Article Journal of Asian Geography, 2025, Volume 4 (Issue 1), 10-19.
https://doi.org/10.36777/jag2025.4.1.2

Climate Change in Sri Lanka's Central Province: A Comprehensive Analysis of Multiple Models Across Various Shared Socio-Economic Pathways

Piratheeparajah N [1*] & Dhanushan K [1],

[1]Department of Geography, University of Jaffna, Thirunelvely, Jaffna, 40000, Sri Lanka.

*Correspondence: npiratheeparajah@gmail.com

Received: 9 Jan 2025, Revised: 21 Feb 2025; Accepted: 22 Feb 2025; Published 29 Mar 2025

Abstract: Climate change has emerged as a critical issue that demands the attention of global communities, becoming a primary concern for many nations. Sri Lanka's Central Province is particularly vulnerable to these shifts. This study aims to outline the expected patterns of temperature and rainfall in the Central Province under different climatic scenarios, using various models across diverse socio-economic pathways. The data for this analysis were obtained from the global coordination system established by the Coupled Model Intercomparison Project Phase 6. Utilizing carbon emission scenarios SSP2-4.5 and SSP5-8.5, a range of models were examined, and overarching conclusions were drawn using MiniTab 17 software. Under the SSP2-4.5 scenario, the consolidated results from the various models suggest that the average projected temperature for the Central Province from 2020 to 2100 will rise by 1.17°C, with May identified as the warmest month, experiencing a temperature increase of 1.33°C. Average rainfall is expected to increase by 105.56 mm, with November showing the most significant rise at 124.62 mm. In the context of the SSP5-8.5 scenario, the combined results indicate that the average temperature is projected to rise by 1.94°C during the same period, with May again exhibiting the highest temperature increase at 2.17°C. Average rainfall is expected to increase by 125.01 mm, with November encountering the greatest uplift at 184.77 mm. By understanding the projected temperature and rainfall changes in the Central Province, sustainable development in the region can be strengthened, thereby contributing to Sri Lanka's broader economic advancement.

Keywords: Climate change; Temperature; Rainfall; Multi-models; Ensemble.

1.0 Introduction

Climate change is recognized as one of the most urgent challenges confronting our world today. It has become a global concern, affecting numerous nations and posing significant challenges to economies and ecosystems. On a worldwide scale, climate change introduces complications not only politically, economically, and socially, but also in the dynamics of international relations, leading to multifaceted complexities (Li et al., 2021). It is central to various predicaments, such as fluctuations in global temperatures and the phenomenon of global warming (Lynas, Houlton, & Perry, 2021). Research on prospective climate change has emerged as a global priority. By understanding future climate shifts, we can proactively implement strategies to mitigate or adapt to their effects (Grigorieva, 2024). Recognizing this imperative, many nations are actively engaged in research on climate change and are taking decisive action (Meinshausen et al., 2020). Climate change is closely linked to extreme weather events, including heatwaves, cold spells, droughts, cyclones, floods, and heavy rainfall (Kumar Guntu & Agarwal, 2020). It contributes to a range of global crises, such as food shortages, environmental degradation, and an increase in natural disasters (Agonafir et al., 2024). The impacts of climate change are far-reaching, transcending regional and national borders and affecting all aspects of society (Qu & Motha, 2022).

At the regional level, significant climatic fluctuations have been documented across the Asian continent. Notably, temperatures in the Asian region are rising at twice the global average rate, increasing by 1.07°C from 1850 to 2019 (Fung, Huang, & Koo, 2020; Sharma, Andhikaputra, & Wang, 2022). The United Nations Framework Convention on Climate Change (UNFCCC) and the Intergovernmental Panel on Climate Change (IPCC) have identified Sri Lanka as a small island nation profoundly vulnerable to the harmful effects of climate change (Lescher Soto et al., 2024). The country's geographical context, combined with annual temperature fluctuations in the Indian Ocean, has led to significant climatic variations within Sri Lanka (Alahacoon & Edirisinghe, 2021b). According to Senatilleke et al. (2022), the annual average temperature of Sri Lanka is increasing by 0.05°C per year. Furthermore, according to global climate risk index data analyzed in 2020, Sri Lanka ranked as the sixth most affected country by extreme weather events and the impacts of climate change, while the United Kingdom ranked 132nd (Dananjaya, Shantha, & Patabendi, 2022).

Within Sri Lanka, altitude significantly influences temperature variations, with markedly cooler conditions prevailing in the south-central mountain ranges. The precipitation regime of Sri Lanka is classified into three distinct zones: the wet zone, the intermediate zone, and the dry zone (Alahacoon & Edirisinghe, 2021b). The wet zone, located in the southwest, receives an annual average rainfall exceeding 2,500 mm, significantly augmented by the southwest monsoon (Alahacoon & Edirisinghe, 2021a). The dry zones in the south and northwest accumulate less than 1,750 mm of rainfall, while the intermediate zones, situated in the eastern and central regions, receive between 1,750 mm and 2,500 mm, primarily driven by the northeast monsoon. The Sri Lankan government is currently grappling with considerable challenges in mitigating the impact of climate change on the nation's water resources (Somasundaram et al., 2020). Climate change is adversely affecting all sectors, with the agriculture and fisheries sectors facing losses worth 1.2 billion USD due to climate change in Sri Lanka (Meegahakotuwa & Rekha Nianthi, 2023).

"Renowned for its Ceylon tea production, the Central Province attracts numerous tourists to its picturesque hill country towns, such as Gampola, Hatton, and Nuwara Eliya (Fernando, Bandara, and Smith, 2016). The province is also home to four UNESCO World Heritage Sites and boasts several historically and culturally significant landmarks, including the ancient town of Matale, the Temple of the Tooth Relic, the Dambulla Cave Temple, the Aluvihare Temple, and the Sigiriya Rock Fortress (Wimalaratana, 2023). Climatically, the Central Province enjoys a relatively cool atmosphere, with chilly nights prevalent in elevated areas exceeding 1,500 meters (De Silva & Kawasaki, 2018). The western slopes experience high humidity, with average annual rainfall ranging from 1,500 mm to 1,773 mm, while certain locales may witness rainfall as high as 7,000 mm per year. Conversely, the eastern slopes are categorized within the central dry zone, receiving moisture solely from the northeast monsoon. In Kandy, temperatures fluctuate between 24°C at sea level and 1,889 meters' altitude, while in Nuwara Eliya, temperatures can plummet as low as 16°C.

The ongoing global climate variations have similarly impacted the climatic characteristics of the Central Province. Among the seven districts in Sri Lanka identified as landslide-prone areas, Kandy, Nuwara Eliya, and Matale in the Central Province are classified as zones at risk for landslides. This underscores the urgent need to understand future climate trends. The analysis of rainfall and temperature patterns has

Article Journal of Asian Geography, 2025, Volume 4 (Issue 1), 10-19.
https://doi.org/10.36777/jag2025.4.1.2

recently become a significant area of scholarly interest. In this context, the Central Province stands out as a highly climate-sensitive region. Although climate change research has been conducted in the Central Province, much of it has primarily focused on historical trends in rainfall and temperature. A critical research gap remains in examining future climate changes specific to the Central Province. Specifically, there has been limited research utilizing globally recognized climate change models and advanced analytical techniques to forecast future trends in temperature and rainfall. This study aims to address this gap by analyzing projected changes in temperature and rainfall patterns in the Central Province from 2020 to 2100. Furthermore, it will offer developmental recommendations aligned with the anticipated future changes in rainfall and temperature for the region.

