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RESEARCH ARTICLE

Crop Science

Changes in crop productivity and the harvested area of rice grown in Sri Lanka over the last four decades (1979-2021) as affected by the season, district, and water management system

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Abstract: In Sri Lanka, rice (*Oryza sativa* L.) is cultivated during two seasons, known as *Yala* and *Maha*, across 25 districts either with or without access to irrigation water. However, variations in crop productivity and harvested extent in the last few decades remain unknown, particularly in relation to the district, season and water management systems (minor and major irrigation schemes, and rainfed). In this context, we conducted this study to determine the changes in rice crop productivity and harvested extent during the last forty years, and how they are affected by the season, district and water management systems. The relevant data for the period from 1979 to 2021 were obtained from the Department of Agriculture. Results revealed that rice crop productivity remained unchanged or increased with time for all the districts, seasons and water management systems, except for Galle where productivity declined under the major irrigation scheme during *Yala*. The harvested extent increased over the years for most districts, seasons and water management systems with a few exceptions. These exceptions were rainfed and minor irrigated paddy lands in the wet zone districts. Development and adoption of new improved varieties, better agronomic and management practices, use of modern technology and effective extension services have contributed to productivity improvement. In order to secure the harvested extent for the future, district, season and water management method-based recommendations are required apart from the common policies applicable at the national level.

Keywords: Districts, irrigation, seasons, water sources, rice productivity, Maha, Yala, Sri Lanka

INTRODUCTION

Rice (*Oryza sativa* L.) is the staple food for most Sri Lankans (Amarasingha et al., 2017) and with an increasing population the demand for rice is also rising. To fulfill the market demand, rice production must be increased (Kekulandara et al., 2019; Suriyagoda, 2022). Rice cultivation in Sri Lanka is dependent on the rainfall received from the two monsoons and two inter-monsoons. The two main cultivation seasons in Sri Lanka are *Yala* and *Maha* and the cultivated extents in these seasons are determined by the amount and distribution of rainfall (Amarasingha et al., 2017).

Rice is cultivated in all districts of Sri Lanka, except at elevations above 1200 m from mean sea level (Amarasingha et al., 2014). Therefore, a large diversity exists in the rice cultivation systems. Rice is grown either as a supplementary irrigated or rain-fed crop (Amarasingha et al., 2014). This is determined by the amount and distribution of rainfall during the cropping season, and the availability of reservoirs and canal systems to store and distribute excess water from rainfall for cultivation.

Although rice has been cultivated for a long period in Sri Lanka, no detailed studies have been conducted

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to examine changes in crop productivity (kg ha^{-1}) and harvested extent (ha) over time. Due to pressure on paddy lands for alternate land uses, pest and disease incidences and reduced productivity, the extent of cultivation may have reduced in some districts. In contrast, crop productivity may also have increased over the years due to the introduction of new agricultural techniques, varieties, awareness programs and expansion of irrigation schemes. Changes in crop productivity and cultivated extent could also be affected by the cultivation season, district and irrigation water availability. This information is vital to understand and implement administrative and agronomic decisions for the sustainable management of the rice sector in Sri Lanka. Therefore, this study was conducted to determine the changes in rice crop productivity and cultivated extent over the last forty years, and the effect of the two seasons, districts and water management system used. Our hypothesis is that crop productivity and cultivation extent have not changed over the years, and were not affected by the season, district and water management system used.

MATERIALS AND METHODS

Seasonal rice crop productivity (kg ha^{-1}) and harvested extent (ha) data for all 25 districts for the *Yala* and *Maha* seasons, and for major, minor, and rainfed irrigation systems in Sri Lanka were obtained for the period 1979 to 2021 from the Socio Economic and Planning Centre of the Department of Agriculture, Sri Lanka. The number of years of rice crop productivity and harvested extent data available for this study, including different districts, seasons and water management systems are presented in Tables S1 and S2.

After compiling, the data was screened, tested for outliers, and descriptive statistics were generated. Average crop productivity in each district, season and water management system was calculated by calculating the arithmetic average over the years. Then, the effects of districts, seasons, water management systems and their interactions on average crop productivity were tested using the ANOVA (PROC GLM) procedure (Table S3). Since the higher order interactions were significant, average crop productivity among districts within each season and water management system was compared. Means were compared using the LSMEANS procedure. A similar approach was adopted to compare the differences in harvested extents among districts, seasons and water management systems. Changes in crop productivity and harvested extent over time, from 1979 to 2021, for each district, season and water management system were examined through simple linear regression analysis (PROC REG). The productivity among districts was compared using the average of the last five years (2017-2021). The last five-year average was considered to avoid any bias in average calculation as it changed over the years. The level of significance of all statistical tests was set at α=0.05.

RESULTS AND DISCUSSION

Variation in crop productivity

Statistical significance of the district, season, water management system and their interactions on the variation of average rice crop productivity as determined by the ANOVA is shown in Table S3. All the main effects and two-way interactions of the variables considered affected crop productivity (p<0.05). The overall model explained 48% of the total variability of crop productivity (Table S3).

Statistical significance of the simple linear regression analysis between rice crop productivity and time (i.e., years) for each district, season and water management system is given in Table 1. Crop productivity has increased over the years from 1979 to 2021 for most districts, seasons and water management systems (Table 1). In Kalutara, Matale, Matara, Mullaitivu, Puttalam, and Ratnapura districts, crop productivity has increased over the years, irrespective of the season and water management system. For other districts, seasons, and water management systems, rice crop productivity has either increased or remained unchanged over the years. However, crop productivity has declined in the Galle district under major irrigation schemes during the *Yala* season.

Developing new improved varieties with higher yield potential, widespread adoption of new improved varieties to replace traditional rice varieties, minimizing the gap between potential and actual yield of already released varieties through better agronomic and management practices, use of modern technology and effective extension services have contributed to the productivity improvement during this period (Dhanapala, 1999; Suresh et al., 2021).

Table 1: Statistical significance of the changes in rice crop productivity from 1979 to 2021, for different districts, water management systems and seasons in Sri Lanka. The symbols +, −, NS and NA indicate an increase, decrease, unchanged productivity over the years or data not available, respectively.

District	Major		Minor		Rainfed	
	Yala	***Maha***	***Yala***	***Maha***	***Yala***	***Maha***
Ampara	(+)***	(+)***	(+)***	(+)*	NS	NS
Anuradhapura	(+)***	(+)***	(+)***	(+)***	NS	(+)***
Badulla	(+)***	NS	(+)*	NS	NS	(+)*
Batticaloa	(+)***	(+)*	(+)**	NS	(+)*	(+)*
Colombo	NS	NS	(+)***	(+)***	(+)***	(+)***
Galle	(−)*	NS	(+)*	(+)*	(+)***	(+)***
Gampaha	(+)**	(+)*	NS	(+)*	(+)*	(+)***
Hambantota	(+)***	(+)***	(+)***	(+)***	NS	(+)***
Jaffna	NS	NS	NA	NA	NA	(+)**
Kalutara	(+)***	(+)***	(+)***	(+)***	(+)***	(+)***
Kandy	(+)***	(+)***	NS	NS	(+)*	(+)*
Kegalle	NA	NA	NS	(+)***	NS	(+)**
Kilinochchi	NS	(+)**	NS	(+)**	NS	(+)***
Kurunegala	(+)***	(+)**	(+)***	(+)***	NS	(+)***
Mannar	NS	(+)*	(+)*	(+)***	NS	NS
Matale	(+)***	(+)***	(+)***	(+)***	(+)***	(+)*
Matara	(+)***	(+)***	(+)***	(+)***	(+)***	(+)***
Moneragala	(+)***	(+)***	(+)***	(+)***	NS	(+)***
Mullativu	(+)***	(+)**	(+)**	(+)*	(+)*	(+)***
Nuwaraeliya	(+)***	NS	NS	NS	NS	(+)*
Polonnaruwa	(+)***	(+)**	(+)***	(+)***	NS	(+)*
Puttalam	(+)***	(+)***	(+)***	(+)***	(+)*	(+)***
Ratnapura	(+)***	(+)***	(+)***	(+)***	(+)***	(+)***
Trincomalee	(+)***	(+)***	(+)***	(+)***	NS	(+)***
Vavuniya	(+)***	(+)***	(+)**	(+)***	NS	(+)***
Sri Lanka	(+)***	(+)***	(+)**	(+)***	(+)***	(+)***

