DOI: https://doi.org/10.4038/jepsl.v15i1.7925

*Journal of Environmental Professionals Sri Lanka: 2026 – Vol. 15 – No. 1*

# Assessing the Impact of Climate variability on Coastal Tourism in Sri Lanka

**W P I Weerasinghe [1] , U T G Perera [1] and M R M P Jayasinghe[1]**

[1]Department of Geography, University of Colombo, Colombo, Sri Lanka
Corresponding author: imasha0001220@gmail.com , Tel - 0714586675

***Abstract***

*Tourism is one of the fastest-growing sectors globally and the third-largest economic sector in Sri Lanka, with coastal tourism playing a major role. As a climate-sensitive subsector, it is particularly vulnerable to climate variability. This study aimed to examine the impacts of climate variability on coastal tourism in Sri Lanka, focusing on the coastal Grama Niladhari Divisions from Kepungoda to Kammalthura in the Negombo Divisional Secretariat Division. Primary data were gathered through 25 questionnaire surveys, 20 semi-structured interviews, and 5 expert interviews, while secondary meteorological data were obtained from Google Climate Engine 2.1. Both quantitative and qualitative spatial analyses were conducted. The results revealed that rainfall variability is the most influential weather factor affecting coastal tourism in Negombo, with heavy and sudden rain events reducing tourist arrivals and limiting outdoor recreational activities. The study further identified various adaptation strategies already in place to reduce these impacts and ensure sustainability of the tourism sector.*

*Keywords: Climate variability, Climate change, Tourism industry, Coastal tourism*

## 1. Introduction

Tourism is one of the most rapidly expanding sectors of the global economy, contributing nearly 10% of the world's Gross Domestic Product (GDP) and supporting the livelihoods and well-being of millions of people worldwide (World Tourism Organization, 2023). Among its various subsectors, coastal tourism is recognized as one of the most significant due to its dependence on natural attractions such as beaches, coral reefs, and marine biodiversity (Camelia et al., 2011). Countries with extensive coastlines, including the Maldives, Thailand, and Australia, have successfully developed their coastal tourism industries based on these natural resources. However, the sustainability of coastal tourism is increasingly threatened by climate variability, which affects environmental conditions, tourism activities, destination attractiveness, and visitor experiences (Camelia et al., 2011). In addition to climate variability and climate change related hazards, including coastal erosion, sea-level rise, coastal pollution, and marine ecosystem degradation have become

significant concerns affecting the long-term sustainability of coastal tourism destinations.

Numerous studies have examined the impacts of climate variability on coastal tourism in different parts of the world (e.g., Scott et al., 2012; Moreno & Becken, 2009; Amelung & Nicholls, 2014). These studies have demonstrated that variations in rainfall, temperature, wind, and other weather factors influence tourist behaviour, seasonal travel patterns, and tourism-related business operations. Despite the economic importance of tourism in Sri Lanka, limited research has investigated these relationships within the local context. Tourism is the third-largest economic sector in Sri Lanka, and approximately 62% of international tourists identify the country's coastline as one of the primary reasons for visiting (SLTDA, 2019). Negombo is one of the country's leading coastal tourism destinations due to its sandy beaches, rich cultural heritage, lagoon ecosystem, and close proximity to Bandaranaike International Airport. Nevertheless, the area is increasingly vulnerable to climate variability, coastal erosion, sea-level rise, unpredictable rainfall patterns, and coastal pollution, all of which pose challenges to the sustainability and resilience of the tourism sector. This lack of empirical evidence highlights the need for research that examines how climate variability influences tourism activities in Sri Lanka's coastal destinations.

Accordingly, this study examines the impacts of climate variability on coastal tourism in the Negombo Coastal Tourism Zone. Specifically, the study aims to identify the major weather factors affecting tourism activities, analyse their spatial and temporal variability, assess the perceptions of tourists and tourism service providers regarding climate-related impacts, and examine the adaptation strategies adopted to minimise these impacts. By integrating quantitative weather data with qualitative evidence from key tourism stakeholders, this study provides a comprehensive assessment of the relationship between climate variability and coastal tourism. The findings are expected to contribute to climate-resilient tourism planning, sustainable destination management, and evidence-based policy development for Sri Lanka's coastal tourism sector.

## 2. Materials and Methods

### *2.1 Study Site*

This research is based on the Negombo Coastal Tourism Zone, one of the most prominent coastal tourist destinations in the Western Province of Sri Lanka. Located

approximately 37 kilometers north of Colombo along the western coastline, this zone is characterized by its sandy beaches, vibrant fishing industry, and a wide range of tourism-related activities. Consequently, the local economy of Negombo is heavily dependent on the tourism sector.

In addition, the Negombo Lagoon represents a unique ecological system within this zone. It provides opportunities for various recreational and ecotourism activities such as boat rides, fishing, and birdwatching, making it a distinctive natural asset. However, the area is increasingly exposed to climate change-related hazards including coastal erosion, sea level rise, and unpredictable weather patterns. These threats pose significant challenges to the sustainability of the tourism industry in Negombo. Therefore, understanding these vulnerabilities is crucial for developing effective adaptation strategies to ensure the long-term resilience of the coastal tourism sector in this region.

The Negombo Coastal Tourism Zone extends from Kepungoda to Kammalthura within the Negombo Divisional Secretariat Division, encompassing several coastal Grama Niladhari Divisions. It is bounded to the north by the Wennappuwa Divisional Secretariat Division, to the east by the Negombo Lagoon and adjacent Grama Niladhari Divisions, to the south by the Ja-Ela Divisional Secretariat Division, and to the west by the Indian Ocean. This strategic coastal positioning enhances Negombo's significance as a major tourism destination, offering both ecological and economic value.