It is imperative to initiate studies that identify climate change and its impacts within the Central Province of Sri Lanka. The Central Province, particularly the Nuwara Eliya district, is recognized as the most vulnerable district to significant temperature changes in Sri Lanka, with an increase of one degree Celsius recorded from 1901 to 2000 (De Silva & Sonnadara, 2009). Regrettably, only a limited number of such studies exist, many of which primarily focus on water resources, often overlooking the physical, climatic, and human factors relevant to Central Sri Lanka. Consequently, this study is of paramount importance, especially in formulating effective adaptations to present and future climate change scenarios. The findings of this research are expected to contribute significantly to the future development planning efforts of the Central Region.

2.0 Study Area

The Central Province has been selected as the study area for this research. Located in the central highlands of Sri Lanka, the province is bordered to the north by the North Central Province, to the east by the Uva Province, to the west by the North Western Province, and to the south and southwest by the Sabaragamuwa Province. It lies between 7° 20″ north latitude and 80° 45″ east longitude. The Central Province consists of the districts of Kandy, Matale, and Nuwara Eliya. Figure 1 illustrates the location map of the study area.

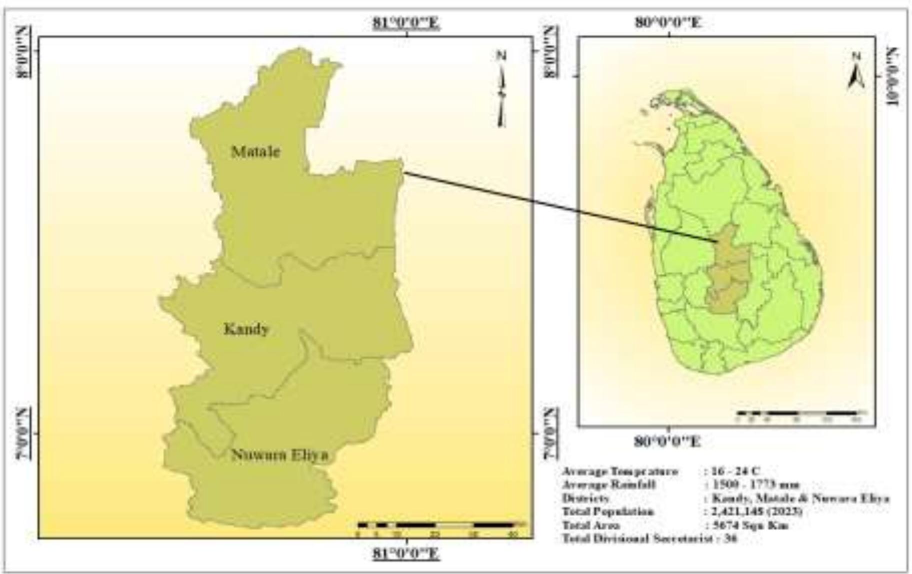

Figure 1: Central province of Sri Lanka.

3.0 Materials and Methodology

This study primarily focuses on identifying projected climate change anomalies within the designated study area. While numerous investigations have attempted to forecast climate change in their respective regions, this is the first such attempt for the central region of Sri Lanka. The future projected climate change data were sourced from the Climate Change Knowledge Portal (CCKP) of the World Bank. Additionally, data for this research were obtained from the global coordinate system through the intercomparison of the Coupled Model Intercomparison Project Phase 6 (CMIP6), which provides outputs from Coupled Atmosphere-Ocean General Circulation Models (CAOGCM), as outlined in the IPCC's sixth assessment report.

The scientific community uses scenarios to convey a range of plausible climate futures and illustrate the impacts of various pathways, policy decisions, and technological advancements (Arfasa, Owusu-Sekyere, and Doke, 2024). These scenarios are framed as 'what-if' cases, selected to encompass a broad spectrum without relying heavily on probability (Xiang et al., 2022). The methodology for developing these scenarios has shifted from a predominant focus on climate to an increasingly development-oriented perspective, offering insights into a variety of potential climate outcomes (Meinshausen et al., 2020).

Shared Socioeconomic Pathways (SSPs), utilized in CMIP6, replace the Representative Concentration Pathways (RCPs) introduced in CMIP5 (Arfasa et al., 2024). The IPCC released four representative concentration pathways in 2022; however, for the present study, only SSP 2.4.5 (medium) and SSP 8.5 (high) are considered as the foundation for assessing future changes in temperature and precipitation across different climatic periods. These shared socioeconomic pathways represent varying levels of carbon emissions. Currently, Sri Lanka's carbon emissions align with SSP 2-4.5. Conversely, for future projections, SSP 5-8.5 is employed, influenced by factors such as population growth, urbanization, and increased transportation activity. The SSP 2-2.6 level of carbon emissions is not applicable at this time. Five SSPs are introduced in CMIP6, each reflecting distinct pathways of societal development.

Each model requires a substantial dataset of historical data to forecast future climate change. However, climate change studies often rely on specific reference periods established by the World Meteorological Organization, such as 1971-2000, 1981-2010, and 1990-2020, for comprehensive analysis. To define each model's reference period, a segment of historical simulations is necessary. For this study, the timeframe from 1990 to 2020 was designated as the historical period, while the intervals of 2020-2039, 2040-2059, 2060-2079, and 2080-2099 were allocated for future projections, focusing on two key parameters: mean monthly temperature and monthly precipitation. The study utilized data refined to the geographical coordinates of the Central region of Sri Lanka, located at 7°20′N latitude and 80°45′E longitude.

Article Journal of Asian Geography, 2025, Volume 4 (Issue 1), 10-19.
https://doi.org/10.36777/jag2025.4.1.2

The validation of future climate change methodologies is crucial for the effective use of this data in the current study. To achieve this, a comparative analysis was conducted to assess data accuracy by using general circulation models to simulate historical data and comparing it with actual observed data to verify its integrity. In this research, temperature and rainfall data were generated under various scenarios by multiple models. These models simulated temperature and rainfall data for the study, including ensemble data, which was then compared with actual historical observations to determine the validity of the future climate change data for this analysis.

The validation assessment of future climate change data is critical to ensuring the reliability of the findings (Figures 2 and 3). Not just one model, but all models indicate an increase in future temperature and rainfall within the study region. Similarly, the comparative analysis revealed a slight discrepancy between the historical data and the actual observed temperature and rainfall. As a result, model-generated data for the Central Province were used to predict forthcoming changes in temperature and precipitation. To assess the accuracy of the downloaded future climate change data, the historical data generated by the models were cross-examined with past observed data from the Central Province. Based on this accuracy, the downloaded data were then used to analyze future climate changes.