Note: * $p < 0.05$, ** $p < 0.01$, ***, $p < 0.001$

In Sri Lanka, rice breeding programs were aimed at developing varieties that are adapted to local field conditions while reaching higher crop productivity (Suriyagoda, 2022). As a result, over 100 new improved rice varieties have been released by the Department of Agriculture with acceptable productivity and grain quality characteristics. Additionally, with the initiation of the *Mahaweli* Development Project in 1961, the number of irrigation systems and the extent of paddy lands that could be irrigated have increased. This has ensured the availability of irrigation water to cultivate more paddy lands over the years and contributed to minimize the gap between actual and expected yield. Along with this, seasonal planning meetings and pre-season meetings were mandated by the Irrigation Act to ensure effective water management, and adopt collective decisions made at those meetings on other agronomic practices (Salman et al., 2022). Comprehensive extension and farmer training programs conducted by the Department of Agriculture over the years have improved the knowledge and technical efficiency of farmers (Athukorala, 2017). As a result, mechanization was introduced to reduce the cost of production and improve the efficiency of field practices (Ayoob & Fowsar, 2020). Fertilizer subsidy schemes operated by the government from time to time ensured proper nutrient management of the rice crop. Additionally, location-specific fertilizer guidelines are available for improving nutrient-use efficiency (Sandika & Dushani, 2009). All these interventions have collectively contributed to substantial increases in the productivity of rice over the years.

During the *Maha* season, as indicated by the slope of the relationship between crop productivity and the year, rice crop productivity increased by 28.3, 23.1 and 23.3 kg ha^{-1} yr^{-1} from 1979-2021 for major irrigation, minor irrigation and rainfed systems, respectively (Table 2). In the *Yala* season, rice crop productivity increased by 37.4, 28.1 and 25.2 kg ha^{-1} yr^{-1} for major irrigation, minor irrigation and rainfed systems, respectively (Table 3). Moreover, this productivity increment of major irrigation systems was significantly higher than that of minor irrigation and rainfed systems during both seasons ($p < 0.05$).

Table 2: Simple linear regression models explaining the relationships between rice crop productivity (y-kg ha^{-1}) and the year of cultivation (x-1971-2021) for different districts and water management systems during the *Maha* season

District	Major irrigation	R²	Minor irrigation	R²	Rainfed	R²
Ampara	y = 35.1x - 65823	0.41	y = 20.4x - 37454	0.11	NS	NS
Anuradhapura	y = 32.7x - 60859	0.37	y = 40.5x - 77227	0.48	y = 35.1x - 66975	0.35
Badulla	NS	NS	NS	NS	y = 19.7x - 36293	0.13
Batticaloa	y = 13.9x - 24800	0.09	NS	NS	y = 11.1x - 19627	0.05
Colombo	NS	NS	y = 27.8x - 52644	0.33	y = 12.8x - 22523	0.21
Galle	NS	NS	y = 29.4x - 55835	0.21	y = 34.3x - 65681	0.62
Gampaha	y = 10.2x - 17070	0.05	y = 16.5x - 29893	0.11	y = 17.7x - 32236	0.39
Hambantota	y = 47.6x - 90319	0.55	y = 51.2x - 98500	0.48	y = 36.7x - 70235	0.49
Jaffna	NS	NS	NA	NA	y = 28.6x - 55019	0.31
Kalutara	y = 36.1x - 69249	0.51	y = 25.2x - 47623	0.51	y = 27.3x - 51874	0.55
Kandy	y = 34.4x - 64464	0.36	NS	NS	y = 11.1x - 19167	0.11
Kegalle	NA	DNA	y = 13.6x - 23518	0.27	y = 16.5x - 29474	0.24
Kilinochchi	y = 23.5x - 43723	0.16	y = 49.1x - 95724	0.33	y = 47.6x - 92654	0.37
Kurunegala	y = 19.4x - 34588	0.17	y = 26.3x - 49106	0.42	y = 22.8x - 42349	0.42
Mannar	y = 27.8x - 51610	0.17	y = 46.1x - 88980	0.33	NS	NS
Matale	y = 26.7x - 49120	0.31	y = 26.3x - 48949	0.33	y = 19.5x - 35480	0.18
Matara	y = 36.9x - 70224	0.55	y = 34.7x - 66093	0.55	y = 36.9x - 70682	0.65
Monaragala	y = 39.5x - 74771	0.44	y = 33.6x - 63759	0.52	y = 27.1x - 51194	0.41
Mullaitivu	y = 33x - 62812	0.26	y = 35.1x - 67441	0.24	y = 37.5x - 72540	0.41
Nuwara Eliya	NS	NS	NS	NS	y = 24.9x - 46553	0.25
Polonnaruwa	y = 15.9x - 27253	0.11	y = 31.9x - 59848	0.27	y = 11.4x - 19140	0.05
Puttalam	y = 47.5x - 91531	0.55	y = 44.7x - 86458	0.62	y = 54.1x - 105210	0.76
Ratnapura	y = 34.1x - 63634	0.41	y = 26.5x - 49945	0.41	y = 26.9x - 51128	0.50
Trincomalee	y = 36.7x - 69525	0.44	y = 46.2x - 89380	0.45	y = 40.7x - 78532	0.48
Vavuniya	y = 50.5x - 97574	0.52	y = 56.2x - 109115	0.37	y = 54.9x - 106759	0.44
Sri Lanka	y = 28.3x - 52457	0.43	y = 23.1x - 52732	0.55	y = 23.2x - 43478	0.58

Note: NS- Not significant, NA- Data not available

Table 3: Simple linear regression models explaining the relationships between rice crop productivity (y-kg ha^{-1}) and the year of cultivation (x-1971-2021) for different districts and water management systems during the *Yala* season

District	Major irrigation	R²	Minor irrigation	R²	Rainfed	R²
Ampara	y = 29.1x - 53687	0.54	y = 32.1x - 60102	0.42	NS	NS
Anuradhapura	y = 51.1x - 98175	0.71	y = 43.8x - 84100	0.65	NS	NS
Badulla	y = 65.2x - 126375	0.74	y = 22.1x - 40463	0.26	NS	NS
Batticaloa	y = 25.3x - 46952	0.37	y = 32.7x - 62011	0.33	y = 22.6x - 41602	0.15
Colombo	NS	NS	y = 35.5x - 68491	0.39	y = 18.7x - 34883	0.29
Galle	y = (-104.3)x + 213303	0.62	y = 23.8x - 44976	0.16	y = 35.3x - 68178	0.75
Gampaha	y = 20.8x - 38395	0.19	NS	NS	y = 10.5x - 18223	0.09
Hambantota	y = 48.6x - 92594	0.65	y = 51.7x - 99716	0.61	NS	NS
Jaffna	NS	NS	DNA	DNA	NA	DNA
Kalutara	y = 36.8x - 71303	0.52	y = 24.4x - 46323	0.51	y = 31.1x - 59543	0.75
Kandy	y = 26.8x - 49622	0.24	NS	NS	y = 13.4x - 24055	0.14
Kegalle	NA	DNA	NS	NS	NS	NS
Kilinochchi	NS	NS	NS	NS	NS	NS
Kurunegala	y = 37.9x - 71867	0.58	y = 25.5x - 47898	0.37	NS	NS
Mannar	NS	NS	y = 53.9x - 104927	0.33	NS	NS
Matale	y = 62.8x - 121895	0.83	y = 33.2x - 62947	0.54	y = 26.7x - 50566	0.43
Matara	y = 38.7x - 73915	0.59	y = 26.9x - 50882	0.51	y = 35.2x - 67674	0.69
Monaragala	y = 52.4x - 100910	0.64	y = 34.6x - 66103	0.44	NS	NS
Mullaitivu	y = 38.5x - 73560	0.45	y = 39.8x - 76391	0.41	y = 163.1x - 323758	0.89
Nuwara Eliya	y = 10.9x - 18028	0.02	NS	NS	NS	NS
Polonnaruwa	y = 42.7x - 80966	0.74	y = 57.4x - 110914	0.74	NS	NS
Puttalam	y = 48.1x - 92393	0.66	y = 43.5x - 84233	0.57	y = 24.2x - 45465	0.16
Ratnapura	y = 36.1x - 68139	0.34	y = 27.8x - 52484	0.52	y = 24.4x - 46286	0.61
Trincomalee	y = 43.5x - 82900	0.75	y = 44.1x - 84487	0.64	NS	NS
Vavuniya	y = 50.8x - 97644	0.53	y = 47.9x - 92141	0.42	NS	NS
Sri Lanka	y = 37.4x - 70715	0.77	y = 28.1x - 42892	0.27	y = 25.2x - 47666	0.71