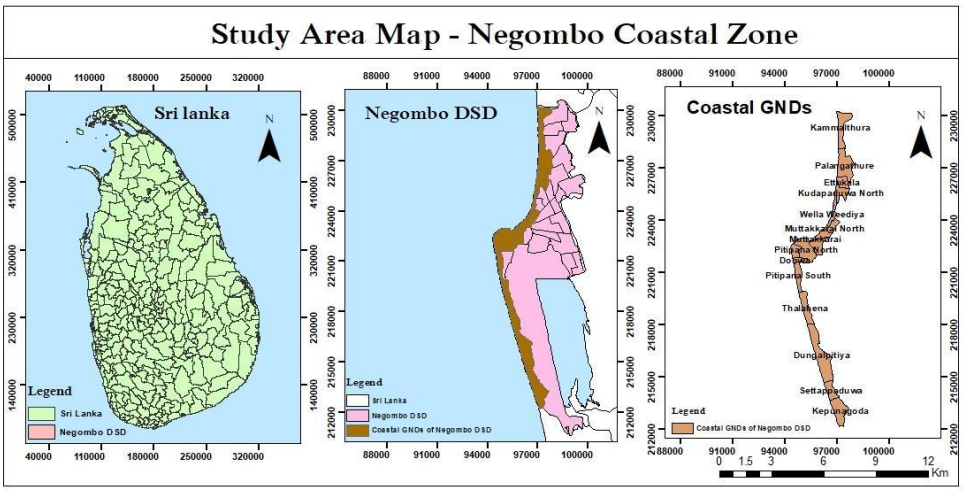



Figure 1: Study Area Map

### *2.2 Methodology*

This study adopted a mixed-methods research approach, integrating quantitative and qualitative methods to comprehensively assess the impacts of climate variability on coastal tourism in the Negombo Coastal Tourism Zone. The quantitative component focused on analysing the temporal and spatial variability of weather variables, including rainfall, temperature, humidity, and wind speed, while the qualitative component explored the perceptions and experiences of tourists, tourism service providers, and tourism experts regarding the impacts of climate variability on tourism activities. The integration of these two approaches enabled the triangulation of findings, thereby improving the validity, reliability, and comprehensiveness of the study.

### *2.3 Data Collection*

Both primary and secondary data were collected to achieve the study objectives.

#### *2.3.1 Primary Data Collection*

Primary data were collected through questionnaire surveys, semi-structured interviews, and key informant interviews conducted within the Negombo Coastal Tourism Zone.

A total of 25 tourists were selected using a convenience sampling technique, as tourists were available only for a limited period during their visits. This method enabled the collection of information regarding tourists' experiences and perceptions of climate variability affecting coastal tourism activities.

A total of 20 tourism service providers, including hotel operators, restaurant owners, tour guides, and other tourism-related stakeholders, were selected using the snowball sampling technique. This approach was adopted because no comprehensive list of tourism service providers was available, and referrals from initial participants facilitated the identification of additional respondents with relevant experience.

In addition, five tourism and climate experts were selected through purposive sampling based on their professional expertise and research experience in tourism, climatology, and environmental management. These interviews provided in-depth insights into the impacts of climate variability on tourism and the adaptation measures currently adopted within the sector.

Although the sample size was relatively small, it was considered appropriate for this exploratory mixed-methods study because the primary objective was to obtain detailed stakeholder perspectives while complementing these findings with long-term weather data. Nevertheless, the use of non-probability sampling limits the generalisability of the findings, and this limitation should be considered when interpreting the results.

*2.3.2 Secondary Data Collection*

Secondary weather data covering the period 2011–2023 were collected for rainfall, temperature, humidity, and wind speed. The weather data was obtained from Google Climate Engine (Version 2.1) using centroid points representing the fifteen coastal Grama Niladhari Divisions extending from Kepungoda to Kammalthura. These data were extracted and processed to analyse the temporal and spatial variability of weather conditions across the study area.

*2.4 Data Analysis*

Qualitative data obtained from interviews and questionnaire surveys were transcribed, coded, and analysed using thematic analysis with QualCoder (Version 3.1). The identified themes were used to understand stakeholder perceptions of climate variability, its impacts on tourism activities, and existing adaptation strategies.

Quantitative weather data were analysed using Microsoft Excel 2016, SPSS Statistics 2022, and ArcMap 10.8. Descriptive statistical analyses were performed to summarise weather variables, while Two-Way Analysis of Variance (ANOVA) was applied to examine temporal and spatial variations in rainfall, temperature, humidity, and wind speed across the study area. Statistical significance was assessed at the 95% confidence level ($p < 0.05$). Spatial distribution maps were developed using ArcMap 10.8 to illustrate the geographic variability of weather conditions within the Negombo Coastal Tourism Zone.

## 3. **Results and Discussion**

The results of the qualitative and quantitative analyses conducted to identify the impacts of unexpected weather variations, arising from climate change, on the Negombo coastal tourism sector in Sri Lanka are presented in the following sections.

### *3.1 Results of Quantitative Analysis*

Figure 2. Word cloud illustrates the weather factors identified by tourists, tourism service providers, and experts during interviews.

The qualitative analysis of interviews and questionnaire responses identified several weather factors perceived to influence tourism activities in the Negombo Coastal Tourism Zone. The most frequently mentioned factors were rainfall, flash floods, wind, and sea-level rise (Figure 2). Among these, rainfall variability was consistently identified by tourists, tourism service providers, and experts as the most influential weather factor affecting tourism activities.

Participants reported that sudden rainfall events disrupted beach recreation, water sports, sightseeing, and outdoor dining activities. Tourism service providers further noted that unexpected rainfall reduced customer arrivals and affected business operations, particularly during peak tourist periods. In contrast, wind variability was generally considered manageable because weather forecasts enabled tourism operators to adjust their activities accordingly.

#### *3.1.2 Rainfall*




Interviews revealed that rainfall variability has a substantial influence on tourism activities in the Negombo Coastal Tourism Zone. Participants indicated that sudden rainfall reduced tourists' participation in outdoor

recreational activities such as sunbathing, beach walks, surfing, boating, and sightseeing. Many respondents also reported that heavy rainfall negatively affected visitor satisfaction by limiting opportunities to experience coastal attractions.

