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Do Farmers' Perceptions Reflect Climate Reality? A Comparative Analysis of Perceived and Observed Rainfall and Temperature Variability among Smallholder Farming Communities of Sri Lanka

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Abstract

This study examined farmers' perceptions regarding climate variability, indigenous knowledge, and rainfall trends over time in the Maho Agrarian Zone in Sri Lanka. Climate change perception, rainfall variability, and shifts in rainy seasons were assessed using a mixed-method approach. A Participatory Index of 0.62 demonstrated that farmers are highly knowledgeable about climate change, especially the variability in rainfall, which is the most important change. The variability in rainfall was found to be fairly constant in the Maho area (CV 14.54%-15.26%) but more variable in the Dry Zone (up to 20.49%). The Maha rainy season was noted to have a constant onset but less likely to fail with a low failure probability of 6.5%, whereas the Yala rainy season was very variable in onset and had a high no-onset probability of 21.1%. Decadal analysis showed reduced growing periods, especially during the Maha period. This study underscores the importance of merging indigenous knowledge with climate science.

Keywords: Climate variability, Rainfall patterns, Indigenous knowledge, Local farmers, Agricultural patterns.

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Introduction

Taking into account the farmers' perceptions and climatic reality have become more effective and efficient way to schedule farming activities particularly in tropical region where the climate change effect significantly (Krishna et al., 2025). In the Sri Lankan context, climate variability has created a high level of risk for farmers engaged in paddy cultivation, as they are highly sensitive to seasonal weather changes (Dananjaya et al., 2023). Farmers in the Dry Zone of Sri Lanka are facing an increasing risk of crop losses as water sources dry up and the growing season is extended due to rising temperatures (Gnanasubramaniam & Hemachandra, 2020; Ratakonda et al., 2024). The unpredictable nature of climate variability is particularly detrimental to the paddy sector, as paddy is sensitive to rainfall variability; thus, climatic variability has disrupted traditional farming practices in the Anuradhapura district, particularly in the Rajanganaya, Nachchaduwa, and Huruluwewa schemes (Dananjaya et al., 2023). Erratic monsoons, increased drought, and severe heat stress threaten food security and elevate economic risks for smallholder farmers in the country's Dry Zone (Dananjaya et al., 2023; Ratnayake et al., 2024).

Anthropogenic activities rather than natural processes mainly cause the current climate change, and its impact has become a global challenge as it continues to affect local economies and ecosystems negatively (Cherinet & Mekonnen, 2019). The agricultural sector is especially vulnerable to climate change, and agricultural producers face multiple serious risks from rising temperatures, unpredictable rainfall, and rising carbon dioxide levels (Ratakonda et al., 2024). For farmers who rely on natural resources (e.g., rain-fed agriculture), particularly in the Global South, climate change is a major threat to their livelihoods. Such issues have emerged in terms of prolonged drought, higher weed problems, and higher risks of crop disease (Ratakonda et al., 2024; Singh et al., 2017).

While climate change may have been more of a global issue before, it is now an actual threat that has affected economies and ecologies at the local level (Cherinet & Mekonnen, 2019). For agricultural communities, such effects are mainly seen in the instability of weather patterns, which will directly affect the agricultural output for each season (Ratakonda et al., 2024). In the Global South, where rain-fed agriculture remains the backbone of many rural communities, farmers' ability to perceive and respond to these changes accurately is essential for their survival rather than for efficiency (Atinkut & Mebrat, 2016; Yeleliere et al., 2023). Some additional factors may influence the level of vulnerability of communities to changing natural resources. Singh et al. (2017) reported that farmers in Arunachal Pradesh, India, noted fewer rainy days and shorter winters. In their study, Singh et al. (2017) highlighted the differing impacts of climatic variables, such as rainfall, on men and women due to their distinct social circumstances. In Arunachal Pradesh, women are facing issues with water, food processing, and the collection of forest resources due to climate change, while men are having more issues with farming, production, and the search for alternative hunting grounds.

Research indicates that change arises when local farmers recognize future events or actions. Increased awareness of climatic variability in the Dry Zone of Sri Lanka has increased the number of farmers using shorter-duration seed varieties and growing a wider range of farm crops (Gnanasubramaniam & Hemachandra, 2020). However, existing perceptions of the reasons for these changes tend to be locally oriented, as seen in the Mahakanumulla Village Tank Cascade System, where farmers believe that climatic change has occurred both globally as well as through local activity, removing trees to clear land for farming, leading to increased production costs as well as degrading land (Ratnayake et al., 2024).

While many scientific models illustrate climate change from a top-down perspective, the practical knowledge and lived experiences of farmers, as well as indigenous insights, are often overlooked when assessing the severity of the impacts they face (Nidumolu et al., 2015). To provide a comprehensive overview of these trends, "top-down" meteorological data has been developed, representing a wide range of information from a broad perspective. However, the data does not reflect the lived experiences of farmers who confront these changing conditions daily at the local level (Nidumolu et al., 2015).

Current literature offers a 'bottom-up' approach to validating historical climate data against farmers' experiences; however, research on 'top-down' assessments often excludes practical wisdom (Nidumolu et al., 2015). Attempts to close these gaps have been made in many recent studies worldwide. Regional Concordance was evident in studies conducted in Kenya, Ghana, and Uganda, all of which indicate that farmers are well aware of long-term patterns of climatic variability. The majority of farmers observed increased frequency of drought and heat, a trend supported by 30 years of weather data (Atube et al., 2022; Rao et al., 2011; Yeleliere et al., 2023). Further, researchers in South India used 'crop calendars' to identify the exact intersection of climate and growing-season risks, effectively merging hard data with real-world experience (Nidumolu et al., 2015). Methodological rigor is evident in many recent studies that have employed the Mann-Kendall test and Sen's slope across varying degrees of climate variability in Ethiopia and Uganda, and have compared these with qualitative survey data (Dechassa et al., 2020; Esayas et al., 2019). Binary Logistic Regression and Multinomial Logit Models are used to analyse the factors that may influence a farmer's decision to adopt soil, water, and nutrient management practices (Atinkut & Mebrat, 2016; Mairura et al., 2021). These factors include socioeconomic conditions, institutions, and the environment.

There is substantial evidence of an ongoing 'adaptation gap', despite significant climate awareness and a large body of knowledge on climate risks. Yet, these have not been translated into action. For example, farmers in many areas possess a similar level of knowledge regarding changing rainfall patterns or rising temperatures. In sampled populations from Somaliland, up to 86.5% reported being aware of changes in both precipitation and temperature; however, only a small percentage have adopted advanced adaptation practices (Omer et al., 2025). Generally, farmers do not resort to adjustment techniques that require high investment or sophisticated technology; rather, they utilise cheaper means, including changes in the timing of cultivation and harvest (Ratakonda et al., 2024; Traoré et al., 2015). It becomes evident from the results that, even in the face of fluctuating weather conditions, other socio-economic constraints hinder the ability of farmers to adapt to climate change hazards, thus constituting an important obstacle to translating awareness into sustainable agriculture practices (Atinkut & Mebrat, 2016; Mairura et al., 2021).

There are different ways of acquiring knowledge. One of the most well-known among these ways in epistemology is the empirical method, which is considered an essential way of knowing about the environment. It is based on empiricism, as proposed by philosophers like John Locke and David Hume, who argue that knowledge is gained from observation, experience, and engagement with the material world (Hume, 1748/2007). The empirical method serves a critical purpose in fields such as geography and climatology, where it helps create knowledge that can be verified through observation and experimentation.

Understanding the phenomenon of climate change on a local level demands more than just relying on scientific measures, as one needs to take into account people's perception of changes in their immediate environment. The perceptions of farmers on climate variability tend to be based on the experiential knowledge acquired through watching patterns in weather, seasons, and harvest. Situated knowledge theory, presented by Haraway (1988) states that all forms of knowledge are situationally specific and affected by the social and natural environment of the person observing it.