Note: NS- Not significant, NA- Data not available

Productivity can be lower during the *Maha* season than in the Y*ala* season due to cloud cover (Jiang et al., 2021). Additionally, the *Yala* season benefits from longer daylight hours, which correlate with increased photosynthesis and crop growth, leading to higher productivity compared to the *Maha* season (Marikar et al., 1992; Suriyagoda et al., 2022). Occasionally, the *Maha* season is more productive due to higher rainfall, while the *Yala* season's production often suffers from irregular weather patterns and lower water availability, leading to reliance on irrigation. Therefore, it is important to identify the strategies that can be used to uplift productivity in both seasons.

Productivity improvement data showed that large-scale irrigation infrastructure played a key role in improving rice production. Under major irrigation schemes, water is issued according to a prescheduled rotation, and channel systems are better equipped than minor irrigation systems. Therefore, crop productivity is enhanced through efficient water management practices, including storing, regulating and distributing the right amount of water at the right time. The Irrigation Department ensures this by conducting pre-seasonal and seasonal planning, scheduling, and coordinating water allocations. This could be a possible reason for higher productivity and productivity increment in major irrigation schemes.

Water management in minor irrigation schemes is based on different types of delivery mechanisms and faces several limitations. Continuous delivery, only practiced in the wet zone, depends on constant rainfall. Rotational delivery ensures fair water distribution but requires full canal flow and careful scheduling. Intermittent delivery helps conserve water but relies heavily on rainfall and frequent adjustments to meet demand. Demand-based delivery is effective in water-scarce regions but is labor-intensive, requiring frequent soil moisture monitoring and precise planning (Salman et al., 2022). Due to these limitations, managing water efficiently in minor irrigation systems is challenging and can cause a reduction in productivity compared to major irrigation systems.

Rainfed systems face limitations due to their reliance on unpredictable and uneven rainfall. Seasonal dependence on monsoons makes crops vulnerable to droughts, delayed rains, and water scarcity during critical growth stages. Farmers have limited control over water availability, resulting in lower productivity compared to irrigated systems (Yoshino & Suppiah, 1984). In this context the possibilities of using rainwater harvesting systems, drought-resistant varieties, and improved soil management need to be explored.

Rainfed systems were more vulnerable during *Yala* than *Maha*. During *Yala* only 12 districts showed significant gains in productivity compared to 23 districts during *Maha*. This highlights the vulnerability of rainfed agriculture to seasonal variability and underscores the need for targeted interventions, such as improved irrigation infrastructure and rainwater harvesting systems (Amarasinghe et al., 2021). Water availability is a critical determinant of productivity, with the *Maha* season benefiting from the North-East monsoon rains. Bridging the productivity gap between the two seasons requires addressing water scarcity during *Yala*.

When comparing districts during the *Maha* season the productivity improvement ranged from 10.2 to 50.5, 13.6 to 56.2 and 11.1 to 54.9 kg ha^{-1} yr^{-1} under major irrigation, minor irrigation and rainfed systems, respectively (Table 2). When comparing districts during the *Yala* season the productivity varied from 104.3 to 65.2, 22.1 to 57.4 and 13.4 to 163.1 kg ha^{-1} yr^{-1} under major irrigation, minor irrigation, and rainfed systems, respectively (Table 3). A decrease in rice crop productivity of 104.3 kg ha^{-1} yr^{-1} was observed in the Galle district under the major irrigation system during *Yala* (Table 3).

The average rice crop productivity in the *Maha* season from 2017 to 2021 under major irrigation schemes ranged from 3,215 to 5,771 kg ha^{-1} with the highest in Hambantota, followed by Monaragala, Ratnapura, Kurunegala, Anuradhapura, Kandy, Polonnaruwa, Matale, Ampara, Badulla, Trincomalee and Mannar districts (Table S4). The average rice crop productivity under minor irrigation schemes ranged from of 3,072 to 5,058 kg ha^{-1} with the highest in Hambantota, followed by Polonnaruwa, Mullaitivu, Matale, Vavuniya, Anuradhapura, Monaragala, Badulla, Kegalle, Ratnapura, Puttalam and Kurunegala districts (Table S4). The average rice crop productivity under rainfed systems ranged from 3,030 to 4,369 kg ha^{-1} with the highest in Matale, followed by Kegalle, Vavuniya, Nuwara-Eliya, Kurunegala, Polonnaruwa, Anuradhapura, Hambantota, Puttalam, Gampaha, Matara, Kandy, Kilinochchi, Mullaitivu, Badulla, Kalutara, Ampara, Galle, Monaragala, Colombo and Ratnapura districts (Table S4).

The average rice crop productivity in the *Yala* season from 2017 to 2021 under major irrigation schemes ranged from 2,583 to 6,107 kg ha^{-1} with the highest in Hambantota, followed by Vavuniya, Polonnaruwa, Mannar and Trincomalee districts (Table S5). The average rice crop productivity under minor irrigation schemes ranged from 2,822 to 4,989 kg ha^{-1} with the highest in Polonnaruwa, followed by Hambantota, Vavuniya, Trincomalee, Ampara, Mullaitivu, Batticaloa, Badulla, Matale, Monaragala, Anuradhapura and Kilinochchi districts (Table S5). The average rice crop productivity under rainfed systems ranged from 2,700 to 4,092 kg ha^{-1} with the highest in Ampara, followed by Batticaloa, Trincomalee, Matale, Puttalam, Badulla, Anuradhapura, Kurunegala, Kandy, Matara, Hambantota, Polonnaruwa, Kalutara, Vavuniya, Kegalle and Ratnapura districts (Table S5). Despite the improved rice crop productivity over the last few decades, the variation of soil and climate among districts, and the lack of equitable distribution of resources and attention to marginalized areas have exacerbated the productivity disparity between districts.

Variation in the harvested extent

Statistical significance of the district, season, water management system and their interactions on the variation of harvested rice extent as determined by the ANOVA is shown in Table S6. All main effects and interactions of the variables considered affected the extent of harvested rice ($p < 0.05$). Overall, the model explained 94% of the total variability of the harvested rice extent (Table S6).

The statistical significance of the simple linear regression analysis between the harvested extent of the rice crop and the year of cultivation for each district, season and water management system is given in Table 4. Most districts, seasons and water management systems have shown an increase in the harvested extent over the years from 1979 to 2021 (Table 4). However, the harvested extent has declined over the years in both seasons and under all three water management systems in the Kalutara district, both minor irrigated and rainfed systems in Kandy, Kegalle, Matara and Ratnapura districts, rainfed systems in Trincomalee and Vavuniya districts, and major irrigation systems in Gampaha and Kalutara districts.

Table 4: Statistical significance of the changes in the harvested extent of rice from 1979 to 2021, for different districts, water management systems and seasons in Sri Lanka. The symbols +, −, NS and NA indicate an increase, decrease, unchanged productivity over the years or data not available, respectively.