Some respondents indicated that light rainfall or drizzle did not significantly affect their travel experience. However, the majority perceived heavy and unpredictable rainfall as a major challenge for coastal tourism.

*3.1.3 Floods*

Flash floods associated with intense rainfall were identified as another important consequence of climate variability. Tourism service providers reported temporary road inundation, reduced accessibility, and interruptions to tourism services during heavy rainfall events. These conditions discouraged tourist movement and affected tourism-related businesses located in low-lying coastal areas.

*3.1.4 Wind*

Interview participants indicated that wind variability had relatively limited impacts on tourism activities. Although stronger winds occasionally affected boating and recreational water activities, most respondents explained that wind conditions could usually be anticipated through weather forecasts, allowing tourism operators to adjust schedules and minimize disruptions.

*3.1.5 Sea Level Rise*

Participants identified sea-level rise as a long-term environmental challenge affecting coastal tourism. Although sea-level rise differs from short-term climate variability, respondents observed gradual beach erosion, reduced recreational beach areas, and increased vulnerability of coastal infrastructure. These changes were perceived as potential threats to the long-term sustainability of tourism in Negombo.

*3.2 Quantitative Analysis*

Based on data obtained from Google Climate Engine, a variability analysis was conducted to identify the spatial and temporal patterns of rainfall, temperature, humidity, and wind variations. The results of the spatial and temporal analyses for each of these weather variables are presented in the following sections.

*3.2.1 Rainfall Variability*

To identify rainfall variability in the Negombo coastal tourism zone, a variability analysis was conducted using the collected data and processed through Excel 2016. The results of this analysis are presented in Table 1.

Table 1. Results of Two-Way ANOVA for Rainfall Variability

| **ANOVA: Two-Factor Without Replication** | | | | |
|---|---|---|---|---|
| ***Summary*** | ***Count*** | ***Sum*** | ***Average*** | ***Variance*** |
| 2011 | 15 | 25029.6 | 1668.64 | 345.944 |
| 2012 | 15 | 27437.8 | 1829.186667 | 691.8940952 |
| 2013 | 15 | 25566.4 | 1704.426667 | 3977.18781 |
| 2014 | 15 | 32264.3 | 2150.953333 | 1042.561238 |
| 2015 | 15 | 39236.6 | 2615.773333 | 1032.056381 |
| 2016 | 15 | 25452.6 | 1696.84 | 823.8125714 |
| 2017 | 15 | 28264.4 | 1884.293333 | 875.7192381 |
| 2018 | 15 | 34704.8 | 2313.653333 | 2852.402667 |
| 2019 | 15 | 32680.3 | 2178.686667 | 2428.058381 |
| 2020 | 15 | 24119.2 | 1607.946667 | 2679.328381 |
| 2021 | 15 | 37902.1 | 2526.806667 | 4522.31781 |
| 2022 | 15 | 29429.2 | 1961.946667 | 516.6998095 |
| 2023 | 15 | 39480.6 | 2632.04 | 2173.166857 |
| | | | | |
| Kammalthura | 13 | 25905 | 1992.692308 | 134090.8974 |
| Palangathure | 13 | 26685 | 2052.692308 | 137975.0641 |
| Ettukala | 13 | 26912 | 2070.153846 | 127800.8077 |
| Kudapaduwa North | 13 | 26127 | 2009.769231 | 131074.5256 |
| Wellaweeediya | 13 | 26662 | 2050.923077 | 136464.0769 |
| Muttakkarai | 13 | 26762 | 2058.615385 | 140217.9231 |
| Muttakkarai North | 13 | 26762 | 2058.615385 | 140217.9231 |
| Pitipana North | 13 | 26762 | 2058.615385 | 140217.9231 |
| Pitipana central | 13 | 26662 | 2050.923077 | 136464.0769 |
| Doowa | 13 | 26762 | 2058.615385 | 140217.9231 |
| Pitipana South | 13 | 26662 | 2050.923077 | 136464.0769 |
| Thalahena | 13 | 26762 | 2058.615385 | 140217.9231 |
| Dungalpitiya | 13 | 27222 | 2094 | 143600.3333 |
| Seththapaduwa | 13 | 27440 | 2110.769231 | 145303.6923 |
| Kepungoda | 13 | 27480.9 | 2113.915385 | 145239.5681 |

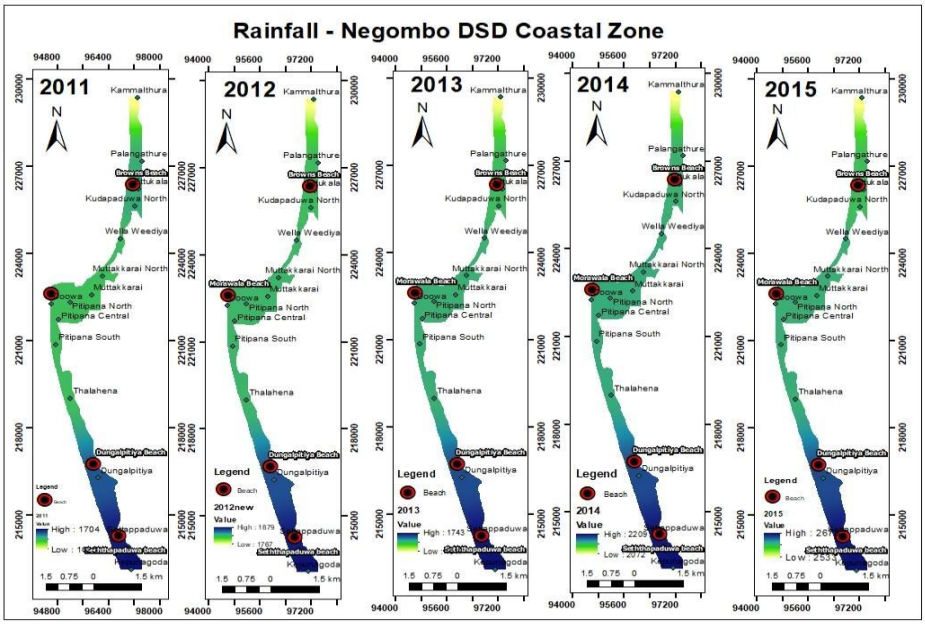
| ANOVA *Source of Variation* | *SS* | *df* | *MS* | *F* | *P-value* | *F crit* |
|---|---|---|---|---|---|---|
| **Rows** | 2.5E+07 | 12 | 2062887.294 | 2277.736325 | 4.2E-179 | 1.810189166 |
| **Columns** | 183302.8 | 14 | 13093.05741 | 14.45669502 | 2.53E-22 | 1.751053567 |
| **Error** | 152153.3 | 168 | 905.6743187 | | | |
| **Total** | 2.5E+07 | 194 | | | | |