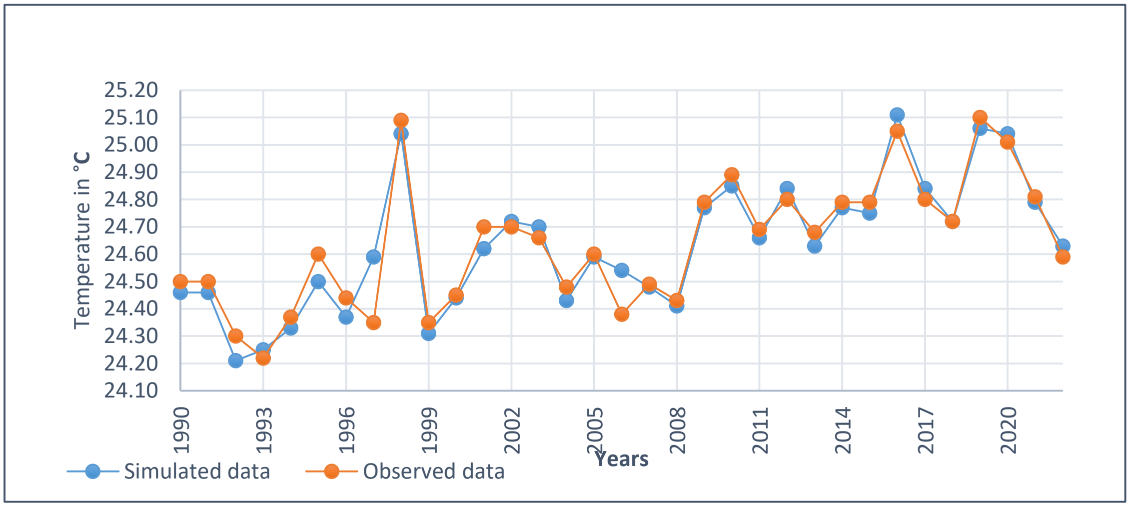

Figure 2: Observed and model simulated annual mean temperature trend for the period from 1990- 2022 in the Central region of Sri Lanka.

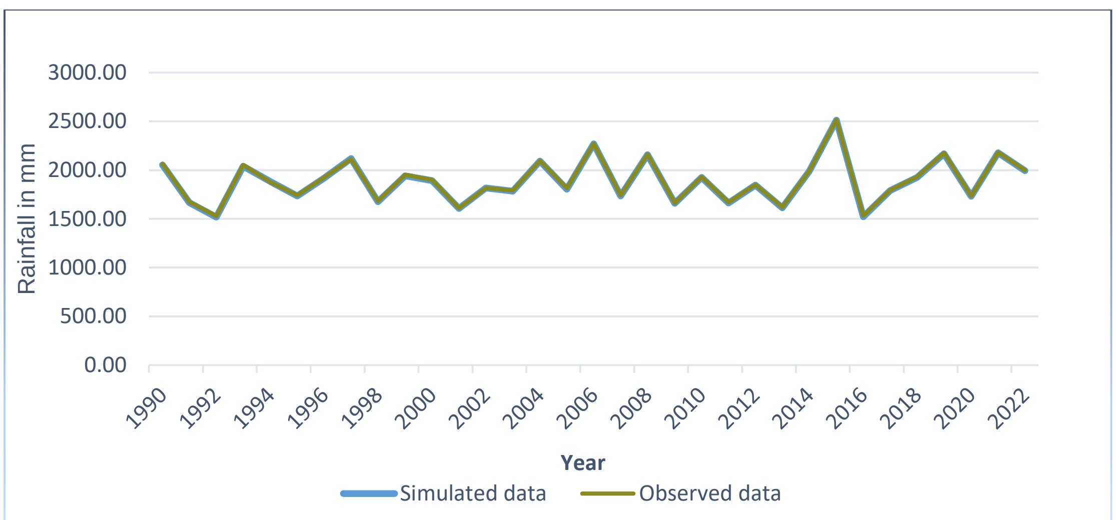

Figure 3: Observed and model simulated annual mean rainfall trend for the period from 1990- 2022 in the Central region of Sri Lanka.

4.0 Results and Discussion

The assessment of projected temperature and precipitation patterns in the Central Province of Sri Lanka has revealed a significant increase across various Shared Socioeconomic Pathways (SSPs) for distinct climatic periods. Moreover, multi-model integrations indicate a rising trend in both temperature and precipitation throughout the climatic timeline from 2020 to 2100.

4.1 Future Temperature Changes under SSP 4.5

Future changes in temperature have been explored through an analysis of ten models across four distinct climatic periods: 2020 to 2039, 2040 to 2059, 2060 to 2079, 2070 to 2099, and the overall period from 2020 to 2100. Temperature anomalies (mean) for the study region have been evaluated. Projections for the climatic period 2020 to 2100, based on the SSP 4.5 scenario, predict various increases in temperature within the study area.

Article Journal of Asian Geography, 2025, Volume 4 (Issue 1), 10-19.
https://doi.org/10.36777/jag2025.4.1.2

All models under the SSP4.5 scenario consistently project a rise in temperature across all climatic periods, particularly with escalating temperatures. The models predict that between 2020 and 2100, the maximum average temperature rise will reach 1.33 degrees Celsius, while the minimum average temperature rise will be 1.02 degrees Celsius (Figure 4). Based on these projections, May is expected to experience the most significant temperature increase in the Central region across all climatic periods, while September will see the least increase. Each model within this scenario indicates a temperature rise throughout all climatic intervals.

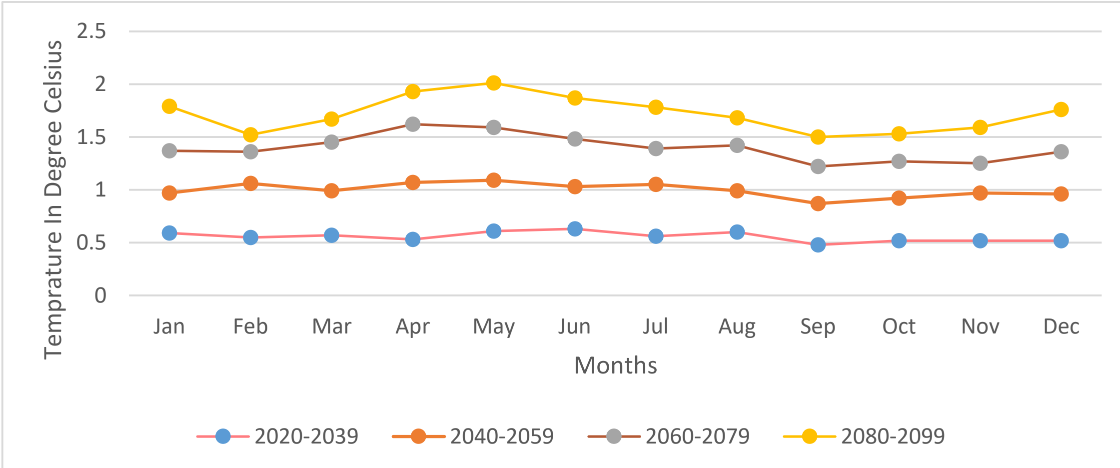

Figure 4: Projected monthly temperature variations for the different climatic periods under SSP 4.5 in the Central region of Sri Lanka.