District	**Major**		**Minor**		**Rainfed**	
	Yala	***Maha***	***Yala***	***Maha***	***Yala***	***Maha***
Ampara	(+)***	(+)***	(+)***	(+)***	(+)*	(+)***
Anuradhapura	(+)***	(+)**	(+)***	(+)***	NS	(+)**
Badulla	(+)***	(+)***	(+)***	(+)***	NS	(+)***
Batticaloa	(+)***	(+)***	(+)***	(+)***	(+)*	(+)***
Colombo	(+)*	(+)*	NS	(+)**	(-)***	(+)*
Galle	NS	(+)*	(+)*	(+)***	(-)***	(+)*
Gampaha	NS	(-)*	(+)*	(+)*	(-)***	(-)*
Hambantota	(+)***	(+)***	(+)***	(+)***	(+)*	(+)***
Jaffna	NS	NS	NA	NS	NA	NS
Kalutara	(-)***	(-)***	(-)***	(-)*	(-)***	(-)***
Kandy	NS	NS	(-)***	(-)***	(-)***	NS
Kegalle	NA	NA	(-)***	(-)***	(-)***	NS
Kilinochchi	NS	NS	NS	(+)***	NA	NS
Kurunegala	NS	(+)**	(+)**	NS	NS	(+)**
Mannar	(+)***	NS	(+)*	NS	NS	NS
Matale	(+)***	(+)***	NS	NS	NS	(+)***
Matara	NS	NS	(-)*	(-)***	(-)***	NS
Moneragala	(+)***	(+)***	(+)***	(+)***	(+)**	(+)***
Mullativu	(+)**	(+)**	(+)**	(+)**	NS	(+)**
Nuwaraeliya	NS	NS	(-)***	(-)***	NS	NS
Polonnaruwa	(+)***	(+)***	(+)***	(+)***	NS	(+)***
Puttalam	(+)***	(+)***	(+)***	(+)*	(+)***	(-)***
Ratnapura	(+)***	(+)**	(-)***	(-)***	(-)***	(+)**
Trincomalee	(+)***	(+)**	(+)***	(+)***	NS	(-)**
Vavuniya	(+)*	NS	(+)*	(+)*	(-)***	NS
Sri Lanka	(+)***	(+)***	(+)***	(+)**	(-)***	(-)***

Note: *; $p < 0.05$, **; $p < 0.01$, ***; $p < 0.001$

During the *Maha* season, as indicated by the trend in the relationship between harvested extent and year of cultivation from 1979 to 2021, the harvested extent of paddy has increased by 3,269 under major irrigation and 1,464 ha yr^{-1} under minor irrigation systems, while decreasing by 166 ha yr^{-1} under rainfed systems

(Table 5). Moreover, the expansion of the harvested area under major irrigation areas was significantly higher than that in rainfed areas ($p<0.05$). In the *Yala* season, the harvested extent of paddy has increased by 3,758 under major irrigation and 1,227 ha yr^{-1} under minor irrigation systems, but decreased by 1,264 ha yr^{-1} under rainfed systems (Table 6). Additionally, the expansion of the harvested area in major irrigation areas was significantly higher than in minor irrigation and rainfed areas ($p<0.05$).

Table 5: Simple linear regression models explaining the relationships between harvested extent of rice (y-ha) and time (x-1971-2021) for different districts and water management systems during the *Maha* season

District	Major irrigation	R²	Minor irrigation	R²	Rainfed	R²
Ampara	y = 700.8x - 60263	0.73	y = 70.1x - 138187	0.30	y = 165.2x - 323800	0.27
Anuradhapura	y = 426.1x - 826654	0.24	y = 606.3x - 42657	0.27	y = 227.6x - 451244	0.42
Badulla	y = 94.9x - 180492	0.43	y = 43.4x - 78128	0.28	y = 87.8x - 172747	0.45
Batticaloa	y = 269.1x - 524030	0.42	y = 64.7x - 127945	0.54	y = 369.3x - 716009	0.23
Colombo	y = 5.9x - 11833	0.29	y = 12.7x - 24738	0.17	y = (-120.4) x + 245101	0.90
Galle	y = 11.1x - 22183	0.44	y = 24.2x - 48098	0.39	y = (-285.1) x + 585892	0.79
Gampaha	y = (-10.7) x + 22938	0.08	y = 26.3x - 50582	0.14	y = (-198.2x + 405050	0.90
Hambantota	y = 276.7x - 536022	0.51	y = 51.2x - 98646	0.33	y = 0.95x - 672.22	0.12
Jaffna	NS	NS	NS	NS	NS	NS
Kalutara	y = (-10.5) x + 21406	0.75	y = (-16.2) x + 34635	0.16	y = (-192.5) x + 398183	0.89
Kandy	NS	NS	y = (-113.1) x + 23264	0.82	NS	NS
Kegalle	NA	DNA	y = -17.8x + 37868	0.31	NS	NS
Kilinochchi	NS	NS	y = 9.6x - 18965	0.50	NS	S
Kurunegala	y = 103.5x - 194974	0.27	NS	NS	y = (-76.6) x + 177510	0.02
Mannar	y = 94.2x - 180383	0.07	NS	NS	NS	NS
Matale	y = 79.1x - 152975	0.80	NS	NS	y = 37.6x - 72022	0.23
Matara	NS	NS	y = (-21.1) x + 45438	0.28	NS	NS
Monaragala	y = 141.9x - 278351	0.73	y = 182.8x - 359932	0.75	y = 286.6x - 567311	0.52
Mullaitivu	y = 64.7x - 125869	0.22	y = 39.1x - 76180	0.21	y = (-11.1) x + 25175	0.06
Nuwara Eliya	NS	NS	y = (-41.3) x + 87268	0.42	NS	NS
Polonnaruwa	y = 798.6x - 22645	0.86	y = 114.8x - 226905	0.44	y = 7.2x - 13138	0.02
Puttalam	y = 92.6x - 180805	0.39	y = 72.3x - 138292	0.15	y = (-7.4) x + 16243	0.02
Ratnapura	y = 32.1x - 62321	0.28	y = (-73.1) x + 153364	0.66	y = (-87.5) x + 179565	0.85
Trincomalee	y = 148.6x - 283201	0.27	y = 111.7x - 219921	0.45	y = 10.5x - 15121	0.002
Vavuniya	NS	NS	y = 99.2x - 192782	0.14	NS	NS
Sri Lanka	y = 3269.1x - 66236	0.78	y = 1464.5x - 32306	0.26	y = (-165.6)x + 495183	0.04

Note: NS- Not significant, NA- Data not available

Table 6: Simple linear regression models explaining the relationships between harvested extent of rice (y-ha) and time (x-1971-2021) for different districts and water management systems during the *Yala* season

District	Major irrigation	R^2	Minor irrigation	R^2	Rainfed	R^2
Ampara	y = 658.4x - 15616	0.59	y = 45.6x - 90068	0.83	y = 11.3x - 22422	0.17
Anuradhapura	y = 395.6x - 778455	0.36	y = 367.2x - 727908	0.39	NS	NS
Badulla	y = 97.6x - 188548	0.38	y = 28.4x - 53623	0.36	NS	NS
Batticaloa	y = 342x - 670746	0.64	y = 89.4x - 177503	0.72	y = 19.8x - 38816	0.13
Colombo	y = 4.7x - 9542.1	0.25	NS	NS	y = (-98.2) x + 198765	0.55
Galle	y = 7.8x - 15812	0.12	y = 11.2x - 22329	0.18	y = (-359.4) x + 729950	0.62
Gampaha	y = 6.3x - 11835	0.02	y = 22.4x - 43871	0.13	y = (-149.2) x + 302479	0.43
Hambantota	y = 340.3x - 665810	0.64	y = 73.1x - 143613	0.61	y = 8.9x - 17143	0.14
Jaffna	NS	NS	NA	NA	NA	DNA
Kalutara	y = (-7.7) x + 15769	0.54	y = (-22.8) x + 47420	0.29	y = (-223.5) x + 457063	0.72
Kandy	NS	NS	y = (-86.7) x + 17724	0.69	y = (-123.4) x + 250208	0.711
Kegalle	NA	DNA	y = (-27.8) x + 57577	0.36	y = (-150.3) x + 306226	0.70
Kilinochchi	NS	NS	NS	NS	NA	DNA
Kurunegala	NS	NS	y = 324.7x - 634127	0.23	NS	NS
Mannar	y = 30.3x - 60033	0.47	y = 12.6x - 25110	0.19	NS	NS
Matale	y = 97.8x - 192916	0.62	NS	NS	NS	NS
Matara	NS	NS	y = (-13.7) x + 30514	0.10	y = (-147.7) x + 303731	0.71
Monaragala	y = 161.9x - 320200	0.77	y = 131.3x - 260073	0.66	y = 16.5x - 32676	0.25
Mullaitivu	y = 58.7x - 115835	0.30	y = 19.8x - 39299	0.26	NS	NS
Nuwara Eliya	NS	NS	y = (-27.9) x + 58028	0.27	NS	NS
Polonnaruwa	y = 818.5x - 25646	0.72	y = 113.3x - 224715	0.59	NS	NS
Puttalam	y = 126.5x - 249702	0.52	y = 126.8x - 250837	0.43	y = 14.3x - 28356	0.34
Ratnapura	y = 30.5x - 59208	0.36	y = (-88.7) x + 18360	0.68	NS	NS
Trincomalee	y = 198.2x - 385393	0.34	y = 77.2x - 153321	0.54	y = 7.3x - 14505	0.23
Vavuniya	y = 19.5x - 38404	0.14	y = 33.3x - 66090	0.17	y = (-0.2) x + 496.76	0.15
Sri Lanka	y = 3757.9x - 74566	0.68	y = 1226.6x - 26596	0.36	y = (-1264.3) x + 34676	0.49

