60	31.18	12.43	24.66

Table 4. Agro-climatic zone-wise CV of sown extent in the *maha* and *yala* seasons.

Agro-climatic Zone	Major Irrigation		Minor Irrigation		Rain-fed		Total	
	Maha	*Yala*	*Maha*	*Yala*	*Maha*	*Yala*	*Maha*	*Yala*
Dry	12.07	24.57	34.54	58.81	37.44	48.90	12.87	23.89
Intermediate	12.04	38.44	18.95	28.67	21.52	70.73	15.80	38.07
Wet	3.94	9.39	10.59	19.85	15.68	31.29	12.60	24.84

Note: This is based on the author's estimation of CV

to put their land under cultivation, but in the *yala* season, the highest instability due to water scarcity was brought about by the uncertainty of rainfall.

According to the district-wise analysis presented in Table 5, the highest CV has recorded from Colombo District both in the *yala* and *maha* seasons, indicating the highest instability in the area cultivated as well as production. On the other hand, districts representing WZ show the minimum value of CV of the area cultivated and production, where the Matale District shows the minimum value of CV in sown extent for the *maha* season and Kalutara shows the minimum value for sown and gross harvested extent and production, indicating the stability in paddy cultivation in the *yala* season. The Kurunegala District is the most vulnerable to food insecurity in terms of paddy cultivation in *yala*. Next to Colombo, the Anuradhapura District shows a higher magnitude of instability in both seasons for paddy cultivation.

Table 5. District-wise CV in *maha* and *yala* seasons.

District	SE		GHE		AY		NHE		PRO	
	M	Y	M	Y	M	Y	M	Y	M	Y
Puttalam	19.9	58.5	23.7	63.4	18.4	20.7	23.7	63.4	28.8	73.9
Anuradhapura	35.0	70.9	38.7	71.7	12.5	15.2	38.7	71.7	42.0	81.0
Polonnaruwa	18.6	29.2	18.8	29.2	11.8	13.5	18.8	29.2	25.0	38.8
Ampara	11.7	22.7	14.9	23.6	13.3	11.3	14.9	25.5	25.0	31.1
Hambantota	13.8	25.0	14.6	25.8	10.0	10.5	14.6	24.9	18.0	30.0
Udawalawe	21.8	21.4	21.8	21.4	9.1	12.3	21.6	20.3	25.0	25.7

Mahaweli 'H'	10.1	62.8	12.5	64.1	9.7	22.3	14.3	64.9	19.3	81.0
Kurunegala	11.7	75.9	23.8	96.6	7.9	99.3	23.8	69.4	25.6	41.8
Matale	8.6	30.7	11.9	32.2	10.2	13.0	11.9	32.2	16.4	39.0
Badulla	10.8	22.9	12.2	23.1	12.1	17.8	12.2	23.1	21.0	33.8
Monaragala	27.9	55.1	32.5	57.8	11.0	15.3	32.5	57.8	41.6	71.9
Colombo	46.0	59.0	45.6	59.2	10.1	16.5	45.6	59.2	44.8	64.0
Kalutara	13.5	21.5	13.5	20.6	12.7	14.5	13.5	20.6	13.6	15.4
Gampaha	22.1	64.9	21.8	65.2	9.6	12.6	21.8	65.2	20.5	66.4
Galle	13.2	38.6	13.3	38.5	18.7	21.4	13.3	38.5	12.9	34.4
Matara	11.6	27.8	11.6	27.9	16.1	22.7	11.6	27.9	11.4	32.3
Ratnapura	9.5	26.6	9.5	26.6	10.7	20.7	9.5	25.3	12.3	27.1
Kegalle	10.5	31.7	14.0	31.7	7.2	19.0	14.0	27.9	14.3	27.8
Kandy	16.0	30.4	16.3	30.4	9.9	18.8	16.3	27.4	16.1	26.8
Nuwara Eliya	12.0	46.1	11.4	46.1	9.7	19.1	11.4	46.9	16.9	44.9

Source: This is based on the author's estimation of CV

Note: SE – sown extent, GHE – gross harvested extent, AY- average yield, NHE – net harvested extent, PRO – production, M (*maha*) and Y (*yala*)

To further analyze the instability in paddy cultivation, this paper developed an index—the production risk of the cultivation index—to analyze the variation in area cultivated within the zones and districts. The deviation of this index (between 0 and 1) clearly shows that WZ receives the minimum risk of paddy cultivation (index is more close to one) under all three irrigation regimes, whereas the index of the other two zones is frequently furthest from 1, thus indicating comparatively a higher risk of production (Figures 6, 7 and 8).