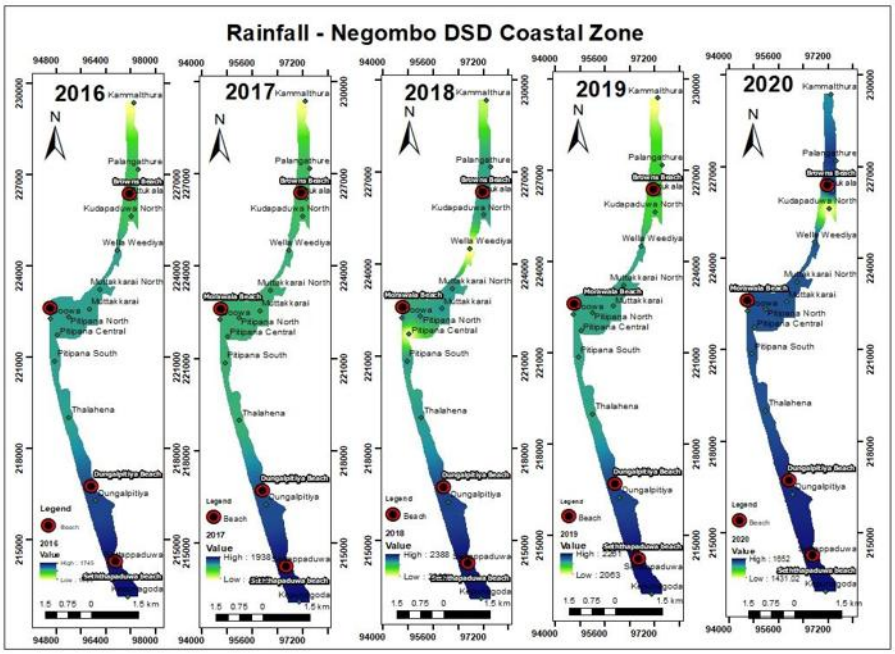
A Two-Way Analysis of Variance (ANOVA) was performed to examine temporal and spatial variability in rainfall across the fifteen coastal Grama Niladhari Divisions between 2011 and 2023. The analysis demonstrated statistically significant temporal variation among years ($F(12,168) = 2277.74$, $p < 0.001$), indicating considerable inter-annual variability in rainfall. Similarly, rainfall varied significantly among the fifteen Grama Niladhari Divisions ($F(14,168) = 14.46$, $p < 0.001$), confirming significant spatial variability within the study area.

Table 2. Summary of Two-Way ANOVA Results for Rainfall Variability

| *Source of Variation* | *df* | *F* | *P-value* | *Interpretation* |
|---|---|---|---|---|
| **Year** | 12 | 2277.74 | <0.001 | Significant temporal variability |
| **GN Division** | 14 | 14.46 | <0.001 | Significant spatial variability |

Furthermore, the analysis indicated the presence of spatial variability in rainfall across the study area at the same confidence level. These spatial patterns are further illustrated in Figure 3, which presents the rainfall distribution map.


Rainfall - Negombo DSD Coastal Zone
2011
2012
2013
2014
2015
Kammalthura
Palangathure
Browns Beach
Kudapaduwa North
Wella Weediya
Muttakkarai North
Muttakkarai
Boowa
Pitipana North
Pitipana Central
Pitipana South
Thalahena
Dungalpitiya Beach
Dungalpitiya
Sekkithopaduwe Beach
Legend
Beach
Value
High : 1704
High : 1879
High : 1743
High : 2209
High : 267
1.5 0.75 0 1.5 km


Rainfall - Negombo DSD Coastal Zone
2016
2017
2018
2019
2020
Kammalthura
Palangathure
Browns Beach
Kudapaduwa North
Wella Weediya
Muttakarai North
Muttakarai
Pitipana North
Pitipana Central
Pitipana South
Thalahena
Dungalpitiya Beach
Dungalpitiya
Seththapaduwa Beach
Legend
Beach
Value
N
1.5 0.75 0 1.5 km