Note: NS- Not significant, NA- Data not available

Positive slopes in Table 5 and 6 for the extent of paddy harvested and major and minor irrigation systems, during *Yala* and *Maha* seasons indicate the expansion of cultivation under irrigation over the last forty years. However, the extent of rainfed paddy declined during both *Yala* and *Maha* seasons with a higher reduction in *Yala*. These disparities in the trends of harvested extent among irrigation systems highlight the critical role of water management in sustaining rice cultivation. Major irrigation systems were the most promising out of the three water management methods, supported by the North-East monsoon rains, initiation of the *Mahaweli* development project, renovation of large reservoirs, and irrigation schemes in drought-prone regions (Amarasingha et al., 2014). In contrast, minor irrigation systems showed moderate growth, constrained by the maintenance of infrastructure and water losses in unlined canals (Jayasiri et al., 2024). Rehabilitating underutilized rainfed rice fields and improving minor irrigation systems in the dry and intermediate zones could contribute to a more balanced and resilient agricultural landscape in those regions (Pokharel, 2024). The contrasting trends between irrigated and rainfed systems also highlight the inequities in resource access. Additionally, increasing climate variability has threatened the stability of rainfed systems more than the irrigated systems (Withanachchi et al., 2014).

During *Maha*, the rate of area expansion by districts ranged between 10.7 and 798.6 ha yr^{-1} for major irrigation, 113.1 and 606.3 ha yr^{-1} for minor irrigation, and 285.1 and 369.3 ha yr^{-1} for rainfed systems (Table 5). During *Yala*, the rate of district wise area expansion ranged between 7.7 and 818.5 ha yr^{-1} under major irrigation, 88.7 and 367.2 ha yr^{-1} under minor irrigation, and 359.4 and 19.8 ha yr^{-1} under rainfed systems (Table 6). The harvested extent of rice in 9 districts (out of 25 districts) increased significantly under the rainfed system during the *Maha* season whereas only 5 districts increased their harvested extent under the rainfed system during the *Yala* season.

Many districts in the dry zone have shown a consistent increase in the extent of paddy harvested during the last forty years, driven by land availability and government-led settlement programs (Mohamed & Naseer, 2005). These gains are largely attributed to investments in large-scale irrigation infrastructure, such as the *Mahaweli* development program, and settlement schemes in the Dry Zone. Moreover, supplementary irrigation has buffered against rainfall variability, leading to an increase in the harvested extent (Mahaweli Authority, 2018).

The decline in the harvested extent during *Yala* and *Maha* seasons under rainfed and minor irrigation schemes in most of the wet zone districts highlights the vulnerability of those systems to erratic rainfall, inadequate availability of irrigation water, and soil degradation (Chandrasiri et al., 2023). Weak or delayed monsoon rains and increased frequency of droughts or floods negatively influenced the area of paddy sown in rainfed systems (De Silva et al., 2007). Additionally, land fragmentation, urbanization and weak policy enforcement have led to a significant decline in the cultivated extents, as paddy fields are converted for industrial and residential purposes (De Silva et al., 2007; De Silva & Yamao, 2010). Moreover, some of the paddy lands are converted to cash crops such as other field crops and leafy vegetables. This transformation is particularly evident in highland regions, where economic incentives prioritize commercial crops over traditional paddy farming (Brow & Weeramunda, 1993; Sirisena & Suriyagoda, 2018). Despite these regional disparities, the overall harvested extent remained relatively stable, reflecting resilience in land-use for rice cultivation (Sandika & Dushani, 2009; DCS, 2021). Our results show that the stability of the paddy extent in the country was largely and positively contributed by the extent under major irrigation schemes in the dry zone districts, while minor irrigation schemes and rainfed systems in the wet zone districts contributed negatively.

The average harvested extent of paddy in the *Maha* season from 2017 to 2021 under major irrigation schemes ranged from 118 to 59,937 ha, with the highest in the Ampara district (Table S7). The harvested extent under minor irrigation schemes ranged from of 501 to 35,382 ha, with the highest in the Anuradhapura district (Table S7). Similarly, the harvested extent under rainfed system ranged from 14 to 33,949 ha, with the highest in the Batticaloa district (Table S7).

The average harvested extent of paddy in the *Yala* season from 2017 to 2021 under major irrigation schemes ranged from 102 to 52,154 ha, with the highest in Polonnaruwa and Ampara districts (Table S8). The harvested extent under minor irrigation schemes ranged from 89 to 18,046 ha, with the highest in the Kurunegala district (Table S8). Similarly, the harvested extent under rainfed system ranged from 2 to 13,467 ha, with the highest in the Kurunegala district (Table S8).

Policy interventions are necessary to expand the harvested extent of rice cultivation in Sri Lanka. Strict land-use regulations and investments in irrigation can enhance the harvested extent. Additionally, strengthening irrigation maintenance in irrigated systems and promoting drought-resistant varieties in rainfed areas are crucial steps. Effective water management practices, especially in minor irrigation tank systems such as alternate wetting and drying compared to continuous flooding, are essential to enhance resilience against rainfall variability and stabilize the extent of rice cultivation (Amarasingha et al., 2014, 2017; Chandrasiri et al., 2020). These approaches would contribute to securing the extent of paddy cultivated in Sri Lanka.

CONCLUSION

During the last 43 years (1979 to 2021), rice crop productivity (kg ha^{-1}) varied among districts, seasons and water management methods. On average, national rice crop productivity in major irrigation, minor irrigation and rainfed-systems increased by 28.3, 23.1, and 23.2 kg ha^{-1} yr^{-1} during the *Maha* season and by 37.4, 28.1, and 25.2 kg ha^{-1} yr^{-1} during *Yala* season , respectively. Similarly, the harvested area for major irrigation, minor irrigation and rainfed systems changed by 3,269, 1,464, and -165.6 ha yr^{-1} during the *Maha* season and, by 3,757, 1,226, and -1,264 ha yr^{-1} during the *Yala* season respectively. To ensure enhancement of rice crop productivity and secure the harvested extent in the future, district, season and water management method-based recommendations are required, in addition to common policies applicable at the national level.