4.2 Projected Temperature under SSP 8.5

The CMIP6 models present a range of predictions regarding temperature changes from 2020 to 2100. Despite these discrepancies, a prevailing consensus among the models indicates an anticipated increase of 1.94°C in the mean temperature of Sri Lanka's Central region over this period. However, a detailed examination of the data on a monthly basis reveals significant variations. The generalized temperature projections from these models suggest that May is expected to experience the most pronounced increase, with an average rise of 2.17°C. In contrast, September is predicted to see the least elevation, with a projected increase of 1.74°C (Figure 5).

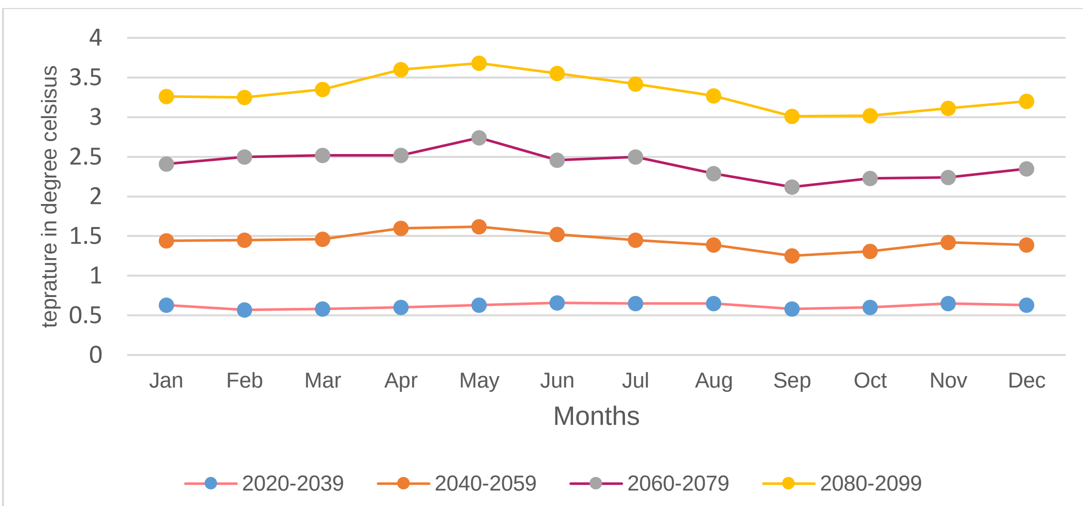

Figure 5: Projected monthly temperature variations for the different climatic periods under SSP 8.5 in the Central region of Sri Lanka.

"The analysis of each model reveals significant disparities in the average temperature increases. The HADAEM3-GC31-LL model exhibits the highest average temperature increase, recorded at 2.72 degrees Celsius. Following closely, the CANESM5 model shows a substantial average of 2.70 degrees Celsius, while the ACCESS-CM2 model reflects 2.49 degrees Celsius, corresponding with the projected SSP 8.5 scenario for the climate period spanning from 2020 to 2100. Conversely, the NORESM2-CM model registers the lowest average temperature increase, at 1.40 degrees Celsius. Subsequently, the MIROC ES-2L model indicates an average value of 1.44 degrees Celsius (Figures 6 & 7). According to the model analysis, the upcoming months of October, November, and December in the Central Province are expected to experience significantly cooler conditions. Conversely, the months of April, May, June, and August are projected to experience higher temperatures.

Article Journal of Asian Geography, 2025, Volume 4 (Issue 1), 10-19.
https://doi.org/10.36777/jag2025.4.1.2

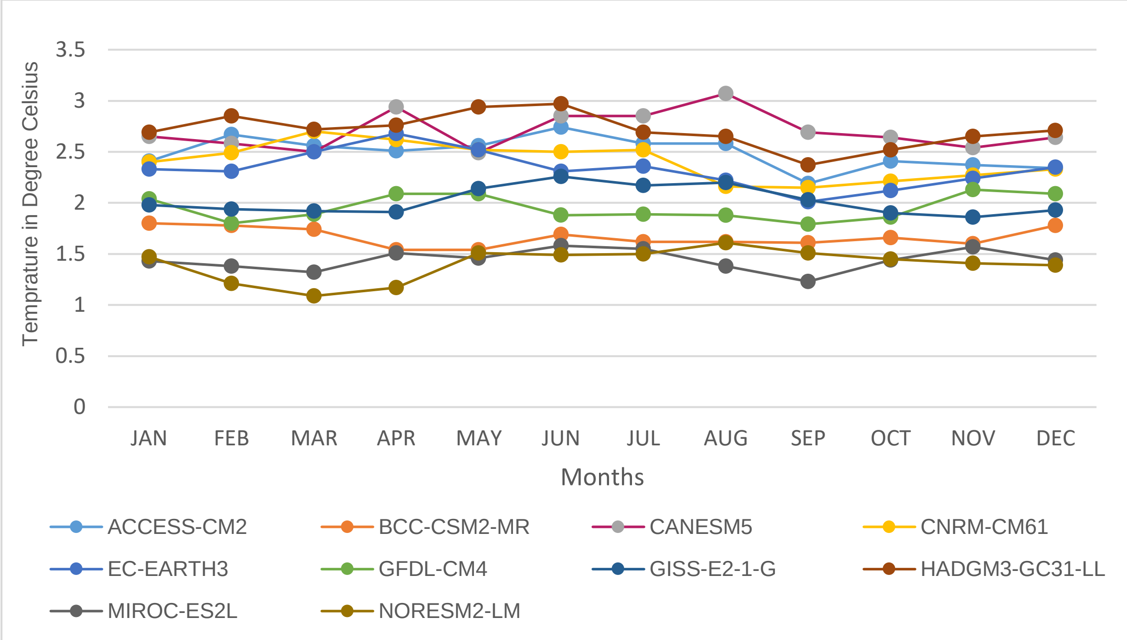

Figure 6: Various models projected temperature for the Central region (2020 to 2100) under SSP 8.5

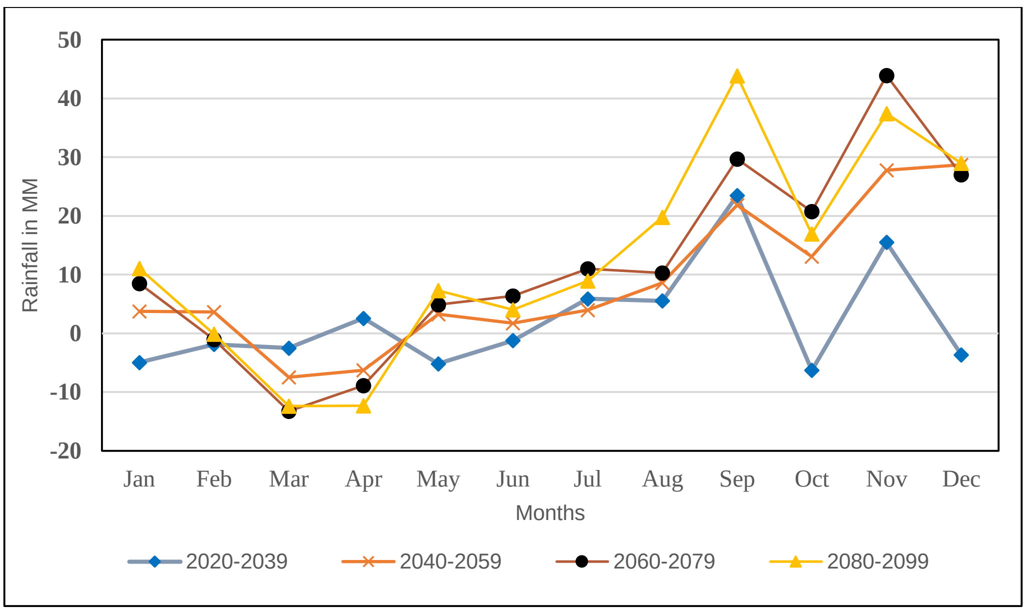

Figure 7: Projected rainfall changes of Central region in multi models for the period of 2020 to 2100 under SSP 4.5 scenario