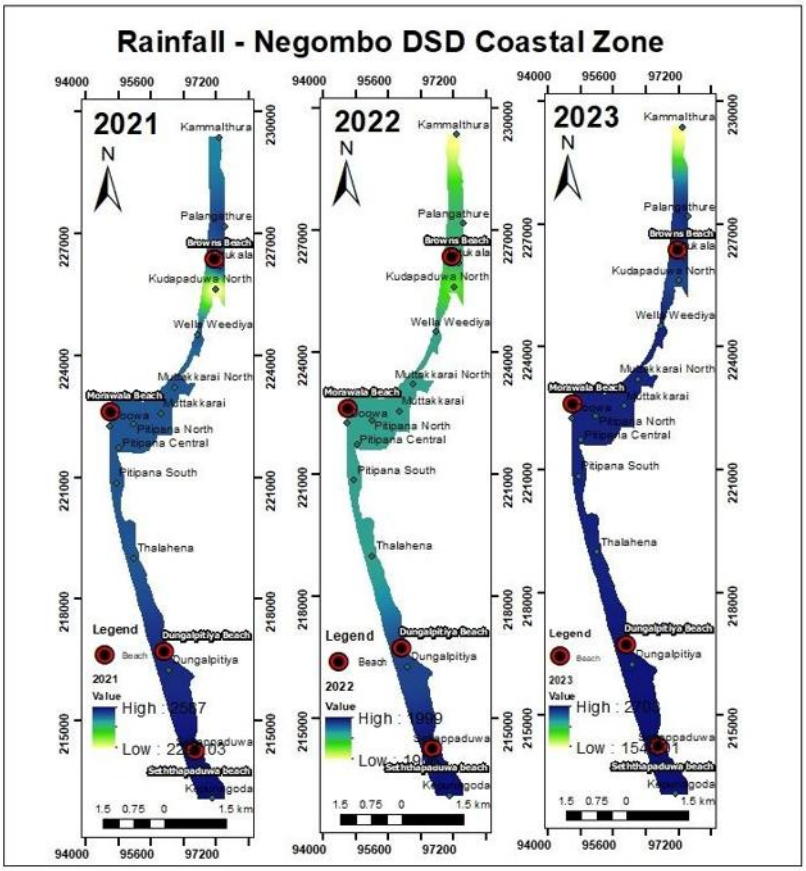



Figure 3 : Rainfall Spatial Distribution Map

According to the rainfall distribution map presented in Figure 3, a relatively uniform rainfall pattern was observed in the Negombo coastal tourism zone during the period 2011–2019. Within this period, Kammalthura, located at the upper boundary of the study area, recorded the lowest rainfall, while the central zone, including Palangathura, Kuda Paaduwa North, Wella Veediya, Muttukattara North, Muttukkara, Duwa, Pitipana North, Pitipana Central, Pitipana South, and Talahena, experienced moderate rainfall. The lower zone, comprising Dungalpitiya and Seththapaduwa, recorded the highest rainfall.

However, during 2020 and 2021, significant deviations in the spatial pattern were observed. Although a relatively uniform rainfall distribution occurred across the

study area, Kuda Paaduwa North recorded the lowest rainfall. In 2022, the spatial variability of rainfall across the upper, central, and lower zones re-emerged, similar to the earlier period. By 2023, a uniform rainfall distribution was again observed throughout the study area, with Kammalthura reporting the minimum rainfall. These observations indicate the unpredictable nature of rainfall within the study region.

Based on data for 2023, it was further identified that areas with high tourist attraction, including Negombo Beach, Browns Beach, Ethukala Beach, and Morawala Beach, exhibited positive rainfall variability. Consequently, this variability was found to have a direct impact on tourism activities in these locations.

Furthermore, interviews revealed that one significant impact of rainfall variability is flooding. To verify this, a temporal distribution analysis of rainfall was conducted, the results of which are presented in Figure 4.

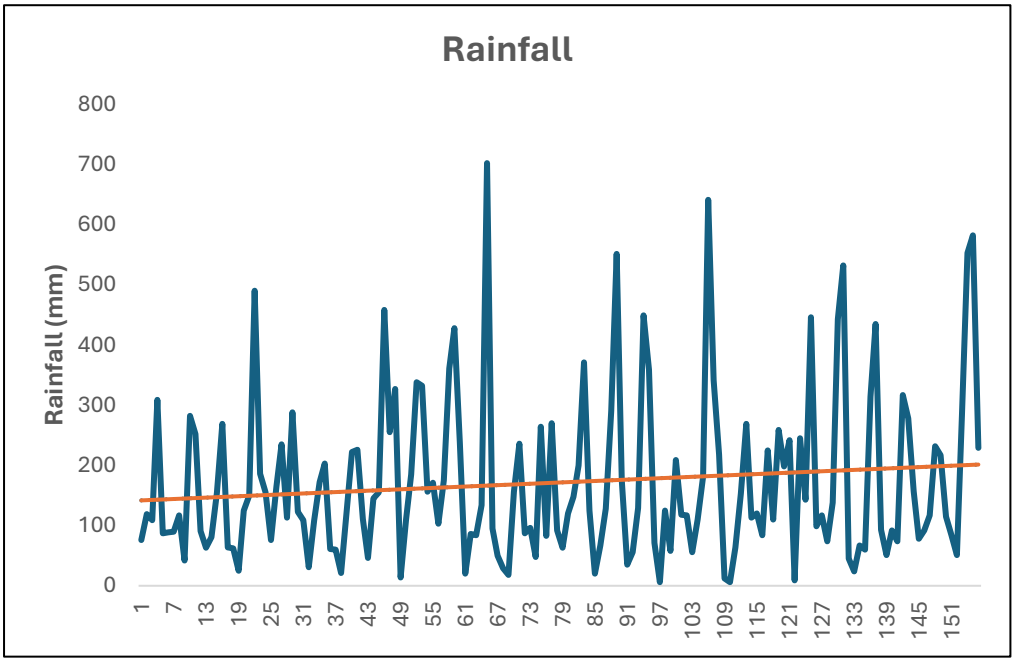



Figure 4 : Time Series Analysis of Rainfall

Although a positive trend in rainfall can be observed from the above figure, it cannot be presented with statistical confidence. Therefore, while a positive rainfall trend in the Negombo tourism zone was identified, it cannot be conclusively stated with a

confidence level, and consequently, it cannot be confirmed whether this trend has escalated to a flood-inducing level.

*3.2.2 Temperature Variability*

To identify the temporal and spatial patterns of temperature variability within the study area, a two-way ANOVA was conducted using Excel 2016, following the methodology described previously. The results of this analysis are presented in Table 3.