According to this analysis the Anuradhapura and Puttalam districts indicated the highest risk of cultivation under the major irrigation regime; the Mahawelli area showed the lowest risk of cultivation because water is secured throughout the year from diverted Mahaweli waters

Figure 6. Fluctuations in the production risk of cultivation under major irrigation regime in *maha* and *yala* seasons.

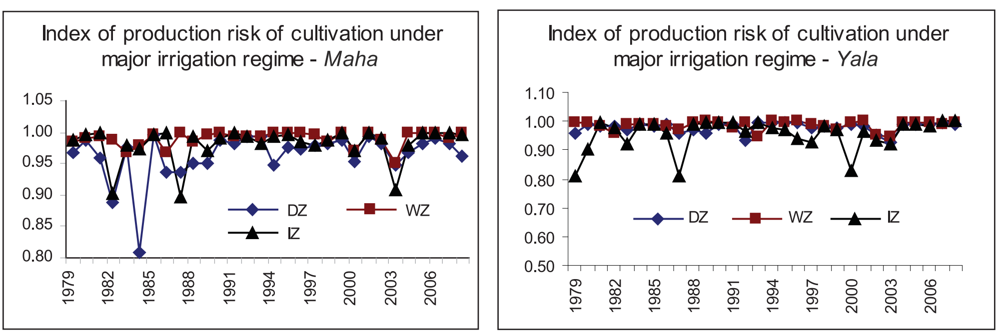


Figure 7. Fluctuations in the production risk of cultivation under minor irrigation regime in *maha* and *yala* seasons.

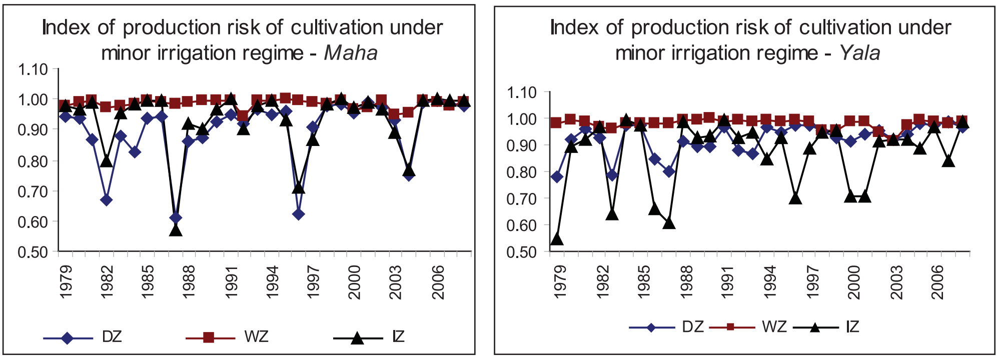
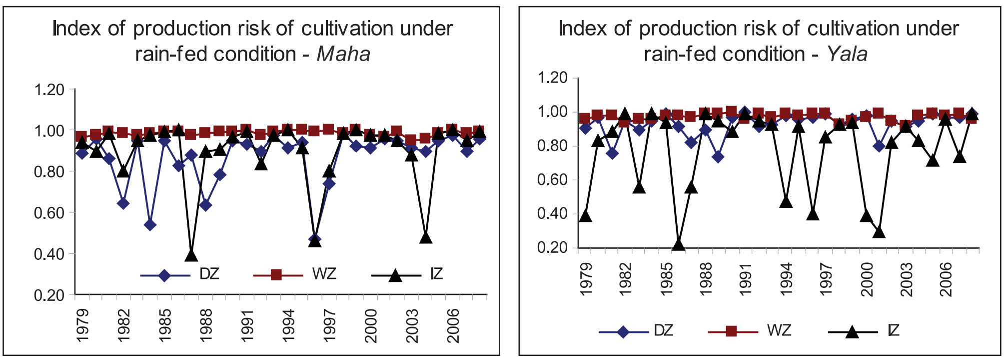


Figure 8. Fluctuations in the production risk of cultivation under rain-fed condition in *maha* and *yala* seasons.