4.3 Future Rainfall Changes in the Central Region of Sri Lanka under SSP 4.5 Scenarios

As outlined in the IPCC's Sixth Assessment Report on Climate Change, projected changes in precipitation have been based on various Shared Socioeconomic Pathways. It is expected that annual rainfall will increase by 105.56 mm from 2020 to 2100 under the SSP4.5 scenario. The most significant increase is projected for November, with a rise of 124.62 mm, followed closely by September, with an increase of 118.84 mm. In contrast, the smallest increase in rainfall is expected for March (-35.61 mm) and April (-24.96 mm). Monthly rainfall forecasts generated by models under SSP2-4.5 predict a decline from January to June, with average projections of 47.09 mm for January, 1.87 mm for February, 42.87 mm for March, 109.57 mm for April, and 104.72 mm for May.

For the period from 2020 to 2100, the model with the highest projected annual rainfall increase is the CANESM5 model, predicting an increase of 600.48 mm. This is followed by the NORESM2-LM model with 420.27 mm and the HADAEM3-GC31-LL model with 267.76 mm. The smallest annual rainfall increases are forecasted by the BCC-CSM2-MR model (23.56 mm) and the CNRM-CM6-1 model (65.84 mm). Under SSP2-4.5, the average projected rainfall from 2020 to 2100 shows variability across the models. The CANESM5 model estimates an increase of 600.48 mm, followed by ACCESS-CM2 (148.35 mm), HADAEM3-GC31-LL (267.76 mm), NORESM2-LM (420.27 mm), and EC-EARTH3 (125.84 mm) (Figure 8).

Article Journal of Asian Geography, 2025, Volume 4 (Issue 1), 10-19.
https://doi.org/10.36777/jag2025.4.1.2

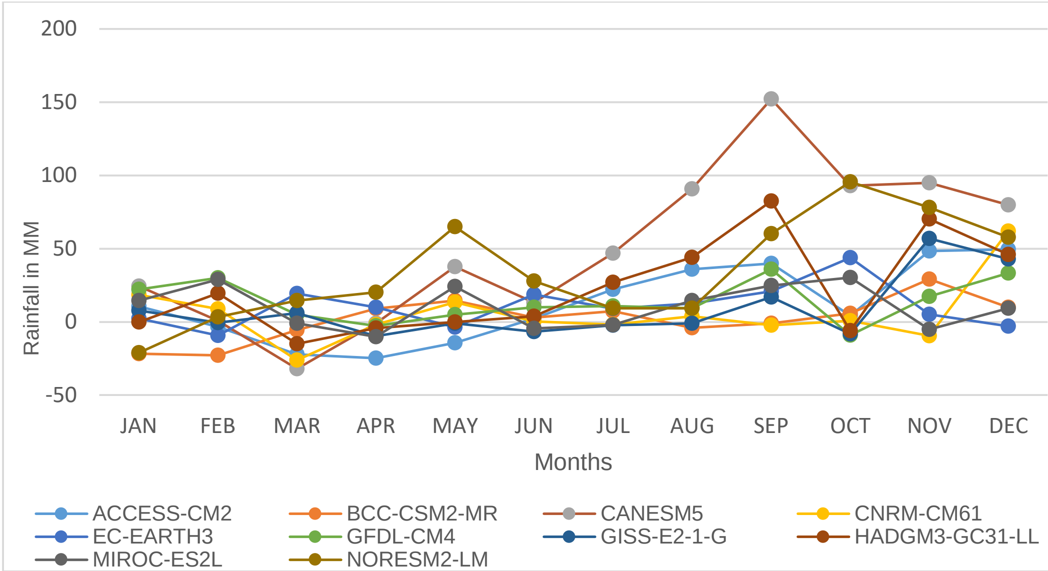

Figure 8: Various models projected rainfall of the Central region of Sri Lanka for the period from 2020 to 2100 under the SSP 4.5 scenario

4.4 Future Rainfall Alterations in the Central Region of Sri Lanka Under SSP 8.5 Scenarios

All climate models uniformly predict an increase in rainfall for the Central Province in the future. Although the magnitude of this increase will vary across different seasons, an overall reduction in rainfall variability is anticipated. By the year 2100, annual precipitation is projected to rise by 125.01 mm (Figure 8). Notably, the most significant increase in precipitation is expected in November (184.77 mm), while a decrease is projected for March (-55.39 mm).

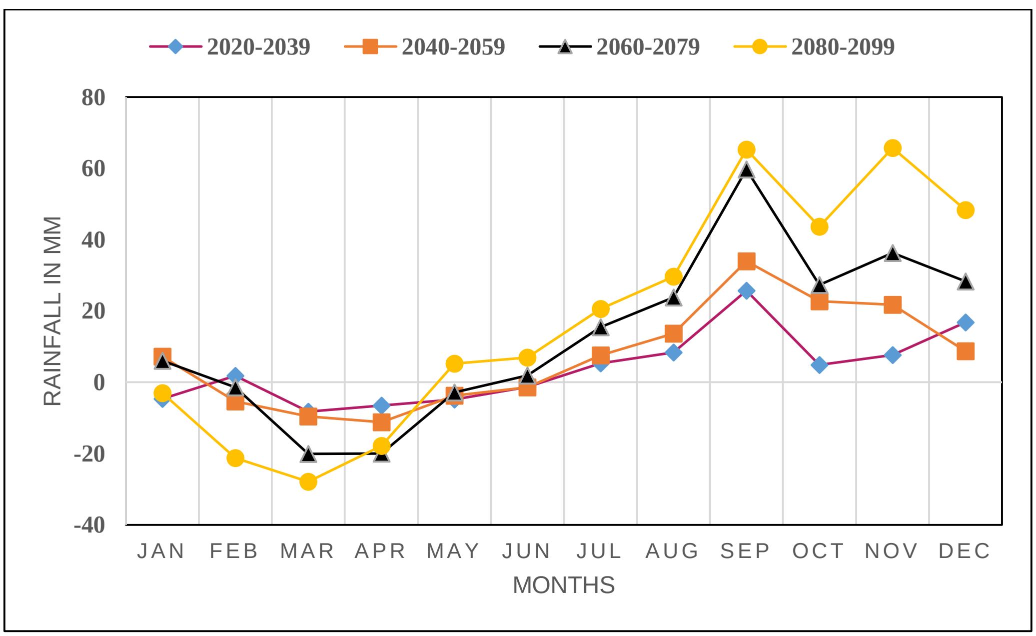

Figure 9: Ensemble projected rainfall for a different climatic period of the Central region of Sri Lanka under the SSP 8.5 scenario