Table 3. Results of Two-Way ANOVA for Temperature Variability

**ANOVA: Two-Factor Without Replication**

| ***Summary*** | ***Count*** | ***Sum*** | ***Average*** | ***Variance*** |
|---|---|---|---|---|
| 2011 | 15 | 469.5167 | 31.30111 | 0.002158 |
| 2012 | 15 | 472.4825 | 31.49883 | 0.002422 |
| 2013 | 15 | 469.7983 | 31.31989 | 0.0032 |
| 2014 | 15 | 472.4558 | 31.49706 | 0.003299 |
| 2015 | 15 | 475.1333 | 31.67556 | 0.002613 |
| 2016 | 15 | 480.2392 | 32.01594 | 0.003417 |
| 2017 | 15 | 471.5125 | 31.43417 | 0.001421 |
| 2018 | 15 | 469.1683 | 31.27789 | 0.00193 |
| 2019 | 15 | 477.7167 | 31.84778 | 0.003412 |
| 2020 | 15 | 481.495 | 32.09967 | 0.002425 |
| 2021 | 15 | 475.16 | 31.67733 | 0.002839 |
| 2022 | 15 | 474.46 | 31.63067 | 0.003308 |
| 2023 | 15 | 477.435 | 31.829 | 0.003918 |
| | | | | |
| Kammalthura | 13 | 411.7333 | 31.67179 | 0.071777 |
| Palangathure | 13 | 412 | 31.69231 | 0.077401 |
| Ettukala | 13 | 412 | 31.69231 | 0.077401 |
| Kudapaduwa North | 13 | 412 | 31.69231 | 0.077401 |
| Wellaweeediya | 13 | 411.0917 | 31.62244 | 0.070236 |
| Muttakkarai | 13 | 411.0917 | 31.62244 | 0.070236 |
| Muttakkarai North | 13 | 411.0917 | 31.62244 | 0.070236 |
| Pitipana North | 13 | 411.0917 | 31.62244 | 0.070236 |
| Pitipana central | 13 | 411.11 | 31.62385 | 0.070559 |

| | | | | |
|---|---|---|---|---|
| Doowa | 13 | 411.0917 | 31.62244 | 0.070236 |
| Pitipana South | 13 | 411.0917 | 31.62244 | 0.070236 |
| Thalahena | 13 | 411.0917 | 31.62244 | 0.070236 |
| Dungalpitiya | 13 | 410.27 | 31.55923 | 0.070424 |
| Seththapaduwa | 13 | 409.8917 | 31.53013 | 0.070805 |
| Kepungoda | 13 | 409.9267 | 31.53282 | 0.071599 |

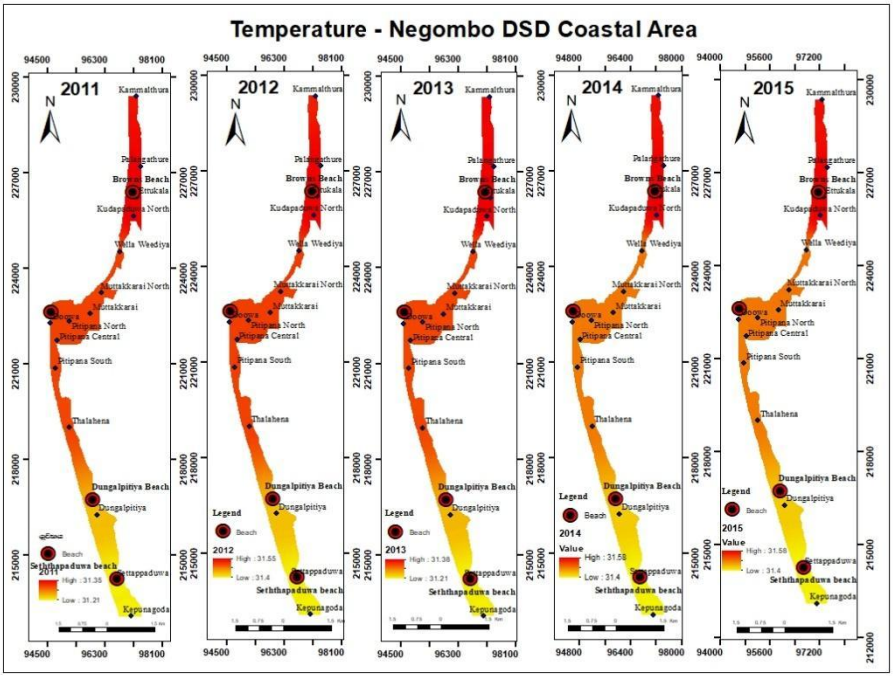
| **ANOVA** | | | | | | |
|---|---|---|---|---|---|---|
| ***Source of Variation*** | ***SS*** | ***df*** | ***MS*** | ***F*** | ***P-value*** | ***F crit*** |
| **Rows** | 12.92814 | 12 | 1.077345 | 9008.655 | 4.4E-229 | 1.810189 |
| **Columns** | 0.489001 | 14 | 0.034929 | 292.0703 | 5.9E-110 | 1.751054 |
| **Error** | 0.020091 | 168 | 0.00012 | | | |
| **Total** | 13.43723 | 194 | | | | |

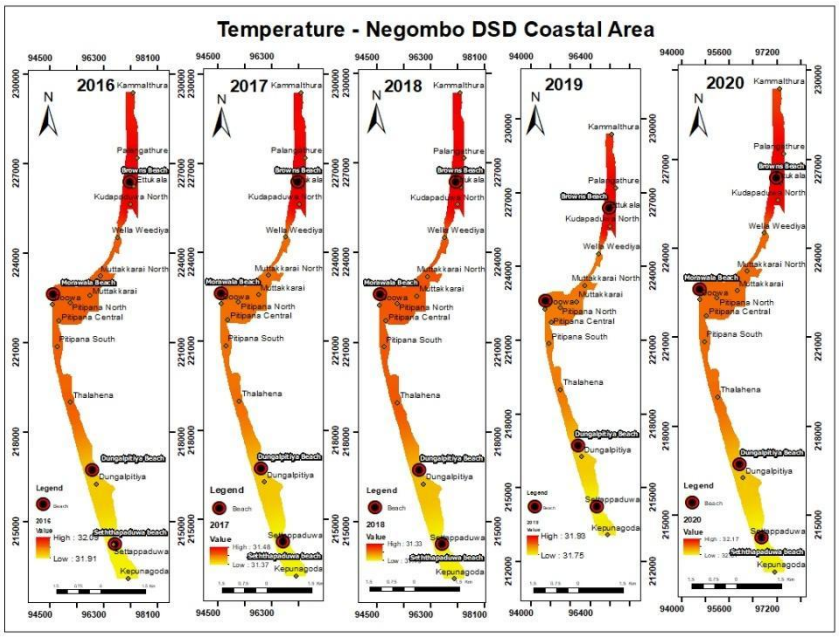
A Two-Way Analysis of Variance (ANOVA) was performed to examine the temporal and spatial variability in temperature across the fifteen coastal Grama Niladhari Divisions between 2011 and 2023. The analysis demonstrated statistically significant temporal variation among years ($F(12,168) = 9008.65$, $p < 0.001$), indicating considerable inter-annual variability in temperature. Similarly, temperature varied significantly among the fifteen Grama Niladhari Divisions ($F(14,168) = 292.07$, $p < 0.001$), confirming significant spatial variability within the study area.