Note: This analysis is based on the authors' estimation of the index (Production risk of cultivation)

(Table 6). Under rain-fed conditions, the Galle, Ratnapura, and Colombo districts also show a minimum risk of cultivation, because these districts are secured from the amount as well as the distribution of rainfall (Table 6).

Table 6. District-wise production risk of cultivation index under three major irrigation regimes in the *maha* and *yala* seasons.

	Major Irrigation		Minor Irrigation		Rain-fed		Total	
District	*Maha*	*Yala*	*Maha*	*Yala*	*Maha*	*Yala*	*Maha*	*Yala*
Puttalam	0.95	0.94	0.90	0.88	0.85	0.83	0.91	0.89
Anuradhdpura	0.97	0.97	0.89	0.89	0.79	0.79	0.93	0.93
Polonnaruwa	0.99	0.99	0.94	0.94	0.92	0.92	0.99	0.99
Ampara	0.96	0.96	0.94	0.94	0.91	0.91	0.96	0.96
Hambantota	0.99	0.99	0.97	0.97	0.96	0.96	0.98	0.98

Udawalawe	1.00	1.00	na	na	na	na	1.00	1.00
Mahaweli ‘h’	0.99	0.99	na	na	na	na	0.99	0.99
Kurunegala	0.98	0.98	0.90	0.90	0.88	0.88	0.91	0.91
Matale	0.98	0.98	0.96	0.96	0.94	0.94	0.96	0.96
Badulla	0.99	0.99	0.99	0.99	0.92	0.92	0.98	0.98
Moneragala	0.98	0.98	0.94	0.94	0.88	0.88	0.93	0.93
Colombo	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
Gampaha	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Kalutara	0.97	0.97	0.99	0.99	0.98	0.98	0.98	0.98
Galle	na	na	0.99	0.99	0.99	0.99	0.99	0.99
Matara	0.99	0.99	0.98	0.98	0.98	0.98	0.98	0.98
Ratnapura	0.99	0.99	0.99	0.99	0.98	0.98	0.99	0.99
Kegalle	na	na	0.98	0.98	0.97	0.97	0.97	0.97
Kandy	1.00	1.00	0.98	0.98	0.98	0.98	0.99	0.99
Nuwara Eliya	0.99	0.99	0.98	0.98	0.96	0.96	0.98	0.98

Note: This analysis is based on the authers estimation of the index of production risk of cultivation, figures highlighted are indicated the minimum value of the index na- data not available.

Production Growth Rate

Paddy production has increased at a rate of around 2 % and 1 % per annum in the DZ and IZ, respectively, during the period of 1979 – 2008. The higher growth rate can be observed in the *maha* crop compared to the *yala* crop. Paddy production in the WZ has decreased at a rate of 0.8 % per annum. However, the decreasing rate is lower in *yala* (Table 7).

Comparisons of unadjusted growth rates for weather and seasons reveal that the weather and seasonal fluctuations do not affect the rate of growth in paddy production. A negative elasticity of production with respect to rainfall can be observed in the DZ (- 1.3). IZ and WZ show a positive elasticity of production with respect to rainfall i.e., 0.27 and 0.17, respectively

Table 7. Unadjusted growth rate of production by agro-climatic zone.