The farmers of Sri Lanka tend to be familiar with their environment in terms of practical observations rather than scientific knowledge and understanding (Gnanasubramaniam & Hemachandra, 2020). The observed phenomena include changes in rainfall, temperature variations, droughts, and growing season changes. While these observations do not necessarily coincide with the official climatological data, they offer a useful source of information regarding the effects of climate change at a local level. It is vital to combine the practical knowledge and observations of farmers with climatological information in order to obtain a full picture of climate change.

Smallholder farmers possess extensive indigenous knowledge developed through long-term interaction with and adaptation to their surrounding environment. The knowledge is important because it affects the perception that they hold with regard to climate change, since their understanding of climate variability is based on experience. As a result, farmers respond to climate-related changes in ways that reflect their accumulated experiential insights and environmental realities.

Farmers' perceptions of climate change can be understood as being shaped by indigenous and local knowledge systems, as well as situated knowledge (Haraway, 1988), which collectively emerge from experiential learning and continuous interaction with the local environment. This study, therefore, examines the extent to which the situated knowledge and perceptions of climate change among smallholder farmers, correspond with scientifically observed climatic trends in the study area. Research indicates that farmers around the world and in Sri Lanka understand that weather conditions are changing, they are becoming more variable, and temperatures are increasing, but often do not have the means or functionality to make their infrastructure more resilient to those climate changes. Socio-economic stability and access to supportive institutions are usually the means by which farmers bridge the gap between awareness of a risk and a solution.

Methodology/ Materials and Methods

A mixed-method design was adopted in this study. Accordingly, the primary data collection process was designed and developed by determining sampling procedure, participant selection criteria, sample size, and data collection techniques such as surveys and interviews, to ensure the relevance and reliability of the findings. The secondary data were collected from several government and non-government organisations directly involved with the agriculture sector of the country. Data validity and triangulation were ensured through multiple validation procedures and triangulation of data obtained from various sources in order to enhance the validity and reliability of the findings. In addition, different analytical Techniques and Methods were employed to analyse data using a range of various tools and methods.

The data were collected at different spatial levels. Primary data were collected from the Maho Agrarian Zone, whereas the secondary data, specifically rainfall and temperature data, were collected from a global gridded dataset that covers the entire country with the same spatial resolution. The data points, including 5 gauging stations in the study area and 10 gauging stations in the entire Dry Zone, have been downloaded. The study area was considered the experiment group, whereas the Dry Zone was considered the control group.

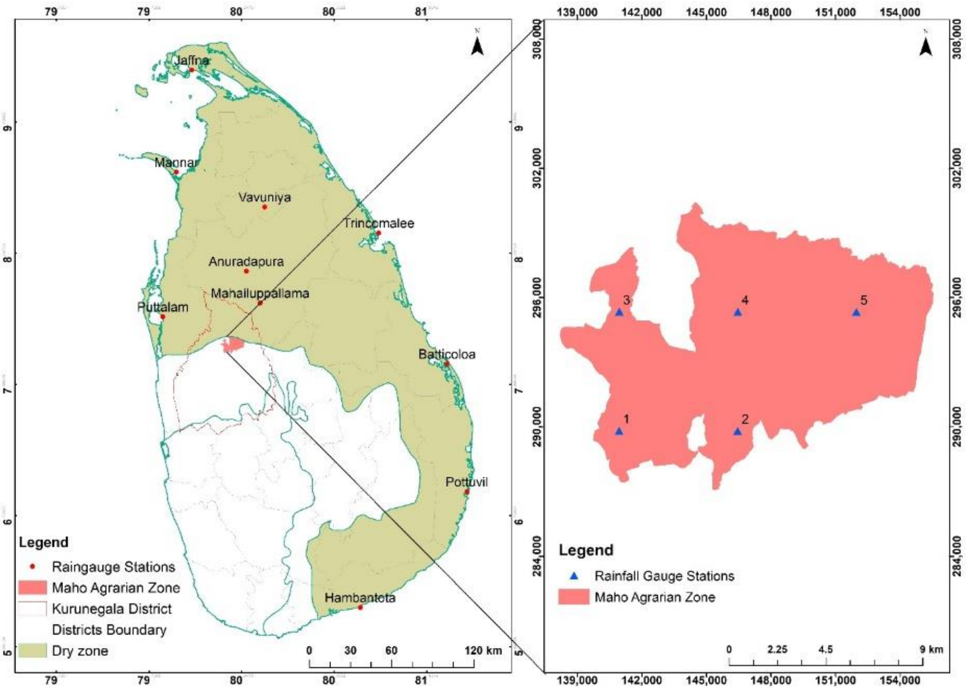
The main purpose of the research is to explore the perceptions of farmers on climate variability and change, their reliability in accordance with the climate data, and adaptation measures practiced by the farming communities of Sri Lanka's dry zone. The sub-objectives of this research include: (1) Exploring the perception of small holder farmers towards climate variability and change within the study area in Sri Lanka, (2) Understanding the time series of rainfall variation in the study area and the Dry Zone of Sri Lanka, (3) Assessing the variation in rainy season onset and withdrawal in the study area and the dry zone of Sri Lanka.

Study Area

The Maho Agrarian Zone, the study area, is situated in the Intermediate Climatic Zone of Sri Lanka. The Intermediate Climatic Zone is a transition zone between the Dry Zone and the Wet Zone of Sri Lanka, both in terms of climate and ecology. Therefore, the area receives medium rainfall with considerable variation, which makes it ideal for agricultural diversification. Geographically, the Maho area is situated in the Northwestern Province of Sri Lanka, and it belongs to the Kurunegala District (Figure 1). Topographically, the Maho area features undulating topography with lowland and upland areas, which have implications for drainage and land usage.

Figure 1

Location Map: The Maho Agrarian Zone



Climate-wise, this zone experiences an average annual rainfall of about 1,7502,500mm that is greatly affected by both southwest and northeast monsoons. Its rainfall pattern is rather bimodal, with its highest peaks falling within two agricultural periods: the Maha period from October to January and the Yala period from April to August. Yet, unpredictable rainfall patterns constitute a threat to farmers in the region due to global warming trends. High temperatures of about 25°C to 32°C characterise this region.

The most common occupation among people living in the Maho Agrarian Zone is farming. The main farm practice in the area involves cultivating paddy using both rain-fed and irrigated village tanks, which are an important element of the farming culture in the dry zones of Sri Lanka. From a socio-economic point of view, the majority of people involved in farming in the Maho agrarian zone are small-scale farmers who depend on their indigenous skills and knowledge for farming practices.

Data Collection

Primary Data Collection and Sampling Procedure

For studying perceptions and adaptation strategies of farmers, information was gathered using a structured questionnaire from three Grama Niladhari Divisions (GNDs) located in the

Maho Agrarian Zone in the Kurunegala district. Information gathering mainly concentrated on smallholder farmers.

Stratified random sampling technique was utilised, and data were obtained from 152 farmer households using questionnaires conducted by enumerators who underwent training organised by the researchers. The 152 farmer households were allocated into three GN divisions according to the total number of households in each GN division, as provided in Table 1. Three broad sections were designed for the questionnaire, including information regarding household background, farmers' perception towards climate change, and adaptation strategies. Field data were collected using KoboToolbox, and the database has been exported into Excel. The tabulation of data was performed using Microsoft Excel software. Some of the important features of the tabulated data are illustrated in Table 2, and the analysis tools were chosen mainly depending on the data features.