Table 4. Summary of Two-Way ANOVA Results for Temperature Variability

| *Source of Variation* | *df* | *F* | *P-value* | *Interpretation* |
|---|---|---|---|---|
| Year | 12 | 9008.655 | <0.001 | Significant temporal variability |
| GN Division | 14 | 292.0703 | <0.001 | Significant spatial variability |

Further details regarding the spatial distribution of these temperature variations can be observed in Figure 5, which presents the temperature spatial distribution map



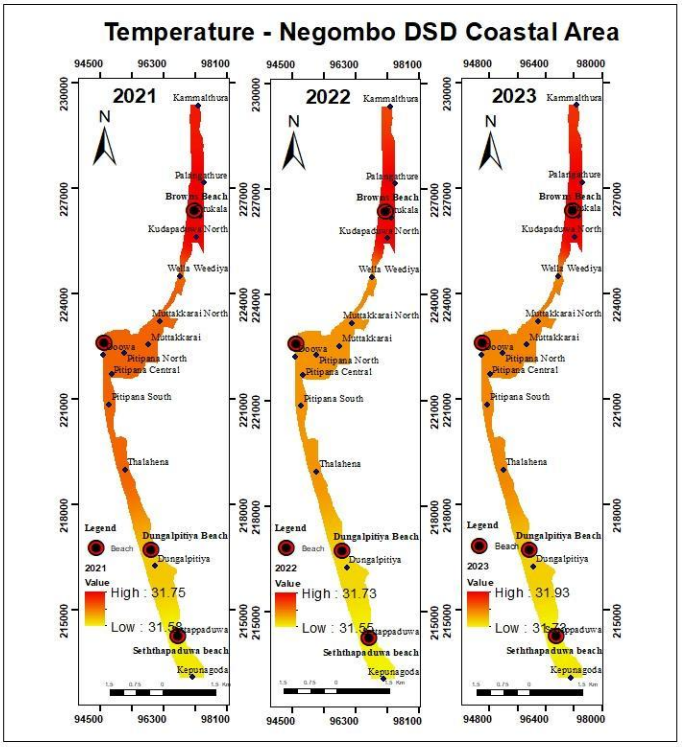



Figure 4 : Temperature Spatial Distribution Map

Based on the temperature spatial distribution map presented above, a consistent pattern of temperature distribution was observed in the study area from 2011 to 2023. The upper limit of the study area, represented by the Kammalthura region, exhibited higher temperatures, while the central region, encompassing Palangathura, Kuda Paduwa North, Wella Vidiya, Muttakkara North, Muttakkara, Duwa, Pitipana North, Pitipana Central, Pitipana South, and Talahena, displayed moderate temperatures. The lower region, including Dungalpitiya and Settipaduwa, recorded relatively lower temperatures. Overall, a slight negative trend in temperature distribution was noted across the study area. Based on data from 2022 and 2023, it was observed that temperatures in the previously high-temperature areas, such as Kammalthura and Palangathura, had decreased. Although temperature variability was identified within the Negombo coastal tourism zone, qualitative and quantitative data confirmed that this variability does not exert a significant impact on tourism activities.

### *3.2.3 Humidity Variability*

The results of the analysis conducted to identify humidity variability within the Negombo coastal tourism zone are presented in Table 5.

Table 5. Results of Two-Way ANOVA for Humidity Variability

| **ANOVA: Two-Factor Without Replication** | | | | |
|---|---|---|---|---|
| ***SUMMARY*** | ***Count*** | ***Sum*** | ***Average*** | ***Variance*** |
| 2011 | 15 | 44.33668 | 2.955778 | 4.33E-06 |
| 2012 | 15 | 44.77014 | 2.984676 | 3.48E-06 |
| 2013 | 15 | 44.38243 | 2.958829 | 6.54E-06 |
| 2014 | 15 | 44.61639 | 2.974426 | 6.9E-06 |
| 2015 | 15 | 44.62935 | 2.97529 | 6.59E-06 |
| 2016 | 15 | 45.557 | 3.037133 | 4.19E-06 |
| 2017 | 15 | 44.92179 | 2.994786 | 4.78E-06 |
| 2018 | 15 | 44.45038 | 2.963358 | 3.73E-06 |
| 2019 | 15 | 45.31738 | 3.021159 | 3.42E-06 |
| 2020 | 15 | 43.93325 | 2.928883 | 4.47E-06 |
| 2021 | 15 | 45.09163 | 3.006108 | 1.28E-07 |
| 2022 | 15 | 44.75284 | 2.983523 | 2.25E-06 |
| 2023 | 15 | 45.85706 | 3.057137 | 7.95E-07 |
| Kammalthura | 13 | 38.81233 | 2.985564 | 0.001323 |
| Palangathure | 13 | 38.81233 | 2.985564 | 0.001323 |
| Ettukala | 13 | 38.81233 | 2.985564 | 0.001323 |
| Kudapaduwa North | 13 | 38.81233 | 2.985564 | 0.001323 |
| Wellaweeediya | 13 | 38.85775 | 2.989058 | 0.001232 |
| Muttakkarai | 13 | 38.85775 | 2.989058 | 0.001232 |
| Muttakkarai North | 13 | 38.85775 | 2.989058 | 0.001232 |
| Pitipana North | 13 | 38.85775 | 2.989058 | 0.001232 |
| Pitipana central | 13 | 38.85775 | 2.989058 | 0.001232 |
| Doowa | 13 | 38.85775 | 2.989058 | 0.001232 |
| Pitipana South | 13 | 38.85775 | 2.989058 | 0.001232 |
| Thalahena | 13 | 38.85775 | 2.989058 | 0.001232 |
| Dungalpitiya | 13 | 38.84048 | 2.987729 | 0.001225 |
| Seththapaduwa | 13 | 38.83225 | 2.987096 | 0.001223 |
| Kepungoda | 13 | 38.83225 | 2.987096 | 0.001223 |