REFERENCES

Amarasingha, R.P.R.K., Galagedara, L.W., Marambe, B., Silva, G.L.L.P., Punyawardena, R., Nidumolu, U., Howden, M., &Suriyagoda, L.D.B. (2014). Aligning sowing dates with the onset of rains to improve rice yields and water productivity: modelling rice (*Oryzasativa* L.) yield of the *Maha* season in the dry zone of Sri Lanka. *Tropical Agricultural Research, 25*, 277-286. https://doi.org/10.4038/tar.v25i3.8038

Amarasingha, R.P.R.K., Suriyagoda, L.D.B., Marambe, B., Rathnayake, W.M.U.K., Gaydon, D.S., Galagedara, L.W., Punyawardena, R., Silva, G.L.L.P., Nidumolu, U., & Howden, M. (2017). Improving water productivity in moisture-limited rice-based cropping systems through incorporation of maize and mungbean: a modelling approach. *Agricultural Water Management, 189*, 111-122. https://doi.org/10.1016/j.agwat.2017.05.002

Amarasinghe, U. A., Amarnath, G., Alahacoon, N., Aheeyar, M., Ghosh, S., Chandrasekharan, K., &Nakada, T. (2021). Adaptation to Climate Variability in Sri Lanka: A Case Study of the Huruluwewa Irrigation System in the Dry Zone (Vol. 200). International Water Management Institute, IWMI, Colombo, Sri Lanka. https://doi.org/10.5337/2021.229

Athukorala, W. (2017). Identifying the role of agricultural extension services in improving technical efficiency in the paddy farming sector in Sri Lanka. *Sri Lanka Journal of Economic Research, 5*, 63-77. https://doi.org/10.4038/sljer.v5i1.58

Ayoob, S.M., & Mohamed Fowsar, M.A. (2020). Invasion of paddy combine harvester (PCH) and its socioeconomic impacts: a study based on Ampara District, Sri Lanka. *Academic Journal of Interdisciplinary Studies, 9*, 138-146. https://doi.org/10.36941/ajis-2020-0092

Brow, J., &Weeramunda, J. (1993). Agrarian change in Sri Lanka, *The Journal of Asian Studies, 52*, 1049-1050. https://doi.org/10.2307/2059406

Chandrasiri, C.K., Tsusaka, T.W., Zulfiqar, F., &Datta, A. (2023). Impact of climate change on paddy crop failure under different water regimes in Sri Lanka. *Singapore Journal of Tropical Geography, 44*, 86-413. https://doi.org/10.1111/sjtg.12495

Chandrasiri, S., Galagedara, L., &Mowjood, M. (2020). Impacts of rainfall variability on paddy production: A case from Bayawa minor irrigation tank in Sri Lanka. *Paddy and Water Environment, 18*, 443-454. https://doi.org/10.1007/s10333-020-00793-9

De Silva, C. S., Weatherhead, E. K., Knox, J. W., & Rodriguez-Diaz, J. A. (2007). Predicting the impacts of climate change-A case study of paddy irrigation water requirements in Sri Lanka. *Agricultural Water Management, 93*, 19-29. https://doi.org/10.1016/j.agwat.2007.06.003

De Silva, D. A. M., &Yamao, M. (2010). Urbanization and its impact on paddy land in Sri Lanka: A case study of Colombo and Gampaha districts. *Journal of Land Use Policy, 27*, 123-130. https://doi.org/10.1016/j.landusepol.2009.07.003

DCS (2021). Paddy Statistics. Department of Census and Statistics (2021) Available at: https://www.statistics.gov.lk/Agriculture/StaticalInformation/PaddyStatistics (Accessed: 01.03.2025).

Dhanapala, M. P. (1999). *Bridging the rice yield gap in Sri Lanka*. Food and Agriculture Organization of the United Nations. FAO Home

Jayasiri, M.M.J.G.C.N., Dayawansa, N.D.K., Ingold, K., &Yadav, S. (2024). Are rice systems sustainable in Sri Lanka?-A case of DeduruOya reservoir irrigation scheme. *Environmental Impact Assessment Review, 106*, 107503. https://doi.org/10.1016/j.eiar.2024.107503

Jiang, R., Sanchez-Azofeifa, A., Laakso, K., Xu, Y., Zhou, Z., Luo, X., Huang, J., Chen, X., &Zang, Y. (2021). Cloud cover throughout all the paddy rice fields in Guangdong, China: Impacts on Sentinel 2 MSI and Landsat 8 OLI optical observations. *Remote Sensing, 13*, 2961. https://doi.org/10.3390/rs13152961

Kekulandara, D.S., Sirisena, D.N., Bandaranayake, P.C.G., Samarasinghe, G., Wissuwa, M., &Suriyagoda, L.D.B. (2019). Variation in grain yield, and nitrogen, phosphorus and potassium nutrition of irrigated rice cultivars grown at fertile and low-fertile soils. *Plant and Soil, 434*, 107-123. https://doi.org/10.1007/s11104-018-3663-0

Mahaweli Authority (2018). Annual Report 2018. Mahaweli Authority, Colombo, Sri Lanka. Available at: https://mahaweli.gov.lk/PDF/document/Annual%20Report%202018%20-%20English.pdf (Accessed: [01.03.2025]).

Marikar, F., Wilkin-Wells, J., Smolnik, S., &Sampath, R.K. (1992). Irrigation system performance and its impact on crop productivity in Sri Lanka. *International Journal of Water Resources Development, 8*, 226-234. https://doi.org/10.1080/07900629208722559

Mohamed, A.R., &Naseer, A.A. (2005). Trends in paddy production in Sri Lanka. *Journal of Management, 3*, 26-33.

Pokharel, A. (2024). Beyond collective action problems: perceived fairness and sustained cooperation in farmer managed irrigation systems in Nepal. Oxford University Press. https://doi.org/10.1093/oso/9780197755792.001.0001

Salman, M., Suzuki, H., Ahmad, W., Giusti, S., Ali, A., Rathnayake, W.M.U.K., Sirisena, D.N., et al., (2022). Efficient Agricultural Water Use and Management in Paddy Fields in Sri Lanka - National outlook. Rome: FAO.

Sandika, A. L., &Dushani, S. N. (2009). Growth performance of rice sector: The present scenario in Sri Lanka. *Tropical Agricultural Research and Extension, 12*, 71-76. https://doi.org/10.4038/tare.v12i2.2793

Sirisena, D., &Suriyagoda, L.D.B. (2018). Toward sustainable phosphorus management in Sri Lankan rice and vegetable-based cropping systems: A review. *Agriculture and Natural Resources, 52*, 9-15. https://doi.org/10.1016/j.anres.2018.03.004

Suresh, K., Wilson, C., Khanal, U., Managi, S., & Santhirakumar, S. (2021). How productive are rice farmers in Sri Lanka? The impact of resource accessibility, seed sources and varietal diversification. *Heliyon, 7*, e07398. https://doi.org/10.1016/j.heliyon.2021.e07398

Suriyagoda, L. B. D. (2022). Rice production in nutrient-limited soils: Strategies for improving crop productivity and land sustainability. *Journal of the National Science Foundation of Sri Lanka, 50*, 521-539. https://doi.org/10.4038/jnsfsr.v50i3.10601

Suriyagoda, L., Illangakoon, T., Wijerathna, S., Devasinghe, U. (2022). Degree-day requirement for heading and maturity of three most popular rice varieties in Sri Lanka as influenced by location and season. *Ceylon Journal of Science. 51*, 229-245. https://doi.org/10.4038/cjs.v51i3.8031

Withanachchi, S.S., Köpke, S., Withanachchi, C.R., Pathiranage, R., &Ploeger, A. (2014). Water resource management in dry zonal paddy cultivation in Mahaweli River Basin, Sri Lanka: An analysis of spatial and temporal climate change impacts and traditional knowledge. *Climate, 2*, 329-354. https://doi.org/10.3390/cli2040329

Yoshino, M.M., &Suppiah, R. (1984). Rainfall and paddy production in Sri Lanka. *Journal of Agricultural Meteorology, 40*, 9-20. https://doi.org/10.2480/agrmet.40.9

Supplementary Data

Table S1: Data available (number of years) on rice crop productivity (kg ha^{-1}) under each district, season and major water source used for rice cultivation

District	Major irrigation		Minor irrigation		Rainfed	
	Yala	*Maha*	*Yala*	*Maha*	*Yala*	*Maha*
Ampara	42	43	42	43	23	43
Anuradhapura	43	43	43	43	16	41
Badulla	43	43	43	43	20	43
Batticaloa	41	42	40	41	40	42
Colombo	26	26	42	43	43	43
Galle	9	11	42	35	43	43
Gampaha	43	43	43	43	43	43
Hambantota	43	43	43	43	43	43
Jaffna	4	6	NA	NA	NA	38
Kalutara	43	43	43	43	43	43
Kandy	43	43	43	43	43	43
Kegalle	NA	NA	43	43	43	43
Kilinochchi	26	30	20	23	NA	30
Kurunegala	43	43	43	43	43	43
Mannar	30	36	22	35	2	24
Matale	43	42	43	43	43	43
Matara	43	43	43	43	43	43
Monaragala	42	43	43	43	27	43
Mullaitivu	32	34	32	34	5	33
Nuwara Eliya	42	41	43	43	24	43
Polonnaruwa	43	43	43	43	4	43
Puttalam	42	43	43	43	38	43
Ratnapura	42	43	43	43	43	43
Trincomalee	33	33	30	32	6	33
Vavuniya	31	37	28	38	6	33
Sri Lanka	43	43	43	43	43	43