Table 1

Selected GN Divisions and Sample Size

Province	District	DS Division	No, and the name of the GN Division	Total Households in 2024*	Sample Size
North Western Province	Kurunegala	Mahawa	Uduweriya (161)	746	40
			Udagama (162)	947	50
			Keththaapahuwa (163)	1,176	62
			Total	2,869	152

Source: *Department of Census and Statistics, 2024

Table 2

Data Themes and Their Characteristics

Data theme	What it measures	Data Type
Climate perception	What farmers observe	Multiple choice frequency/ordinal
Climate impacts	Experienced impacts	Multiple choice frequency/ordinal
Adaptation practices	Responses adopted	Multiple choice frequency/ordinal
Adaptation constraints	Barriers faced	Multiple choice frequency/ordinal

Secondary Data Sources and Data Collection Procedure

The secondary data were obtained from different sources, such as the Ministry of Agriculture, Agrarian Services Department, and the technically-oriented approach was applied to obtain gridded precipitation and temperature data with higher spatial resolutions as compared to the conventional rainfall and temperature data from stations. The main precipitation data source for this research is the satellite-derived gridded precipitation data from CHIRPS (Climate Hazards Group InfraRed Precipitation with Station data). CHIRPS offers high-resolution precipitation data globally between 1981 to date, at temporal resolutions of daily, pentadal, and monthly with spatial resolution of 0.05° (5km). The validation of CHIRPS data indicates high correlation with gauge-based observations (often above 0.7 - 0.9) (Funk et al., 2015). Google Earth Engine (GEE) was used to access the datasets and extract daily CHIRPS precipitation data values for the study area, as well as the main rainfall gaging stations covering the entire dry zone of the country (dry zone gaging station locations are given in Figure 01) between 1981 and 2024 in CSV format, following the recommended and standardised methods (Abatzoglou , 2013). The CHIRPS data source was selected for its proven reliability in data-scarce regions and its suitability for climate variability and extreme rainfall analysis.

Secondary data were used to calculate the onset and withdrawal of rainy seasons using gridded datasets covering the entire Dry Zone of the country. The data extraction points, five gauging stations in the study area, and ten gauging stations in both the Dry Zone and their relative locations are included. The study area was designed as an experimental group, and the Dry Zone was considered the control group in this study, which was considered the baseline data for comparison

Data Validation and Triangulation

The triangulation of farmers' perceptions was conducted through a three-stage approach: (1) frequency analysis of survey responses, (2) comparison with existing literature, and (3) validation against the onset and withdrawal of rainy seasons and for the Dry Zone of the country.

Analytical Tools and Techniques

The data analysis comprises three sections. 1) data pre-processing, 2) computation of the Perception Index (PI), 3) analysis of the onset and withdrawal of rainy seasons.

Data Pre-processing: Data preprocessing plays a critical role in ensuring that the quality, accuracy, and integrity of the data set are achieved before carrying out any analysis. The two data sets, the data collected from the farmers' perceptions and the CHIRPS data set, were thoroughly checked for any possible errors.

Computation of the Perception Index (PI): The perception index (PI) is used to determine the farmers' perception of climate variability and change, which is rated on a five-point Likert scale (1 for strongly disagree to 5 for strong agreement), because this method has been successfully applied to other perception-based agricultural research projects (Ceesay et al., 2025). Basic computation is provided in Table 5, while the formula is presented in Equation 1.

$$PI = \frac{\sum(F \times W)}{N \times 5} \quad \text{..........................Equation I}$$

Where;

F = Frequency (number of respondents who selected a certain response)
W = Weight (value assigned, typically ranging from 1 to 5 on the Likert Scale)
N = Number of Respondents

Values for Perception Index (PI) usually vary from 0 to 1, where higher values represent stronger perceptions. Researchers classified PI values (Ceesay et al., 2025) into three categories in interpretation: Low perception (0.00 to 0.33), Moderate Perception (0.34 to 0.66), and High Perception (0.67 to 1,00).

Analysis of the Onset and Withdrawal of Rainy Seasons: The analysis of the onset and withdrawal of rainy seasons was conducted using the CHIRPS daily rainfall data at two spatial scales. 1) the study area, and 2) the entire dry zone of Sri Lanka (locations are shown in Figure 01). The technical definition of rainfall onset was adopted from the literature, following the criteria proposed by Punyawardena (2002). R scripts were developed to identify the onset of rainfall seasons, based on a threshold criterion of more than 30mm of rainfall sustained over three consecutive weeks. Withdrawal was determined when three consecutive weeks recorded rainfall below 30mm per week. The cessation week was recorded as the week immediately preceding the onset of this three-week dry spell, marking the practical end of the growing season (Punyawardena, 2002). Similarly, the duration of rainy seasons was identified. Appropriate, graphical presentations such as charts and figures are used to effectively present the results.

Appropriate statistical techniques were employed to assess the significance of the results as given in Table 3.

Table 3

Statistical Method Employed in This Study

Assessment	Statistical Method	Description
Assessment of Farmers' Perception	Perception Index (PI)	Farmers' perceptions were quantified using a Likert scale, and responses were aggregated to construct a Perception Index (PI) to measure the overall perception of climate change.
Assessment of the Temporal Dynamics and Trends of Rainfall	Linear Regression and the Mann–Kendall (MK) Trend test	Linear regression was used to identify the direction and magnitude of rainfall trends, while the Mann–Kendall test was applied to detect the

		statistical significance of monotonic trends in rainfall data over time.
Assessment of similarity between the onset week distribution	Chi-square test of homogeneity	The chi-square test of homogeneity was used to evaluate whether the distribution of rainfall onset weeks is statistically similar across different time periods or groups.

Data Analysis & Results

Farmers' Observations of Climate Change

Farmers’ observations on climate change have been mostly divided in the literature into four main areas: erratic precipitation patterns (late onset, early termination), temperature increase (hotter days and nights), occurrence of extreme events, and seasonality. The observations made by farmers regarding climate change parameters as obtained from the field survey have been presented in Table 4 below.

Table 4

Farmers' Observations of Climate Change

Observed Climatic Changes	Frequency	Rank	Weights	Weighted Scores
Seasonal Rainfall Shifts	132	1	5	660
Unpredictable Rainfall	80	2	4	320
Increase in temperature	77	3	3	231
Increase in rainfall	68	4	2	136
More droughts	66	5	1	66
Extreme weather events	54	6	1	54
Total	477			1467

Source: Field Survey, 2025 November

The maximum number of responses received on seasonal rainfall variation, i.e., 132 responses (27.67%). Hence, variations in rainfall patterns are considered the most observable climatic phenomenon from the perspective of the respondents. Moreover, unpredictable rainfall (80 responses or 16.77%) and higher temperatures (77 responses or 16.14%) were also mentioned by farmers. Other phenomena, such as higher rainfall, droughts, and extreme weather events, were also mentioned by the farmers. Overall, the frequency of responses show~~s~~ that farmers tend to mention mostly climate change factors associated with rainfall and temperature variations rather than those based on events. As evident from Table 04, the major changes reported by farmers are in the seasonality of rainfall without any regularity in magnitude and direction, with rainy seasons being early in some years and late in others. It was observed that irregularities in rainfall seasons affected the calendar of crop growth and associated agricultural practices, leading to agricultural production problems.

The Perception Index (PI) was used to measure and evaluate the significance of perceptions regarding climate change observed by farmers in the area using weighted scores on Likert scales in their responses, since the approach has been successfully utilised in such agricultural perception studies before (Ceesay et al., 2025). Calculation of PI can be illustrated using Table 4 and Equation 1 below. The Perception Index was calculated using the equation I provided in the methodology section

- $\sum(F \times W) = 1467,\ N = 477,\ W_{max} = 5$

$$\text{PI} = \frac{1467}{477 \times 5} = \frac{1467}{2385} = \mathbf{0.62}$$

The Perception Index (PI) usually falls between 0 and 1, where a larger number means greater perception. Categorization of PI values was done by researchers (Ceesay et al., 2025) into three groups, which were: Low Perception (0.00-0.33), Moderate Perception (0.34-0.66), and High Perception (0.67-1.00) (Ceesay et al., 2025). This shows that the Perception Index (PI) of 0.62 obtained means that the farmers have a high perception of climate change witnessed within the research area.

Temporal Dynamics and Trends of Rainfall in the Study Area

Variability and trends in rainfall represent key factors in studying climate processes in particular, for those areas where agriculture is dominated by small farms. The following section evaluates the trends in annual rainfall in the study area using linear regression and the Mann-Kendall (MK) trend test. Trends show an overall increase in rainfall in all stations with slopes varying from 6.08 mm/yr to 9.33 mm/yr (Table 5).