Significant discrepancies are evident in the projected changes in rainfall from 2020 to 2100 across ten distinct climate models for Sri Lanka's Central region. This section explains the anticipated fluctuations in rainfall as indicated by each of the ten models for this area. It is estimated that the annual rainfall in Central Sri Lanka will increase by 125.01 mm from 2020 to 2100 according to all models. Nonetheless, noteworthy differences emerge in the monthly projections among the models. Under the SSP5-8.5 scenario, the models exhibit variations in the anticipated rainfall for the specified period. The CANESM5 model predicts the most substantial increase in rainfall, amounting to 868.16 mm, followed by the MIROC-ES2L model at 297.13 mm. The HADAEM3-GC31-LL model predicts 371.17 mm, the NORESM2-LM model forecasts 530.44 mm, and the EC-EARTH3 model estimates 266.48 mm, all of which also predict increases. The models demonstrating the smallest annual rainfall increases are BCC-CSM2-MR (17.82 mm) and CNRM-CM6-1 (92.36 mm), as shown in Figure 10.

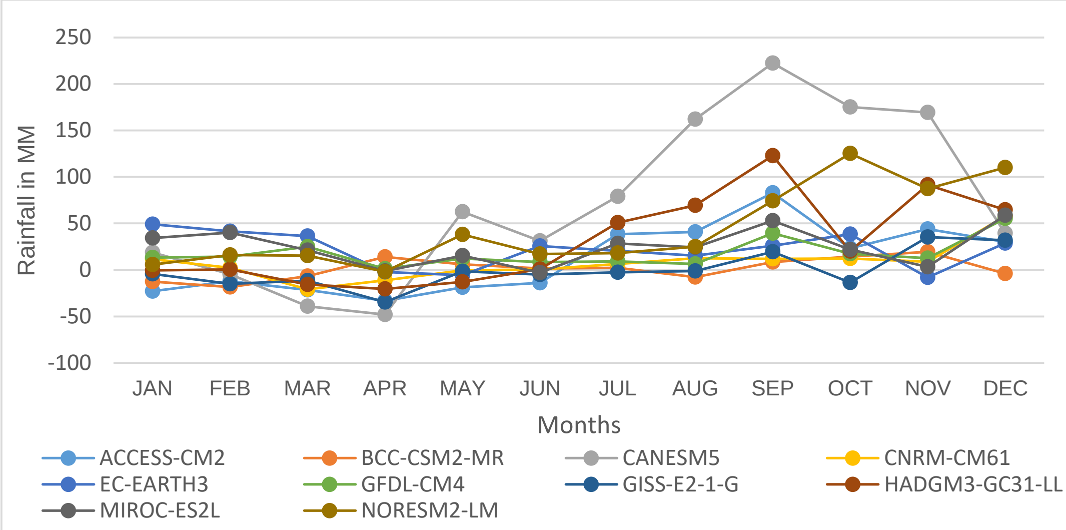

Figure 10: Various models projected rainfall of the Central region of Sri Lanka for the period from 2020 to 2100 under the SSP 8.5 scenario

4.5 Temperature Trends

Based on the combined results of various models under the Shared Socioeconomic Pathways (SSPs) 2-4.5 regarding carbon emission scenarios for the years 2020 to 2100, the anticipated temperature change in the Central Province indicates an average increase of 1.17°C. The month of May is expected to experience the most significant temperature rise at 1.33°C, while September is projected to show the smallest increase at 1.02°C.

The projected temperature increase for the Central Province under the SSP2-4.5 scenarios is anticipated as follows:

- 2020 to 2039: An increase of 0.56°C
- 2040 to 2059: An increase of 1.00°C
- 2060 to 2079: An increase of 1.40°C
- 2080 to 2099: An increase of 1.72°C

The cumulative average temperature increase from 2020 to 2100 is projected to reach 1.17°C. Under SSP5-8.5, the anticipated temperature change for the same period indicates an average increase of 1.94°C. May continues to be the month with the most significant projected rise at 2.17°C, while September shows the least increase at 1.74°C.

In the context of SSP2-4.5 scenarios from 2020 to 2100, under higher emission scenarios (SSPs 5-8.5), the projected temperature rise for the Central Province is expected to follow these trends:

- 2020 to 2039: An increase of 0.62°C
- 2040 to 2059: An increase of 1.44°C
- 2060 to 2079: An increase of 2.41°C
- 2080 to 2099: An increase of 3.31°C

The cumulative average temperature increase from 2020 to 2100 is projected to reach 1.94°C. Among the various models, the HADAEM3-GC31-LL model forecasts the most significant temperature increase of 2.71°C, while the NORESM2-LM model predicts the least rise at 1.4°C. The CANESM5 model, compared to other models, predicts a peak temperature of 3.07°C in August, while the NORESM2-LM model forecasts a minimum value of 1.09°C in March. The temperature in the Central Province is expected to rise progressively over time, with each model providing distinct projections of future temperature change in the study area. Table 1 presents the monthly temperature changes under the SSP2-4.5 scenarios, as projected by the various models. These projections highlight the variability in temperature increases predicted by different models, with HADAEM3-GC31-LL forecasting the highest rise (2.72°C) and NORESM2-LM predicting the lowest (1.40°C).

Table 1: Monthly basis projected temperature changes in various models under SSP2 4.5 scenarios for the Central region of Sri Lanka.

Type of Models	Increasing average values in °C (2020- 2100)
ACCESS-CM2	2.49°C
BCC-CSM2-MR	1.67°C
CANESM5	2.70°C
CNRM-CM6	2.41°C
EC-EARTH3	2.33°C
GFDL-CM4	1.95°C
GISS-E2-1-G	2.02°C
HADAEM3-GC31-LL	2.72°C
MIROC-ES2L	1.44°C
NORESM2-LM	1.40°C

4.6 Rainfall Trends

Based on the aggregated outcomes of various models under the SSPs 2-4.5 carbon emission scenarios for the years 2020 to 2100, the anticipated change in rainfall for the Central Province indicates an annual average increase of 105.56 mm. November is projected to experience the most significant rise in rainfall, amounting to 124.62 mm, while March is expected to witness the largest decline, estimated at -35.61 mm. Each model offers unique projections regarding future rainfall increases in the study area. Table 2 illustrates the monthly variations in rainfall under the SSP2-4.5 scenarios, as forecasted by the various models.

Table 2: Monthly basis projected rainfall changes in various models under SSP2 4.5 scenarios for the Central region of Sri Lanka.