NA- Data not available

Table S2: Data available (number of years) on rice crop harvested (ha) extent under each district, season and major water source used for rice cultivation

District	Major irrigation		Minor irrigation		Rainfed	
	Yala	*Maha*	*Yala*	Location	*Yala*	*Maha*
Ampara	42	43	42	43	30	43
Anuradhapura	43	43	43	43	22	42
Badulla	43	43	43	43	34	43
Batticaloa	41	42	40	42	40	42
Colombo	26	26	43	43	43	43
Galle	9	11	43	43	43	43
Gampaha	43	43	43	43	43	43
Hambantota	43	43	43	43	43	43
Jaffna	5	6	NA	6	NA	41
Kalutara	41	41	43	43	43	43
Kandy	43	43	43	43	43	43
Kegalle	NA	NA	43	43	43	43
Kilinochchi	30	30	26	29	NA	30
Kurunegala	43	43	43	43	43	43
Mannar	37	41	32	41	5	31
Matale	43	43	43	43	43	43
Matara	43	43	43	43	43	43
Monaragala	43	43	43	43	38	43
Mullaitivu	40	40	40	40	6	39
Nuwara Eliya	43	43	43	43	35	43
Polonnaruwa	43	43	42	43	9	43
Puttalam	43	43	43	43	40	43
Ratnapura	42	43	43	43	43	43
Trincomalee	41	41	37	41	11	41
Vavuniya	39	41	37	41	9	38
Sri Lanka	43	43	43	43	43	43

Note: NA- Data not available

Table S3: Statistical significance of the variables considered when determining rice crop productivity from 1979 to 2021 in Sri Lanka

Source of variability	*df*	F value	Pr > F
Overall model	153	32.49	<.0001
District	27	57.98	<.0001
Season	1	34.44	<.0001
Water mgt.	2	471.88	<.0001
District×Season	27	14.42	<.0001
District×Water mgt.	48	9.3	<.0001
Season×Water mgt.	2	0.71	0.4915
District×Season×Water mgt.	46	1.18	0.1895
Error	5472		
Corrected Total	5625		
R-Square	*Coefficient of Variation*	*Root Mean Square Error*	*Productivity Mean*
0.48	*18.7*	*654.6*	*3496.9*

Table S4: Rice crop productivity (kg ha-1) in different districts under various water management systems in the Maha season during 2017-2021

Major irrigation District	Mean ±Std Error	Minor irrigation District	Mean ± Std Error	Rainfed District	Mean ± Std Error
Hambantota	5771± 475[a]	Hambantota	5058±510[a]	Matale	4369±351[a]
Monaragala	5273±496[ab]	Polonnaruwa	4989±197[ab]	Kegalle	4283±236[a]
Ratnapura	5123±345[abc]	Mullaitivu	4399±320[abc]	Vavuniya	4071±573[ab]
Kurunegala	5027±425[abcd]	Matale	4337±114[abcd]	Nuwara Eliya	4001±64[abc]
Anuradhapura	5001±538[abcde]	Vavuniya	4306±555[abcd]	Kurunegala	3977±194[abc]
Kandy	4788±456[abcdef]	Anuradhapura	4249±448[abcd]	Polonnaruwa	3849±387[abc]
Polonnaruwa	4770±402[abcdef]	Monaragala	4194±198[abcd]	Anuradhapura	3822±385[abc]
Matale	4649±459[abcdefg]	Badulla	4143±198[abcd]	Hambantota	3720±258[abcd]
Ampara	4631±402[abcdefg]	Kegalle	4094±193[abcd]	Puttalam	3684±286[abcd]
Badulla	4499±432[abcdef]	Ratnapura	3796±331[abcd]	Gampaha	3646±188[abcd]
Trincomalee	4421±309[abcdefg]	Puttalam	3787±478[abcd]	Matara	3617±303[abcd]
Mannar	4392±432[abcdefg]	Kurunegala	3758±261[abcd]	Kandy	3556±283[abcd]
Vavuniya	4319±498[bcdefg]	Mannar	3720±372[bcd]	Kilinochchi	3455±408[abcd]
Matara	4259±296[cdefg]	Gampaha	3632±275[bcd]	Mullaitivu	3443±410[abcd]
Nuwara Eliya	4104±226[cdefg]	Nuwara Eliya	3616±238[bcd]	Badulla	3380±392[abcd]
Mullaitivu	3994±537[defg]	Kilinochchi	3576±300[bcd]	Kalutara	3362±204[abcd]
Puttalam	3977±423[defg]	Ampara	3533±316[bcd]	Ampara	3359±402[abcd]
Kilinochchi	3944±305[defg]	Trincomalee	3532±373[bcd]	Galle	3291±256[abcd]
Colombo	3586±98[efg]	Kandy	3519±157[bcd]	Monaragala	3286±304[abcd]
Kalutara	3559±134[fg]	Matara	3428±132[bcd]	Colombo	3278±195[abcd]
Galle	3499±255[fg]	Kalutara	3277±234[cd]	Ratnapura	3231±277[abcd]
Batticaloa	3221±354[g]	Colombo	3206±248[cd]	Trincomalee	3054±332[cd]
Gampaha	3215±460[g]	Galle	3072± 255[d]	Mannar	3030±81[d]

Means followed by the same letter within each column are not significantly different at $p < 0.05$.

Table S5: Rice crop productivity (kg ha^{-1}) in different districts under various water management systems in the *Yala* season from 2017 to 2021

Major irrigation District	Mean ±Std Error	Minor irrigation District	Mean ± Std Error	Rainfed District	Mean ± Std Error
Hambantota	6107±180[a]	Polonnaruwa	4989±197[a]	Ampara	4092±301[a]
Vavuniya	5340±366[ab]	Hambantota	4859±186[a]	Batticaloa	4066±457[ab]
Polonnaruwa	5253±112[abc]	Vavuniya	4749±371[ab]	Trincomalee	3860±729[abc]
Mannar	5219±163[abc]	Trincomalee	4504±244[abc]	Matale	3710±189[abcd]
Trincomalee	5177±100[abc]	Ampara	4441±196[abc]	Puttalam	3703±378[abcd]
Monaragala	5140±372[bc]	Mullaitivu	4399±320[abc]	Badulla	3624±543[abcd]
Badulla	5111±121[bcd]	Batticaloa	4378±222[abc]	Anuradhapura	3615±213[abcd]
Matale	5049±199[cde]	Badulla	4346±239[abcd]	Kurunegala	3499±166[abcd]
Anuradhapura	5033±247[cde]	Matale	4337±114[abcd]	Kandy	3372±227[abcd]
Ampara	4965±194[cde]	Monaragala	4194±198[abcde]	Matara	3366±71[abcd]
Kurunegala	4899±97[cde]	Anuradhapura	4173±306[abcde]	Hambantota	3318±130[abcd]
Ratnapura	4834±509[cde]	Kilinochchi	3862±542[abcdef]	Polonnaruwa	3316±461[abcd]
Kilinochchi	4770±228[cde]	Puttalam	3861±465[bcdef]	Kalutara	3131±98[abcd]
Puttalam	4657±305[cde]	Ratnapura	3841±138[bcdef]	Vavuniya	3124±85[abcd]
Mullaitivu	4612±418[cde]	Kurunegala	3758±261[cdef]	Kegalle	3091±156[abcd]
Nuwara Eliya	4338±604[cdef]	Mannar	3720±372[cdefg]	Ratnapura	3074±92[abcd]
Kandy	4327±559[cdef]	Nuwara Eliya	3616±238[cdefg]	Gampaha	3042±256[bcd]
Batticaloa	4062±264[def]	Matara	3428±132[defg]	Galle	2890±127[cd]
Matara	3993±192[ef]	Colombo	3333±277[efg]	Colombo	2876±156[cd]
Gampaha	3592±172[fg]	Kegalle	3199±182[fg]	Monaragala	2732±156[d]
Kalutara	3024±272[gh]	Kandy	3187±121[fg]	Nuwara Eliya	2700±165[d]
Colombo	2901±179[gh]	Kalutara	2992±84[fg]		
Galle	2583±121[h]	Gampaha	2943±173[fg]		
		Galle	2822±252[g]		

Means followed by the same letter within each column are not significantly different at $p < 0.05$.