Table 5

Rainfall Variability and Long-term Trends

Station	Slope	Intercept	R-squared	*p*-value	Significance	MK-Trend	MK-P-Value
SD1	7.9101	-14452.43	0.1168	0.0599	Not Significant	increasing	0.0615
SD2	8.8668	-16362.70	0.1431	0.0359	Significant	increasing	0.0351
SD3	8.0368	-14695.01	0.1089	0.0698	Not Significant	increasing	0.0771
SD4	9.3304	-17299.46	0.1599	0.0258	Significant	increasing	0.0249
SD5	6.0809	-10859.66	0.0776	0.1291	Not Significant	increasing	0.1261
Study Area	7.2357	-13045.30	0.0920	0.0971	Not Significant	increasing	0.0771

However, it should be pointed out that the statistical significance of the trends varies from one station to another. Two stations (SD2 and SD4) have shown an increasing trend that is statistically significant at the 95% confidence interval. On the whole, the study area average shows an upward tendency, although it does not have statistical significance. Moreover, the fairly low values of the coefficient of determination (R^2) imply that a fairly significant part of the rainfall variation occurs due to other factors, except for long-term time trends. Overall, there are noticeable variations in rainfall, indicating high interannual variations and the complexity of the climate of the area.

Similar changes and trends in rainfall in relation to time can also be observed in the Dry Zone. From the total number of 10 observatories, it can be seen that rainfall tends to increase significantly ($p < 0.05$) in three stations, while the rest of the stations indicate a statistically insignificant positive trend in relation to rainfall increase. In general, it may be said that there is a tendency towards rainfall increase; however, the lack of statistical significance implies that the results obtained cannot be regarded as statistically significant. It should be emphasised that observatories in Mannar, Vavuniya, and Trincomalee show statistically significant rainfall trends.

Rainfall Variability in the Study Area and the Dry Zone

The rainfall variability both in the study area and the Dry Zone has been determined via the use of descriptive statistics such as mean, standard deviation (SD), and the coefficient of variation (CV). To illustrate this, deviation graphs have been used (Figure 2). The average annual rainfall value is recorded as 1439 mm for the study area, with SD 210.4 mm and a CV of 14.62%. This indicates that there is some inter-annual variability in the rainfall amounts in the study area. The coefficient of variation is somewhat similar at the station level; this ranges between 14.54% (ID5) and 15.26% (ID2). The amount of rainfall varies between 868.8 mm (ID3) and 1005.8 mm (ID5); although somewhat less than in the Dry Zone, these show significant annual variations (Table 6).

Table 6

Descriptive Statistics of Rainfall Variability of the Study Area and the Dry Zone of the Country

Study Area				Dry Zone			
Station	Mean	SD	CV	**Station**	Mean	SD	CV
SD1	1450.8	213.1	14.69	**Jaffna**	1287	259.3	20.15
SD2	1450.9	221.4	15.26	**Mannar**	1098.5	215	19.57
SD3	1445.3	212.1	14.68	**Vavuniya**	1494	247.1	16.54
SD4	1356.9	198.4	14.62	**Trincomalee**	1696.6	307.7	18.13
SD5	1491.2	216.9	14.54	**Anuradapura**	1288.1	239.3	18.58
Study area	1439	210.4	14.62	**Puttalam**	1231.1	199.1	16.17
				Mahailuppallama	1424.1	246.7	17.33

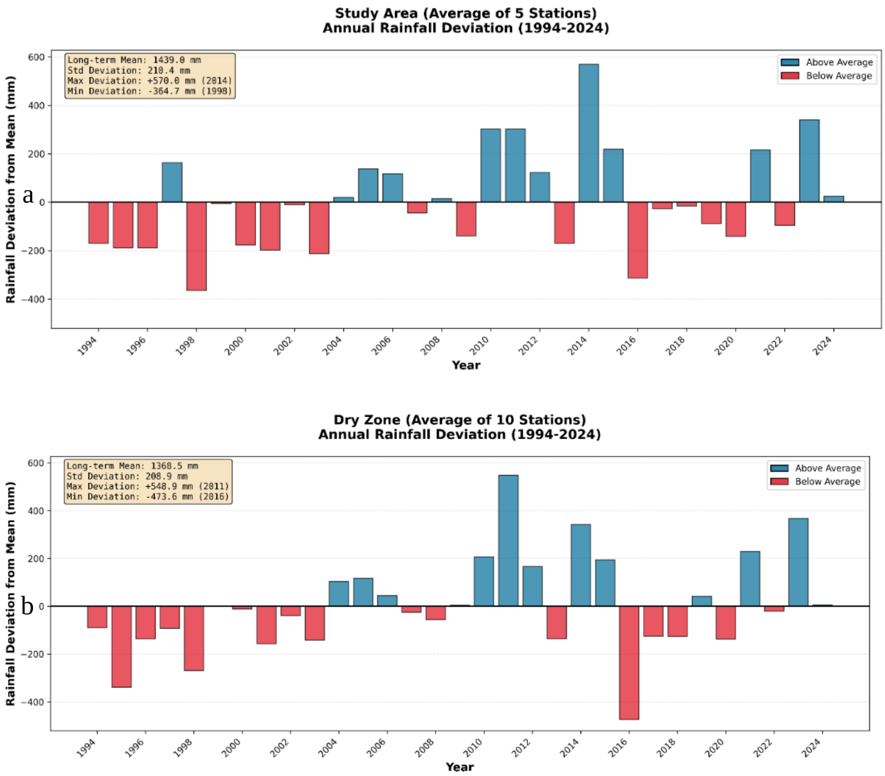
Batticoloa	1696.6	337.9	19.92
Pottuvil	1357.8	278.2	20.49
Hambantota	1111.6	200	17.99
Dry Zone	1368.5	208.9	15.26

On the other hand, the variability in the Dry Zone has higher spatial variability, where the coefficients of variation are higher, with ranges of 15.26% to 20.49%, in addition to high standard deviations. This is because rainfall variability is more pronounced regionally than locally within the study area. Deviation plots indicate that rainfall variability in both regions is characterised by deviations from the average, indicating the presence of frequent wet and dry years.

Additionally, comparing both regions indicates that there is a noticeable disparity between both regions, whereby rainfall variability in the study area is less compared to that of the Dry Zone, which means that the climatic conditions in the Dry Zone are highly variable. In other words, rainfall variability confirms farmers' perceptions about changing rainfall patterns that have been mainly influenced by rainfall variability rather than trends.

Figure 2

Deviation Diagrams of Annual Rainfall; a. Study Area, b. Dry Zone



Overall, it is evident that there exists significant spatial variability between the two regions, where the study site is characterised by relatively stable rainfall, while the Dry Zone displays relatively unstable rainfall variability patterns.

Seasonal Rainfall Shift and Unpredictable Rainfall

Farmers participating in this research have unanimously indicated a considerable change in the timing of precipitation occurrence and cessation. In particular, the rainy season may commence earlier, while on other occasions it can be delayed for several weeks, disrupting agricultural processes significantly. Thus, the use of a multi-level method made it possible to evaluate whether changes identified by farmers are a result of their experience or reflect an objective climatic change.

From analysing the rainfall data for 30 years, it becomes evident that the timing of the Maha season onset varies significantly, falling within the timeframe of weeks 38 to 44, which implies that there is a significant amount of interannual variation. The early onset of Maha (weeks 38) is exceptionally rare, with an incredibly low frequency. The probability of Maha onset increases gradually from the 39th week onward, reaching its maximum value in week 40 (probability = 0.1935), which is followed immediately by the next two weeks, 41 and 42. These three weeks are the main period of onset; however, the continued high probability of onset in the following weeks (42–44) indicates that the onset timing may vary significantly. Therefore, the possibility of late onset of the season is quite common, which is supported by a higher probability in weeks 42 and 44. The existence of "no onset" weeks (6.5%) should be noted as well, since it increases the risk of the season failure. Overall, the results confirm the significant variation of the Maha onset timing and support farmers' perceptions regarding unpredictable rains (Table 7).