Type of Models	Increasing average values in mm (2020- 2100)
ACCESS-CM2	148.35mm
BCC-CSM2-MR	23.56mm
CANESM5	600.48mm
CNRM-CM6	65.84mm
EC-EARTH3	125.84mm
GFDL-CM4	166.78mm
GISS-E2-1-G	100.99mm
HADAEM3-GC31-LL	267.76mm
MIROC-ES2L	123.52mm
NORESM2-LM	420.27mm

These projections reveal considerable variability among the models, with CANESM5 predicting the most substantial increase of 600.48 mm, while BCC-CSM2-MR forecasts the least at 23.56 mm. Under the SSP 5-8.5 scenario, the annual average rainfall is anticipated to rise by 125.01 mm. November continues to show the most significant increase in rainfall at 184.77 mm, while March is expected to witness the largest decline at -55.39 mm. Among the models, CANESM5 predicts the greatest rainfall increase of 868.16 mm, while the GISS-E2-1-G model estimates the lowest increase at -2.68 mm. Furthermore, CANESM5 projects the maximum rainfall for September at 222.39 mm and the most considerable decrease for March at -47.98 mm. Rainfall trends in the Central Province display variability, marked by alternating periods of increase and decrease. Each model provides distinctive forecasts for future rainfall escalation in the study area. Table 3 illustrates the monthly rainfall variations under the SSP5-8.5 scenarios, as projected by the various models.

Table 3: Monthly basis projected rainfall changes in various models under SSP5 8.5 scenarios for the Central region of Sri Lanka.

Type of Models	Increasing average values in mm (2020- 2100)
ACCESS-CM2	137.33mm
BCC-CSM2-MR	17.82mm
CANESM5	868.16mm
CNRM-CM6	92.36mm
EC-EARTH3	266.48mm
GFDL-CM4	215.88mm
GISS-E2-1-G	-2.68mm
HADAEM3-GC31-LL	371.17mm
MIROC-ES2L	297.13mm
NORESM2-LM	530.44mm

5.0 Discussion

The Central Province of Sri Lanka, characterized by its mountainous terrain and unique climate, is likely to experience significant changes in temperature and rainfall patterns due to climate change. These changes could have profound implications for agriculture, water resources, biodiversity, and the livelihoods of communities in the region. Recent studies indicate that Sri Lanka has been experiencing an increase in mean temperatures. The analysis shows that the country has recorded a noticeable rise in temperature over the past few decades. Projections for the Central Province suggest an increase in the average temperature by about 1.5 to 2.0 degrees Celsius by 2050, with higher elevations experiencing different rates of change compared to lower elevations (Dasandara et al., 2021).

Rainfall variability is another critical factor that will impact the Central Province. The region typically experiences two monsoon seasons: the Southwest Monsoon and the Northeast Monsoon. However, projections indicate that the monsoonal patterns may become more erratic, with both increases and decreases in rainfall amounts. While overall annual rainfall may not change significantly, the intensity of rainfall during the monsoon seasons could increase, leading to more frequent flooding, particularly in valley regions. Conversely, the Central Province may also experience prolonged dry spells at other times of the year, resulting in drought conditions. A study by Battaramulla et al. (2021) highlights that some areas could see a 20-30% reduction in rainfall during certain months.

Traditional cropping systems in the Central Province, which rely heavily on predictable rainfall patterns, may become increasingly vulnerable. Adjustments to planting schedules and crop types may be necessary to adapt to these changes. The Central Province is home to a rich diversity of flora and fauna. Changes in temperature and precipitation could disrupt ecosystems, leading to shifts in species distribution and potentially causing some species to become endangered (Jayawardena, 2012). Altered rainfall patterns will affect water availability, influencing both domestic water supply and irrigation for agriculture. This could exacerbate competition for water resources among different sectors (Perera & Rathnayake, 2019). The increase in extreme weather events will also pose health risks, ranging from heat-related illnesses due to rising temperatures to waterborne diseases linked to flooding and changes in water quality. Agriculture is a significant part of the economy in the Central Province. Adaptation strategies such as improved farming techniques, crop diversification, and water management practices will be essential for maintaining agricultural productivity (Jayawardene et al., 2020).

Article Journal of Asian Geography, 2025, Volume 4 (Issue 1), 10-19.
https://doi.org/10.36777/jag2025.4.1.2

6.0 Conclusion

Climate change continues to be one of the most pressing global challenges. It has become a global issue, presenting multifaceted dangers to various nations. This urgent challenge is linked to political, economic, social, and international relational dilemmas. Despite the urgency, research on climate change awareness among the populace of Sri Lanka, particularly regarding future climate scenarios, remains alarmingly inadequate. Additionally, region-specific studies are exceedingly scarce. This research aims to analyze the anticipated climate change within Sri Lanka's Central Province across diverse future scenarios. By investigating the future climate dynamics of the Central Province, this study seeks to guide policy decisions and advocate for sustainable practices to mitigate the impacts.

This study identified an upward trend in projected temperature and precipitation under varying future climate scenarios for Sri Lanka's Central Province. Using a multi-model ensemble approach, a wide range of changes in temperature and precipitation patterns were illustrated. From 2020 to 2100, different models yielded divergent values. Specifically, under SSP2-4.5, the temperature is projected to rise by 1.17 degrees Celsius, accompanied by an increase in precipitation of 105.56 mm. Conversely, under the SSP5-8.5 scenario, temperatures may rise by 1.94 degrees Celsius with a precipitation increase of 125.01 mm. As a primary climate variable, temperature rise is expected to significantly impact the region's climatic conditions, physical infrastructure, and socio-economic frameworks. Additionally, the frequency of extreme weather events is anticipated to increase.

Promoting sustainable development in the Central Province is of utmost significance in adapting to the climate change challenges prevailing in the study area. Considering its vulnerability to the impacts of future climate change, it is imperative to implement measures that mitigate these effects. In this regard, the following developmental recommendations are proposed to adapt to forthcoming shifts in rainfall and temperature within the Central Province: (1) Formulating future strategies to regulate temperature increases, with a rise of 1.17°C projected under SSP2-4.5 and 1.94°C under SSP5-8.5; (2) Executing strategic plans for future rainfall management, factoring in an increase of 105.56 mm under SSP2-4.5 and 125.01 mm under SSP5-8.5; (3) Augmenting disaster management for droughts and floods in light of seasonal temperature and rainfall variations under both SSP2-4.5 and SSP5-8.5, alongside the construction of new reservoirs and the use of cascade methods for water conservation; (4) Minimizing the impacts of future climate change by curtailing carbon emissions under SSP5-8.5 and reducing emissions under SSP2-4.5; and (5) Fostering climate-resilient urban planning to adapt effectively to evolving climatic conditions.

Strategies aimed at reducing carbon emissions and enhancing climate resilience must be prioritized. By emphasizing sustainable agricultural practices, efficient water resource management, infrastructural development, and the conservation of coastal ecosystems, the adverse effects of climate change on the region can be significantly mitigated. Furthermore, raising individual and community awareness is recognized as one of the most effective ways to confront climate change. As individual consciousness expands into community, regional, and national awareness, collective action on climate change can profoundly reduce our overall impact.

Acknowledgement: I would like to express my sincere gratitude to the editor and reviewers for their invaluable feedback and thoughtful suggestions. Their expertise and dedication have greatly contributed to enhancing the quality of this work. I truly appreciate their time and effort in reviewing this manuscript.

Conflicts of Interest: The authors declare that there are no conflicts of interest.