Table S6: Statistical significance of the variables considered when determining the harvested extent of rice crop during the period from 1979-2021 in Sri Lanka

Source of variability	*df*	F Value	Pr > F
Overall model	156	555.88	<.0001
District	27	2429.3	<.0001
Season	1	391.43	<.0001
Water mgt.	2	441.97	<.0001
District×Season	27	178.4	<.0001
District×Water mgt.	50	257.62	<.0001
Season×Water mgt.	2	5.8	0.003
District×Season×Water mgt.	47	6.29	<.0001
Error	5866		
Corrected Total	6022		
R-Square	*Coefficient of Variation*	*Root Mean Square Error*	*Productivity Mean*
0.94	*69.2*	8707.5	12578.5

Table S7: Harvested extent of rice crop (ha) in different districts under various water management systems in the Maha season from 2017 to 2021

Major irrigation		Minor irrigation		Rainfed	
District	Mean ±Std Error	District	Mean ±Std Error	District	Mean ±Std Error
Ampara	59937 ± 619^{a}	Anuradhapura	35382 ± 8837^{a}	Batticaloa	33949 ± 4374^{a}
Polonnaruwa	53465 ± 2898^{b}	Kurunegala	26303 ± 6581^{b}	Kurunegala	19791 ± 4483^{b}
Anuradhapura	38850 ± 8964^{c}	Monaragala	9063 ± 1079^{c}	Kilinochchi	12199 ± 1861^{c}
Hambantota	25993 ± 2105^{d}	Vavuniya	8961 ± 1982^{c}	Ampara	11934 ± 1453^{c}
Batticaloa	21894 ± 1291^{d}	Badulla	8885 ± 546^{c}	Monaragala	10327 ± 2354^{cd}
Trincomalee	19460 ± 1092^{de}	Puttalam	7218 ± 1962^{cd}	Kalutara	8728 ± 461^{cde}
Kurunegala	14648 ± 2003^{ef}	Polonnaruwa	6693 ± 399^{cd}	Trincomalee	8643 ± 2009^{cde}
Mannar	14457 ± 844^{ef}	Trincomalee	6449 ± 971^{cd}	Anuradhapura	8083 ± 2645^{cde}
Kilinochchi	11352 ± 419^{fg}	Matale	6226 ± 954^{cd}	Jaffna	7806 ± 1562^{cdef}
Badulla	9503 ± 913^{fgh}	Hambantota	5161 ± 524^{cd}	Galle	7627 ± 526^{cdefg}
Monaragala	7884 ± 590^{fghi}	Ratnapura	5035 ± 273^{cd}	Matara	5670 ± 217^{defgh}
Matale	6627 ± 522^{ghi}	Kandy	4618 ± 279^{cd}	Gampaha	4965 ± 670^{defgh}
Mullaitivu	6191 ± 808^{ghi}	Ampara	3817 ± 582^{cd}	Mullaitivu	4357 ± 1175^{efgh}
Puttalam	5815 ± 1189^{ghi}	Mannar	3663 ± 262^{cd}	Badulla	4204 ± 740^{efgh}
Kandy	4092 ± 139^{ghi}	Batticaloa	3484 ± 227^{cd}	Kegalle	3510 ± 599^{efgh}
Matara	3886 ± 134^{ghi}	Mullaitivu	3359 ± 577^{cd}	Matale	3379 ± 694^{efgh}
Vavuniya	3637 ± 458^{hi}	Nuwara Eliya	3275 ± 508^{cd}	Ratnapura	2328 ± 224^{fgh}
Ratnapura	3164 ± 490^{hi}	Gampaha	2949 ± 316^{cd}	Colombo	2169 ± 175^{gh}
Gampaha	1359 ± 157^{i}	Matara	2949 ± 89^{cd}	Polonnaruwa	1996 ± 400^{h}
Nuwara Eliya	801 ± 99^{i}	Kegalle	1507 ± 209^{cd}	Kandy	1971 ± 245^{h}
Colombo	246 ± 50^{i}	Galle	1406 ± 313^{cd}	Vavuniya	1496 ± 497^{h}
Galle	162 ± 26^{i}	Kalutara	1397 ± 4^{cd}	Puttalam	1249 ± 294^{h}
Kalutara	118 ± 7^{i}	Colombo	650 ± 49^{d}	Hambantota	1150 ± 54^{h}
		Kilinochchi	501 ± 50^{d}	Mannar	72 ± 8^{h}
				Nuwara Eliya	14 ± 4^{h}

Means followed by the same letter within each column are not significantly different at $p < 0.05$.

Table S8: Harvested extent of rice crop (ha) in different districts under various water management systems in the *Yala* season from 2017 to 2021

Major irrigation District	Mean ± Std Error	Minor irrigation District	Mean ± Std Error	Rainfed District	Mean ± Std Error
Polonnaruwa	52154±3979[a]	Kurunegala	18046±4965[a]	Kurunegala	13467±3367[a]
Ampara	50871±3981[a]	Anuradhapura	10467±3259[b]	Kalutara	6272±1125[b]
Hambantota	24172±2574[b]	Monaragala	5541±574[c]	Matara	5351±446[bc]
Anuradhapura	21648±5995[bc]	Polonnaruwa	5058±317[cd]	Galle	5229±1209[bc]
Batticaloa	20319±805[bc]	Puttalam	4696±1560[cde]	Gampaha	3097±776[bcd]
Trincomalee	15849±2127[cd]	Hambantota	4160±298[cdef]	Kegalle	2907±658[d]
Kurunegala	10854±1915[de]	Ratnapura	4140±396[cdef]	Batticaloa	1660±296[d]
Badulla	7210±531[efg]	Batticaloa	3983±342[cdef]	Kandy	1418±329[d]
Monaragala	7014±432[efg]	Badulla	3598±179[cdef]	Ratnapura	1274±336[d]
Kilinochchi	6325±2128[efg]	Trincomalee	2930±580[cdef]	Colombo	1235±344[d]
Puttalam	5069±1222[efg]	Matara	2868±207[cdef]	Hambantota	929±98[d]
Matale	4506±698[efg]	Matale	2646±633[cdef]	Puttalam	630±164[d]
Matara	3742±261[fg]	Kandy	2438±320[cdef]	Monaragala	531±116[d]
Kandy	3427±308[fg]	Ampara	2048±159[cdef]	Matale	422±123[d]
Mullaitivu	3366±1005[fg]	Gampaha	1993±472[cdef]	Ampara	372±73[d]
Ratnapura	3080±471[fg]	Nuwara Eliya	1951±468[cdef]	Trincomalee	263±146[d]
Mannar	1296±381[fg]	Kegalle	1148±237[cdef]	Anuradhapura	261±89[d]
Gampaha	1116±163[fg]	Kalutara	1104±153[cdef]	Badulla	27±83[d]
Vavuniya	895±392[g]	Vavuniya	1037±487[def]	Vavuniya	4±1.1[d]
Nuwara Eliya	468±101[g]	Galle	829±316[def]	Nuwara Eliya	3±1.1[d]
Colombo	163±53[g]	Mullaitivu	763±240[def]	Polonnaruwa	3±1.5[d]
Kalutara	125±16[g]	Colombo	289±80[ef]		
Galle	102±66[g]	Mannar	163±121[f]		
		Kilinochchi	89±12[f]		

Means followed by the same letter within each column are not significantly different at $p< 0.05$.