On the other hand, the Yala season is considerably less stable and more unpredictable. Its onset takes place during the period between the 9th and 19th weeks of the calendar year. It is characterised by a wide and scattered time interval. Early onset occurrences during weeks 9, 10, and 12 occur rarely. An increase in the frequency of onsets is noticeable starting at the 13th week, but unlike Maha, no single peak can be found. Instead, several peaks are found for the 13th (0.159), 14th (0.152), and 17th (0.177) weeks. As such, the two-mode distribution is indicative of the lack of a clear onset time. In addition to that, the ratio of the number of ‘no onset’ years is notably larger (21.1%). It is an indication of high unpredictability and unreliability. Overall, the described features prove the inherent instability and unpredictable nature of the Yala season (Table 08). Thus, farmers' beliefs about the unreliability of the Yala season can be confirmed by this analysis.

Taking climate change into consideration, such patterns signify growing temporal unpredictability of the seasonal rainfall patterns. Changes in the onset window of rainfall, development of two or fewer distinct peaks, and occurrences of delayed or failed onsets, especially in the Yala season, are consistent with available evidence on changes in monsoon-related mechanisms. Such changes may be explained by changes in the patterns of atmospheric circulation, growing variability in sea surface temperature, and climate extremes. Greater variability of the Yala season onset signifies its greater vulnerability to climate influences, which might be explained by the fact that the Yala season depends on rainfall, while Maha is influenced by stronger and more reliable monsoonal mechanisms.

In terms of agriculture, these changes are important when it comes to crop calendars, in particular, paddy production and chena farming in the dry zone. Stable Maha onset usually provides the necessary time to prepare the land, establish nurseries, and transplant paddy. However, even during Maha, variation in the timing of the onset may result in poor synchronisation between expected and actual planting.

On the other hand, the high level of variations and uncertainties of the Yala season creates difficulties for agricultural activities. Since there is no fixed onset period, coupled with the increased chances of having 'no onset', the danger of losing crops increases, especially when rain-fed paddy and chena cultivation rely much on the rainfall within the season. A late onset of the season will limit soil moisture content and reduce the period available for crops to mature. The Yala 'no onset' phenomenon was a regular occurrence starting from 1994, approximately at four-year intervals. The Yala 'no onset' years are 1994, 1998, 2000, 2006, 2012, 2013, 2019, 2020. As seen above, the Maha 'no onset' events are less frequent compared to Yala (2013, 2016).

These developments have compelled the farmers to adapt their behaviours accordingly. They do so by delaying their planting time, shrinking their cultivated areas, switching to either short-duration or drought-resistant crops, and, in some instances, not cultivating the Yala season at all.

In general, the results clearly indicate that climate-driven changes in rainfall are changing the seasons and upsetting the agricultural schedule as well. The remarkable consistency between observed data and farmers' perception validates their understanding and emphasises the necessity to adopt a more adaptable approach towards agriculture in the form of crop scheduling, climate-proof crops, and seasonal forecasts.

Table 7

Frequencies and Probability of a Week Being the Onset of the Maha Season in the Study Area and the Dry Zone of the Country

Study Area - Maha Season			**Dry Zone – Maha Season**		
Onset Week	Frequency	Probability	Onset Week	Frequency	Probability
38	1	0.0323	**38**	2	0.065
39	5	0.1613	**39**	4	0.129
40	6	0.1935	**40**	5	0.161
41	5	0.1613	**41**	6	0.194

42	5	0.1613	**42**	4	0.129
43	3	0.0968	**43**	2	0.065
44	4	0.129	**44**	4	0.129
No onset	2	0.0645	**45**	0	0
Total	31	1.000	**46**	2	0.065
			47	1	0.032
			No Onset	1	0.032
			Total	31	1.000

The above table provides the onset occurrences by the week of the calendar year. During the last 30-year period, the onset of the Maha season in the study area occurred between the 38th and 44th weeks of the year, indicating considerable interannual variability in the timing of seasonal onset. The frequencies 38th week is relatively low, while the highest frequency of onset occurs in the 40th week. However, frequencies remain consistently high from the 39th to the 44th weeks. Similar to the study area, the onset of the Maha season in the Dry zone also begins in the 38th week and continues until the 47th week, indicating a longer duration compared to the study area (Table 8).

Table 8

Frequencies and Probability of a Week Being the Onset of the Yala Season in the Study Area and the Dry Zone of the Country

Study Area – Yala Season			**Dry zone – Yala Session**		
Onset Week	Frequency	Probability	Onset Week	Frequency	Probability
9	1	0.032	**9**	1	0.03
10	1	0.032	**10**	0	0.00
11	0	0.000	**11**	0	0.00
12	1	0.032	**12**	0	0.00
13	5	0.161	**13**	0	0.00
14	5	0.161	**14**	1	0.03
15	2	0.065	**15**	3	0.10
16	2	0.065	**16**	0	0.00
17	5	0.161	**17**	3	0.10
18	0	0.000	**18**	1	0.03
19	1	0.032	**19**	1	0.03
No onset	8	0.259	**No onset**	21	0.68
Total	31	1.000	**Total**	31	1.00

A comparison between the dry zone–level results and those derived from the study area shows a strong overall agreement, indicating that the temporal behaviour of rainfall in the study area closely follows broader regional climatic patterns.

Therefore, while the overall similarity between the dry zone and the study area results confirms regional climatic coherence, the observed week-level variations, strongly aligned with farmers’ perceptions, highlight the urgent need for localised, climate-resilient adaptation strategies and flexible crop calendar adjustments. However, significant variations in the frequency distribution at the week-level clearly illustrate changes in the periods of rainfall initiation and termination. Such changes seem to be associated with the influence of microclimate on rainfall in addition to spatial variation within the dry zone area. However, the results obtained above prove to be in strong accordance with the views of local farmers, who report that the onset and withdrawal periods of rainfall have become increasingly unpredictable lately, with some seasons beginning either too early or too late. Consequently, such changes can be viewed as additional proof of the high accuracy and reliability of the farmers' claims in terms of climatic phenomena. As far as climate change is concerned, the findings presented above suggest that rainfall periods have become increasingly unstable lately. The consequences of the phenomenon will be particularly disastrous for agriculture in the case of Yala and Maha farming. For instance, the Maha season may begin late, causing complications in the land preparation process. On the other hand, premature termination may decrease the effective growing period. To examine the similarity between the onset week distribution, a Chi-square test of homogeneity was established for both the Maha and Yala seasons, corresponding to the study area and the Dry zone. The test hypotheses were:

Maha Season:

H_0 – There is no significant difference in the Maha onset distribution between the study area and the Dry Zone

H_1 - There is a significant difference in the Maha onset distribution between the study area and the Dry Zone

Yala Season:

H_0 – There is no significant difference in the Yala onset distribution between the study area and the Dry Zone

H_1 - There is a significant difference in the Yala onset distribution between the study area and the Dry Zone

The Chi-square test results revealed contrasting seasonal behavior between the study area and the Dry Zone. There is no notable difference in the distribution of onset weeks during the Maha season ($\chi^2 = 2.82$, df = 10, $p > 0.05$), thus showing similarity in the distribution of onset in both areas.

However, in the case of the Yala season, there is a notable difference in the distribution ($\chi^2 = 20.53$, df = 11, $p < 0.05$), thus showing a considerable difference between the distribution of onset in the study area and that of the Dry Zone.

Table 9

Chi-Square Test Results Summary

Season	Comparison	χ^2 Value	df	*p*-value	Decision ($\alpha = 0.05$)	Interpretation
Maha	Study Area vs Dry Zone	2.82	10	> 0.05	Accept H_0	Distributions are similar
Yala	Study Area vs Dry Zone	20.53	11	< 0.05	Reject H_0	Distributions are significantly different

Seasonal variation observed indicates that, whereas the onset of the rains for Maha follows a similar regional trend, the Yala season onset is more variable, possibly due to some local climatic influence and higher inter-monsoon variability in rainfall.