Zone	Annual		*Maha*		*Yala*	
	R2 %	Growth Rate Percent	R2 %	Growth Rate Percent	R2 %	Growth Rate Percent
DZ	69.5	2 (0.002)	51.1	1.5 (0.002)	73.1	0.031 (0.003)
IZ	20.1	1 (0.004)	14.9	0.8 (0.004)	18.3	0.016 (0.006)
WZ	40.6	-0.8 (0.002)	25.9	-0.5 (0.001)	35.4	-0.013 (0.003)

Note: Figures in parentheses are standard errors
The determinants are significant at 1 % level

(determinants are not significant). Table 8 shows that the inclusion of rainfall index and seasonal dummy improved the value of R2 for all three zones. It indicates that variation in rainfall and season partly explains the variation in paddy production within the zones. IZ reports the highest value with respect to the seasonal elasticities. Furthermore, it indicates that the growth rate in the *maha* season is higher in DZ and IZ whereas it is lower in WZ.

Table 8. Zonal-wise growth rate of paddy production (adjusted).

Zone	R2		GR %		ER	ES
	unadjusted	adjusted	unadjusted	adjusted		
Dry	69.5	83.9	2* (0.002)	2 (0.002)	-0.13** (0.09)	0.59* (0.04)
Intermediate	20.1	76.7	1* (0.004)	1 (0.003)	0.09** (0.16)	0.8* (0.066)
Wet	40.6	78.9	-0.8* (0.002)	-0.9 (0.002)	0.18** (0.10)	0.44* (0.03)

Note: figures in parentheses indicated the standard error
* Coefficients are significant at 1 % level
** Coefficients are not significant
GR – growth rate, ER – elasticity of production with respect to rainfall, ES – elasticity of production with respect to season

Area Growth Rate

The highest adjusted and non-adjusted area of growth rate has been recorded in the DZ (Table 9). It has increased at a rate of 0.8 and 1 % per annum, respectively. Mass irrigation infrastructure programs have been implemented during the period concerned, weather adjusted R2 has increased from 28.2 to 84 in DZ and from 18 to 83 in IZ, explaining the importance of the weather factor, even where developed irrigation infrastructure is available.

Table 9. Zonal-wise growth rate of paddy area cultivated.

Zone	Unadjusted	Adjusted			ER	ES
	GR %	R2	GR %	R2		
Dry	0.8* (0.002)	28.2	1* (0.002)	84	-0.11*** (0.1)	0.71* (0.04)
Intermediate	0.5** (0.002)	18	0.4** (0.002)	83	-0.005*** (0.1)	0.66* (0.039)
Wet	-1.8** (0.001)	82	-1.9* (0.001)	80.4	0.03*** (0.09)	0.33* (0.03)

Note: figures in parentheses indicated the standard error
* Coefficients are significant at 1 % level
** Coefficients are significant at 10 % level
*** Coefficients are not significant
GR – growth rate, ER – elasticity of area cultivated with respect to rainfall, ES – elasticity of area cultivated with respect to seasonal effect

On the other hand, the WZ area growth rate decreases at a rate of 1.8 % per annum. A similar set of observations were made in the case of trend analysis. The higher stability in production could be utilized to augment regional food security as well as the supply of seed paddy for other regions. Thus the results highlight the importance of maintaining WZ as a buffer zone of production and investments in irrigation in the IZ to secure the availability of paddy.

Conclusion

The production levels of paddy have been accompanied with wide regional variations due to irregularities in the rainfall patterns and cyclical effects of the production fluctuations.

More thrust has been placed on irrigated paddy production in the areas of the dry zone, while traditional areas of the wet zone have been subjected to immense population pressure amidst various institutional arrangements. However, according to the derived results, the highest production stability was recorded in the WZ. This could be utilized to augment regional food security as well as the supply of seed paddy for other regions. Thus the results highlight the importance of maintaining WZ as a buffer zone of production, and investments in irrigation in the IZ to secure the availability of paddy. In the *maha* season, the IZ shows the lowest variation in the sown extent and highest variation in the harvested extent. It indicates the higher risk of production at the later stage of the crop. The IZ shows the general risk in paddy production in the *yala* season, indicated by the highest instability in both sown and harvested extents. This reiterates the importance of directing investments into irrigation developments for the IZ.

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