References

Agonafir, C., Lakhankar, T., Khanbilvardi, R., Krakauer, N., Radell, D., Devineni, N., Gaurkhede, N. T., Adane, V. S., Shekhar, M. S., Gupta, P., Sharma, V., Nag, K., Paul, S., Saklani, D. R., Venkatramanan, V., Singh, G. P., Singh, A., Pakhale, G., Nale, J., … Sujatha, E. R. (2024). Land and atmospheric drivers of the 2023 flood in India. Climate, 12(10), 1–17. https://doi.org/10.1029/2024EA003750

Alahacoon, N., & Edirisinghe, M. (2021a). Spatial variability of rainfall trends in Sri Lanka from 1989 to 2019 as an indication of climate change.

Alahacoon, N., & Edirisinghe, M. (2021b). Spatial variability of rainfall trends in Sri Lanka from 1989 to 2019 as an indication of climate change. ISPRS International Journal of Geo-Information, 10(2). https://doi.org/10.3390/ijgi10020084

Arfasa, G. F., Owusu-Sekyere, E., & Doke, D. A. (2024). Climate change projections and impacts on future temperature, precipitation, and streamflow in the Vea catchment, Ghana. Environmental Challenges, 14, 100813. https://doi.org/10.1016/j.envc.2023.100813

Dananjaya, P. K. V. S., Shantha, A. A., & Patabendi, K. P. L. N. (2022). Impact of climate change and variability on paddy cultivation in Sri Lanka. Research Square, 1–13. https://doi.org/10.21203/rs.3.rs-2149945/v1

Dasandara, S. P. M., Kulatunga, U., Ingirige, M. J. B., & Fernando, T. (2021). Climate change challenges facing Sri Lanka: A literature review. World Construction Symposium, July, 183–195. https://doi.org/10.31705/WCS.2021.16

De Silva, M. M. G. T., & Kawasaki, A. (2018). Socioeconomic vulnerability to disaster risk: A case study of flood and drought impact in a rural Sri Lankan community. Ecological Economics, 152(November 2017), 131–140. https://doi.org/10.1016/j.ecolecon.2018.05.010

Fernando, S., Bandara, J. S., & Smith, C. (2016). Tourism in Sri Lanka. The Routledge Handbook of Tourism in Asia, October, 251–264. https://doi.org/10.4324/9781315768250

Fung, K. F., Huang, Y. F., & Koo, C. H. (2020). Assessing drought conditions through temporal pattern, spatial characteristics, and operational accuracy indicated by SPI and SPEI: Case analysis for Peninsular Malaysia. Natural Hazards, 103(2). Springer Netherlands. https://doi.org/10.1007/s11069-020-04072-y

Grigorieva, E. A. (2024). Climate change and human health in the Arctic: A review. Climate, 12(7). https://doi.org/10.3390/cli12070089

Jayawardena, C. (2012). Challenges of the plantation sector of the Central Province of Sri Lanka. Journal of Agricultural Research, 34–45.

Jayawardene, H., Sonnadara, D., Jayewardene, D., Sandamali, K. U. J., Chathuranga, K. A. M., Zubair, L., Yahiya, Z., Agalawatte, P., Lokuhetti, R., Ehelepola, N. D. B., Ariyaratne, K., Dissanayake, W. P., Jayaratne, A., Bandara, P., Abenayake, C. C., Jayasinghe, A. B., Mahanama, P. K. S., Sanjeewani, R. M. S. S. S. S., Manawadu, L., … Carlson, D. (2020). Spatial and temporal variation of land surface temperature (LST) in the Kandy District of Sri Lanka. Global Health Action, 8(1), 1–20. https://doi.org/10.1088/1755-1315/1266/1/012074

Kumar Guntu, R., & Agarwal, A. (2020). Investigation of precipitation variability and extremes using information theory. Sciforum Electronic Conference Series, 3.

Lescher Soto, I., Villamizar, A., Olivares, B. O., Gutiérrez, M. E., & Nagy, G. J. (2024). Navigating the uncertain terrain: Venezuela’s future using the Shared Socioeconomic Pathways framework—A systematic review. Climate, 12(7). https://doi.org/10.3390/cli12070098

Li, J., Chen, X., Kurban, A., Van de Voorde, T., De Maeyer, P., & Zhang, C. (2021). Coupled SSPs-RCPs scenarios to project the future dynamic variations of water-soil-carbon-biodiversity services in Central Asia. Ecological Indicators, 129, 107936. https://doi.org/10.1016/j.ecolind.2021.107936

Lynas, M., Houlton, B. Z., & Perry, S. (2021). Greater than 99% consensus on human-caused climate change in the peer-reviewed scientific literature. Environmental Research Letters, 16(11). https://doi.org/10.1088/1748-9326/ac2966

Meegahakotuwa, U. S., & Rekha Nianthi, K. W. G. (2023). Environmental studies poster 258: Rainfall variations in Kandy District of Sri Lanka. March.

Meinshausen, M., Nicholls, Z. R. J., Lewis, J., Gidden, M. J., Vogel, E., Freund, M., Beyerle, U., Gessner, C., Nauels, A., Bauer, N., Canadell, J. G., Daniel, J. S., John, A., Krummel, P. B., Luderer, G., Meinshausen, N., Montzka, S. A., Rayner, P. J., Reimann, S., … Wang, R. H. J. (2020). The shared socio-economic pathway (SSP) greenhouse gas concentrations and their extensions to 2500. Geoscientific Model Development, 13(8), 3571–3605. https://doi.org/10.5194/gmd-13-3571-2020

Perera, A., & Rathnayake, U. (2019). Rainfall and atmospheric temperature against the other climatic factors: A case study from Colombo, Sri Lanka. Mathematical Problems in Engineering, 2019. https://doi.org/10.1155/2019/5692753

Qu, J. J., & Motha, R. P. (2022). Climate change and a sustainable earth. https://www.ebsco.com/terms-of-use

Senatilleke, U., Gunathilake, M. B., Alyousifi, Y., & Rathnayake, U. (2022). Analysis of recent trends and variability of temperature and relative humidity over Sri Lanka. Mausam, 73(3), 511–524. https://doi.org/10.54302/mausam.v73i3.3184

Sharma, A., Andhikaputra, G., & Wang, Y. C. (2022). Heatwaves in South Asia: Characterization, consequences on human health, and adaptation strategies. Atmosphere, 13(5), 1–19. https://doi.org/10.3390/atmos13050734

Silva, G. J. D., & Sonnadara, D. U. J. (2009). Climate change in the hill country of Sri Lanka. Proceedings of the Technical Sessions, 25(March 2009), 7–12.

Somasundaram, D., Zhang, F., Ediriweera, S., Wang, S., Li, J., & Zhang, B. (2020). Spatial and temporal changes in surface water area of Sri Lanka over a 30-year period. Remote Sensing, 12(22), 1–23. https://doi.org/10.3390/rs12223701

Wimalaratana, W. (2023). Cultural tourism potential in the Northwestern Province of Sri Lanka. Colombo Economic Journal (CEJ), 1(April), 27–48.

Xiang, Y., Wang, Y., Chen, Y., & Zhang, Q. (2022). Impact of climate change on the hydrological regime of the Yarkant River Basin, China: An assessment using three SSP scenarios of CMIP6 GCMs. Remote Sensing, 14(1). https://doi.org/10.3390/rs14010115