Table 10

Onset and the Withdrawals (Duration) of Yala Maha Rainy Seasons

Maha Season			**Yala Season**		
No.of Weeks	Frequency	Probability	No.of Weeks	Frequency	Probability
6	1	0.0357	3	3	0.1304
7	1	0.0357	4	6	0.2609
8	2	0.0714	5	6	0.2609
9	2	0.0714	6	1	0.0435
10	2	0.0714	7	2	0.0870
11	5	0.1786	8	1	0.0435
12	5	0.1786	9	3	0.1304
13	1	0.0357	13	1	0.0435
14	2	0.0714	Mean	5.7	
15	2	0.0714	SD	2.49	
18	2	0.0714	CV	43.79	
19	1	0.0357			
20	1	0.0357			
22	1	0.0357			
Mean	12.5				
SD	3.99				
CV	31.89				

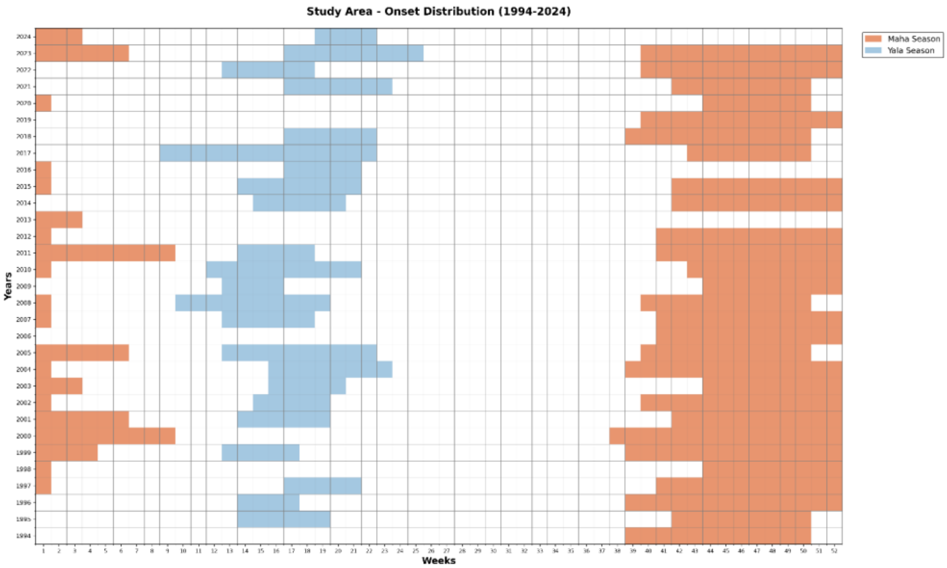
Concerning the beginning and cessation of rains, the duration of the growing period was estimated for both the Maha and Yala seasons between 1994 and 2024 in the research area (Table 10).

Compared to the Maha growing period, the Yala growing period is relatively shorter. The Yala season exhibits much variance in terms of growing period, which ranges from as little as three weeks up to a maximum of thirteen weeks. Nevertheless, the variance is significantly clustered between four and five weeks, where both have the highest occurrence (6) and likelihood (0.2609). In other words, the most representative duration of the growing period within the Yala season is four to five weeks, implying a shorter growing period.

On the other hand, the growing period for Maha displays a larger variance, ranging between 6 weeks and up to 22 weeks. It can be observed that the highest frequency is recorded at 11 weeks and 12 weeks (five times each with a probability of 0.1786). This implies that the average growing period for Maha is between 11 and 12 weeks. In comparison with the Yala season, the growing period in the Maha season is significantly higher, with some values exceeding fifteen weeks.

Figure 3

Annual Distribution of Growing Period

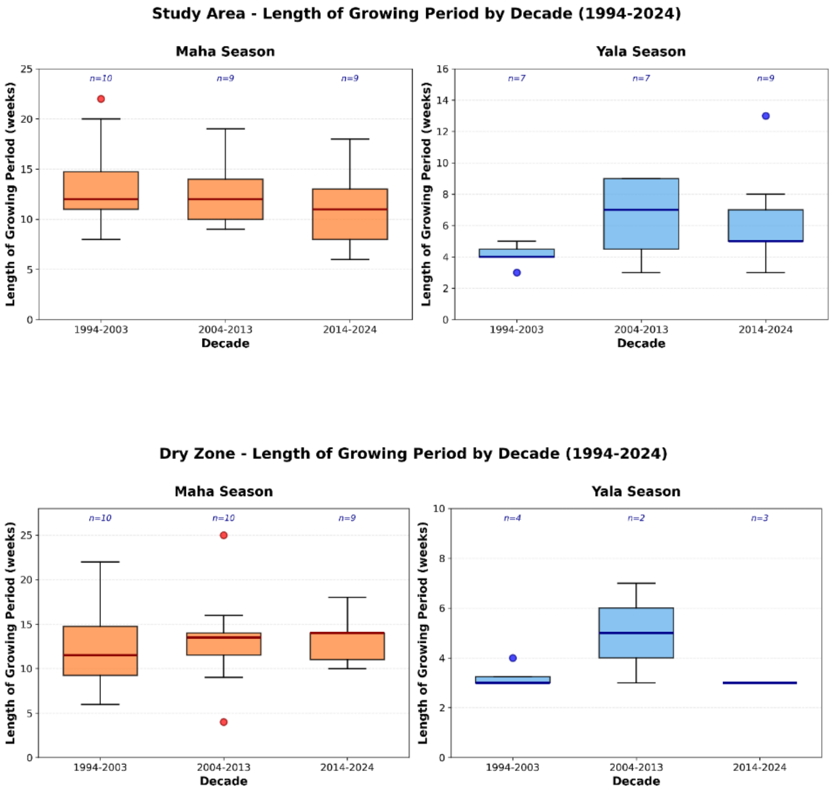


The difference between seasons is evident in the consistency of rainfall, which favors a more extended cultivation period for the Maha season. On the other hand, the relatively short duration of the Yala season is due to the inconsistency in rainfall. This shows that it becomes necessary for farmers to be adaptive in their approach, especially during the Yala season, when there is a short growth period. Figure 3 illustrates the annual distribution of growing periods, highlighting significant fluctuations with a zig-zag pattern. In some years, the growing period is limited to a few weeks, and in some years, the growing period has increased up to 10 weeks, especially in the Maha season.

It can be observed that the growing periods have been gradually decreasing in both the Maha and Yala seasons in the study area and the entire Dry Zone. The following box plots are evident for this gradual shrinking pattern of the growing period.

Figure 4

Temporal Pattern of Annual Growing Periods



The Figure 4, shows the decadal comparison of the growing period of the Maha and Yala seasons and the study area, and the dry zone of the country. The mean value of the growing period of the Maha season shows a gradual decrease over the period. The variability of the Maha season is very prominent, indicating outliers increased up to 22 weeks. The distribution of the Length of Growing Period (LGP) for both Maha and Yala seasons was examined across three decades (1994–2003, 2004–2013, and 2014–2024) using box plot analysis. The method makes it possible to study the patterns related to central tendency, dispersion, and extremes, thus helping us see how seasonality and agricultural potential have changed through time.

Maha Season LGP Distribution

Maha season, which is the major farming season in Sri Lanka, demonstrates a longer growth duration than Yala due to its primary nature as the season. Nevertheless, there are some minor temporal changes observed in the box plot analysis.

During the 1994 to 2003 period, the LGP values demonstrate a median duration of 12 weeks, while having an interquartile range. The presence of upper extreme values greater than 20 weeks shows the occurrence of extended growth periods in some particular years due to prolonged precipitation periods. Therefore, there have been relatively suitable and occasionally long growing periods during the indicated decade.

Over the next decade (2004-2013), the median growth period is still 12 weeks; thus, some degree of consistency may be identified as far as the growth duration is concerned. At the same time, the dispersion of values becomes a little bit narrower than it used to be earlier, indicating a slight reduction in the level of variability.

An even more pronounced change is found during the last decade (2014–2024), in which the median LGP has dropped to about 11 weeks. The lower quartile too seems to drop, signifying that there is an increase in the occurrence of growing seasons that are shorter. However, there are some years in which LGPs are rather higher compared to other years, indicating a general decrease in LGP.

Mean LGP values for different decades have revealed a similar trend with values gradually decreasing from one decade to another, possibly due to early withdrawal of rainfall, reduced rainfall frequency within the year, or intra-seasonal droughts in the Maha season.

In conclusion, although the Maha season provides the longest growing period, there is an apparent reduction in its median LGPs, thus increasing the vulnerability of crops to climate change.

Yala Season LGP Distribution

Unlike the Maha season, the Yala season was marked by shorter growing seasons that varied significantly from one year to another. The box plot distributions illustrate temporal differences, thus indicating the changing dynamics in the seasonal pattern.

Over the years 1994 to 2003, the Yala season had a low median value for LGP, which ranged from 4 to 5 weeks. There is also a very small interquartile range, implying that the growing period in the season remained quite short and consistent. The small variability further implies that climatic conditions were quite stable.

The next remarkable feature that can be noted is that in the 2004-2013 decade, the median LGP reached about 7 weeks. Besides, the interquartile range becomes considerably wider in this decade, implying higher variability. The fact that there are both relatively low values and rather high values means that the Yala season became much less predictable, because now some seasons have quite favorable conditions, whereas others remain limited by time.

The median in the last 2014-2024 decade decreases somewhat, reaching only about 6 weeks, but remains above the value for the first decade. As for variability, it remains relatively high, as there are extreme values that exceed 12 weeks in some observations. This implies that the wet season became longer in some years due to particular circumstances.

The variability that increases in the Yala season indicates that it started changing from being short and rather stable to being unpredictable. There may have been irregular rainfalls that were too short or even interrupted, and also excessive rains in some years.

Comparative Analysis of Maha and Yala Seasons

The differences between the two seasons can be highlighted through a comparative analysis of both seasons. While the Maha season continues to be the major farming season, with longer growth periods and steady median values, the declining trend in LGP and consistent variability suggest an eventual reduction in its reliability.

On the other hand, the Yala season, which is regarded as the minor and water-scarce farming season, exhibits a growing LGP and high variability. The expansion of the growing period in the second decade and the persistence of extreme values in the most recent decade suggest that Yala is becoming more climatically dynamic.

This divergence points to a possible redistribution of seasonal rainfall patterns, where:

- The Maha season may be experiencing shortened or less consistent rainfall durations, and

- The Yala season may be receiving more episodic or intensified rainfall events, leading to occasional extensions of the growing period.

Temperature Variation of the Study Area

The surveyed farmers were very strongly presented with the temperature of the study area, showing a very significant increasing trend during the study period. A trend analysis has been conducted across two spatial scales to validate the farmers' observations. 1) The temperature trend analysis in the study area and 2) temperature variability.

Both analyses show a very significant positive upward trend in temperature across two different spatial scales (Figure 05), confirming that the farmers' perception is scientifically supported. Even though the slope parameters of the trend analysis are slightly different in the two spatial scales analysis, the overall trend patterns are somewhat identical (Table 11) and show a statistically significant difference.

Table 11

The Regression Parameters of the Temperature Trend Pattern of the Study Area

Station	Slope	Intercept	R-squared	*p*-value	Significance	MK-Trend	MK-P-Value
SD1	0.0161	-5.3283	0.1711	0.0207	Significant	increasing	0.0322
SD2	0.0149	-3.2010	0.1560	0.0279	Significant	increasing	0.0322
SD3	0.0147	-2.5290	0.1470	0.0332	Significant	increasing	0.0570
SD4	0.0159	-5.1696	0.1740	0.0196	Significant	increasing	0.0351
SD5	0.0159	-5.1696	0.1740	0.0196	Significant	increasing	0.0351
Study Area	0.01547	-4.2795	0.1648	0.0235	Significant	increasing	0.0487

Figure 5

The Comparative Trend Patterns of Mean Temperature in the Study Area

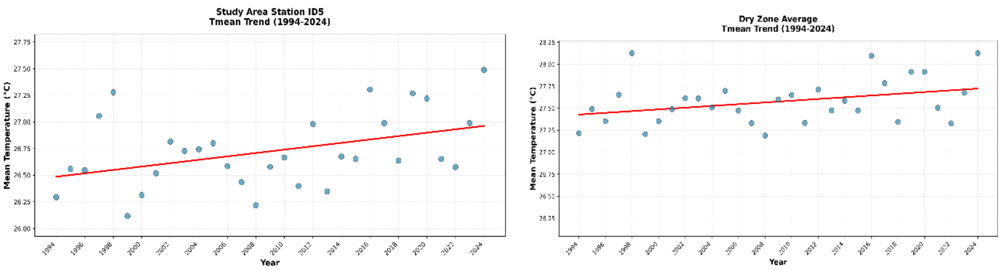
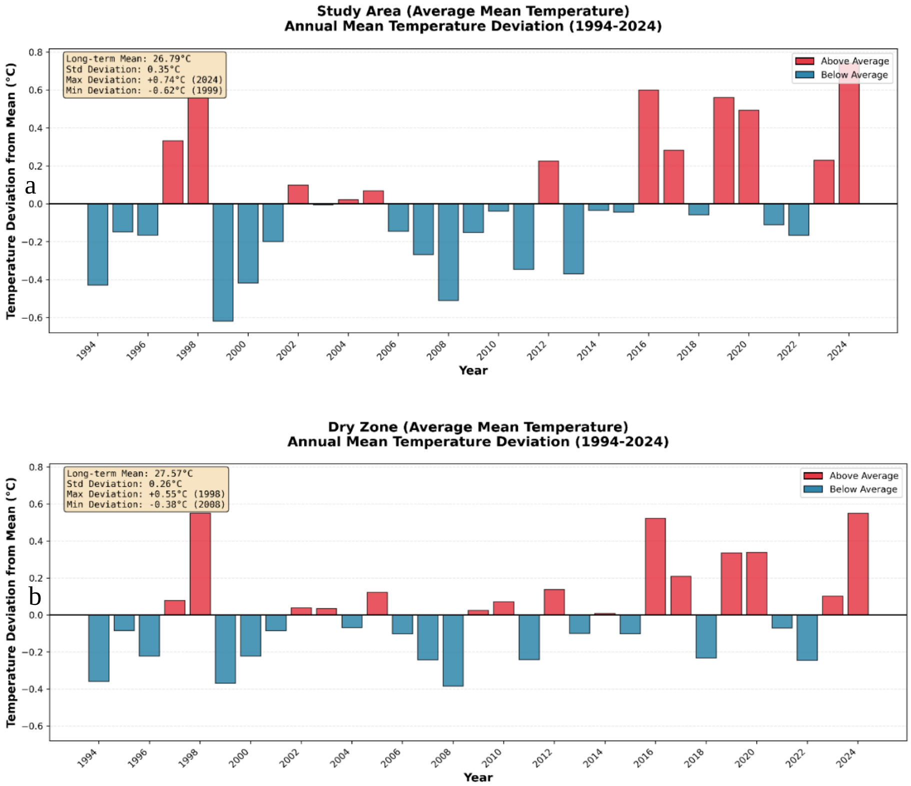


Figure 05 illustrates the comparative trend patterns of mean temperature in the study area and the Dry Zone of Sri Lanka. Although both trends are statistically significant, a clear difference in the magnitude of the trend slopes is observed. It is observed that the study location shows a steeper positive trend when compared with the entire Dry Zone, thereby showing that there is a higher rate of temperature increase in the study location. The difference between the two areas signifies that there may exist some variability in the climate of the region, and therefore, the study location may experience a higher rate of warming because of other reasons. Temperature variability also shows an irregular pattern with a sudden increase from negative deviations to positive deviations, and also the reverse pattern (Figure 06).

Figure 6

Annual Mean Temperature Deviation; a. Study Area b. Dry Zone



Discussion

Farmers' Perception and Scientific Reality

The present study shows the significant level of climate change awareness among farmers, as indicated by their relatively high Perception Index (PI) value of 0.62. This means that people working in local communities actively notice changes occurring in their environment. It agrees with the conclusion made by Javed et al. (2025), according to whom farmers living in semi-arid zones have a high awareness of climate change and associate it with human activities.

One of the questions which deserve consideration relates to the interrelationship between experience and weather statistics. The observations made by the farmers were mainly on the variations in seasonality and unpredictability of rainfall patterns. Increasing trends in precipitation that are statistically significant occurred at two of the five stations under study (SD2 and SD4). In addition to this, there was an observed gradual decrease in the Length of Growing Period (LGP). These results correlate with the findings of Menike and Arachchi

(2016) that in rural Sri Lanka, farmers experienced increased unpredictability in rainfall patterns.

However, another point worthy of attention concerns the difference between perceived climate changes and reality. As an illustration, there have been more droughts, and there is now less predictability concerning rainfall. However, the Mann-Kendall test indicates that rainfall generally increases annually in SD2 and SD4. Thus, while the farmers perceive that the pattern of precipitation has become less reliable, the facts show that there is an increasing trend in annual precipitation amounts. One of the reasons for this gap is that farmers consider dry periods within the growing season rather than annual precipitation levels. Indeed, Imran et al. (2020) came to a similar conclusion when analysing precipitation perceptions of farmers.

Seasonal Dynamics and the Vulnerability of the Yala Season

The observed disruption includes the growing unpredictability of the seasonal start-ups, especially concerning the emergence of the Yala season. For instance, there is a high probability for at least one Yala season not to have an onset; therefore, the term "no onset" is used, occurring in 21.1% cases. On the contrary, the Maha season presents a stable onset window within six weeks; however, the Yala onset is still quite unstable and unforeseeable. Sonnadara (2010) explains that an earlier onset might be connected with the prolongation of the rainy period. Due to such strong variations and corresponding delays in Yala onset time (during the last decade, the Yala onset changed from the 17th-19th week to the 20th week), there should be a shorter duration of Yala rainfall. The idea of seasonal slipping introduced by Imran et al. (2020) can be considered the ending point of the transition period between two rainy seasons in rain-fed agriculture.

The number of "no onset" years in the Yala season from around 1994 (almost every fourth year witnesses no onset) proves the continuing climatic vulnerability. According to Basnayake (2023), intra-seasonal rainfall variations in Sri Lanka are caused by complicated harmonic cycles and additional factors. There seems to be no clear dominant pattern of Yala onset, which means that the impact of micro-scale events is increasingly significant for the global scale of monsoons seen so far. Therefore, traditional farming calendars will not work anymore.

Moreover, a chi-square test for homogeneity in terms of comparing the onset-week distribution of both seasons shows another distinction between the onset patterns of the two seasons. In the case of the Maha season, there is no statistically significant difference ($\chi^2 = 2.82$; df = 10; $p > 0.05$), indicating that the Maha onset distribution in the Maho Agrarian Zone is similar to the overall regional onset distribution. On the contrary, the Yala season showed a significant regional difference ($\chi^2 = 20.53$, df = 11, $p < 0.05$). Therefore, the onset behaviour of the Yala season in the study area follows a unique localised distribution that differs from the one prevailing in the Dry Zone region. This finding implies that regional climatic data would be adequate for planning concerning the Maha season, but local climatic data would be required when making agricultural plans for the Yala season in the Maho Agrarian Zone.

The Shrinking Length of Growing Period (LGP) and Adaptive Responses

Decadal information regarding the length of the growing period (LGP) from 1994 to 2024 shows a shrinking of the agricultural window. The median LGP of the Maha season decreased from 12 weeks to 11 weeks, while for the Yala season, it is only around four to five weeks, making it an incredibly short window. As such, there is a need for the farming system to change. According to Menike and Arachchi (2016), farmers adapt to this change through the use of drought-resistant or short-duration crops.

The study found that risk-averse behaviour was exhibited by the respondents in the following ways: delays in planting due to uncertainty about onset dates; reducing planted acreage to lower water-related risks; and increased use of short-season crops. This practice aligns with the Triple-loop concept by Ricart et al. (2023), which posits an association between risk awareness and adaptations. Despite the above adaptation measures, the complete reluctance to plant crops in the Yala season could be classified as maladaptation because the risks outweigh the adaptive responses.

The combined findings from this study suggest that there is a considerable ability of farmers in the Maho Agrarian Zone to identify and react to changes in the patterns of rainfall seasons. There is a high degree of consistency between the results obtained from onset and cessation analysis and those from farmers' field observations. Nevertheless, economic barriers, as well as the lack of region-specific adaptation mechanisms, have made it difficult for farmers to adapt to changes in the weather patterns. These findings underscore the urgent need for targeted interventions to prevent the gradual transition from the current bimodal two-season agricultural system to a more vulnerable single-season cultivation system.

Therefore, the findings of this study have revealed that some farmers operating within the Maho Agrarian Zone struggle with the problem of relying on their own resources when dealing with the problems brought about by climatic variability. This is partly attributed to the lack of sufficient official assistance to risk reduction in favor of aged and weak farmers, as well as a lack of information exchange between the scientists and the local agricultural community (Imran et al., 2020). Despite the PI indicating a high level of climate awareness among farmers (PI = 0.62), the development and adoption of sustainable adaptation measures have been constrained due to (i) a lack of information on how to adapt and (ii) the very variable nature of the Yala season, with no onset events occurring up to 21.1% of the time, leaving farmers vulnerable to agricultural risks (Javed et al., 2025; Yamba et al., 2019). From these, it is clear that there needs to be a location-based approach to climate recommendations rather than a uniform one.

Based on the results of this study, suggest three distinct areas that require policy interventions. The first area relates to the need to provide information about the season to agricultural communities, since the statistically significant differences observed in the distribution of Yala onset in the study area compared to the entire Dry Zone (chi-square = 20.53; $p<0.05$) show that season information provided at a zone level will serve the purpose in the Maho Agrarian Zone, where Yala rainfall behavior is more localised. Consequently, agrarian service centers should be equipped to disseminate station-level seasonal onset forecasts rather than relying solely on regional or district-level averages. Secondly, the continued shortening of the growth period underscores the need for an organised programme to cultivate fast-growing, drought-resistant crops as part of a regular risk management strategy. Finally, considering that the Yala season occurs about once every four years, contingency planting schedules and input supply systems should be put in place so that farmers have ready options when the rain does not set in.

To translate awareness of climate risks into confidence and action, there is a need for policy options that enable adaptable (flexible) solutions to climate change (Ricart et al., 2023). For example, integrating scientific projections with disaster planning techniques can result in climate-driven planting schedules in which specific actions are triggered by specific climate events. The government can enhance agricultural extension services through technology, ensuring that relevant climate change information is available to rural farmers (Menike & Arachchi, 2016). In addition, sound management practices involving micro-loans, interest-free loans, and subsidy programs will facilitate the adoption of agricultural approaches, including protected agriculture and agroforestry, to promote forest canopy while maintaining agricultural income among rural communities.

Conclusion

The research findings reveal the high degree of awareness and understanding held by smallholder farmers within the Maho Agrarian Zone concerning climatic variability characterised by increasing temperatures and the increasingly unpredictable timing of rainfall. The comparison between farmer perceptions and long-term gridded data on climate variability reveals that "climate reality" includes not only annual variability but also intra-seasonal changes influencing planting practices, water supply conditions, and duration of growing periods. Crucially, the results reveal that the perceived unpredictability of rainfall can be consistent with statistically significant increases in total rainfall in a year, since farmers tend to focus on the negative effects of drought, late onset of rains, early cessation of rainfall periods, and irregular rainfall. Yala appears to be the most vulnerable part of the bimodal farming cycle due to its greater frequency of failure and delayed onset, in addition to local onset compared to the larger Dry Zone environment. The shortened growing period, coupled with increasing temperatures, implies production risks that require reconsideration of the crop calendar and resource allocation due to the narrowed and less certain window for rainfall events. It is necessary, therefore, to develop seasonal forecasts, improve extension services, and provide appropriate risk management strategies (such as shorter-duration crop varieties, alternative input plans, irrigation scheduling plans, and proper financing methods).

In terms of policy implications, the results suggest a move away from standardizing policies at the zone level towards station-specific recommendations or community-specific recommendations, especially for Yala. The future research agenda, therefore, will need to build on this study to include other agroclimatic variables (such as evapotranspiration and soil moisture), analyze differences in perceived agreement based on location and farmer groups, and determine what adaptation packages are most successful in mitigating livelihood and food security risks in the dry and intermediate zones of Sri Lanka. It will be important in future research to link the rainfall conditions nationally to the experiences of local farmers.

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