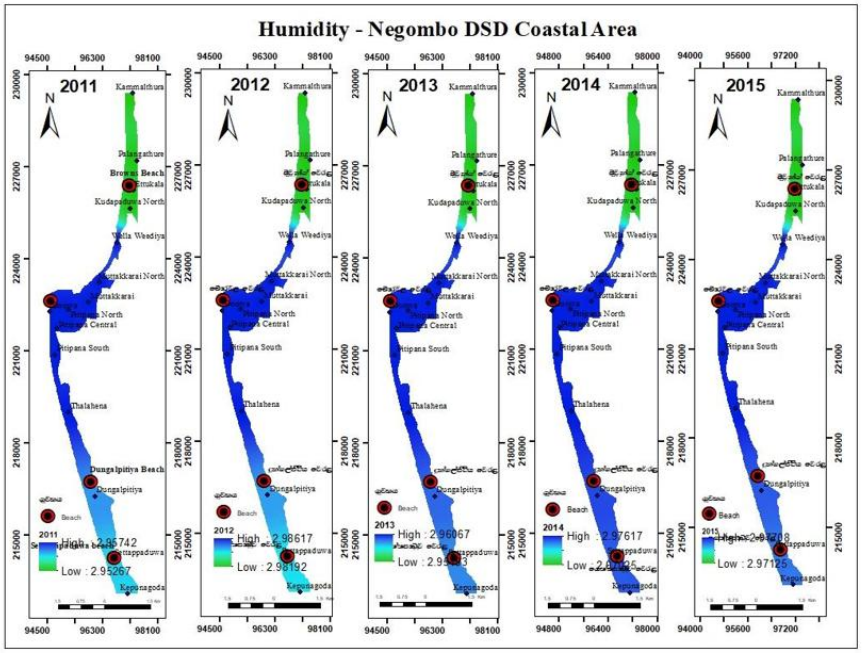
| **ANOVA** | | | | | | |
|---|---|---|---|---|---|---|
| ***Source of Variation*** | ***SS*** | ***df*** | ***MS*** | ***F*** | ***P-value*** | ***F crit*** |
| **Rows** | 0.225524 | 12 | 0.018794 | 11072.61 | 1.3E-236 | 1.810189 |
| **Columns** | 0.000437 | 14 | 3.12E-05 | 18.40301 | 3.91E-27 | 1.751054 |
| **Error** | 0.000285 | 168 | 1.7E-06 | | | |
| | | | | | | |
| **Total** | 0.226246 | 194 | | | | |

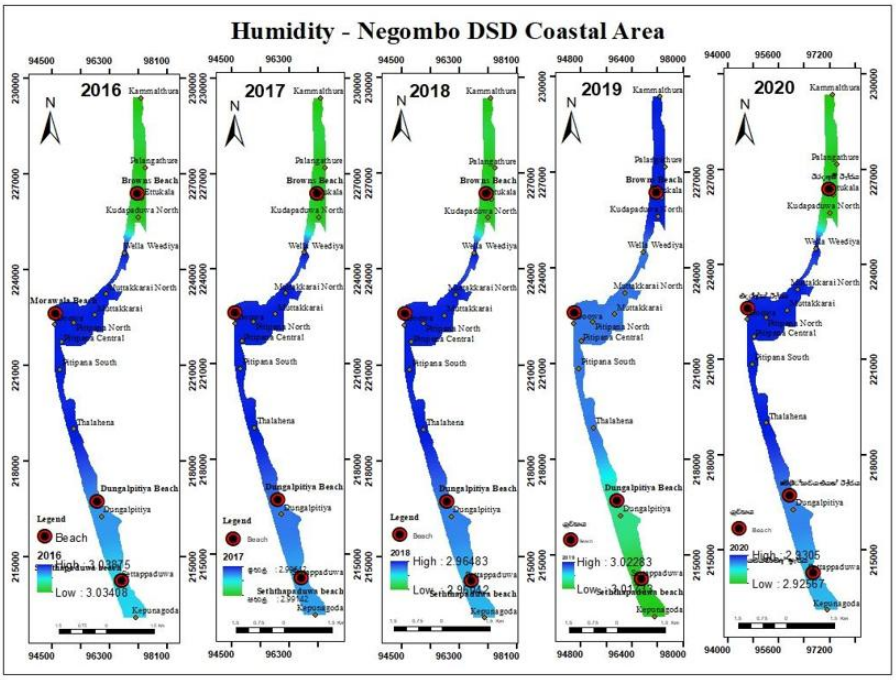
A Two-Way Analysis of Variance (ANOVA) was performed to examine the temporal and spatial variability in humidity across the fifteen coastal Grama Niladhari Divisions between 2011 and 2023. The analysis demonstrated statistically significant temporal variation among years ($F(12,168) = 11072.61$, $p < 0.001$), indicating considerable inter-annual variability in humidity. Likewise, humidity varied significantly among the fifteen Grama Niladhari Divisions ($F(14,168) = 18.40$, $p < 0.001$), confirming significant spatial variability within the study area.

Table 6. Summary of Two-Way ANOVA Results for Humidity Variability

| ***Source of Variation*** | ***df*** | ***F*** | ***P-value*** | ***Interpretation*** |
|---|---|---|---|---|
| Year | 12 | 11072.61 | <0.001 | Significant temporal variability |
| GN Division | 14 | 18.40301 | <0.001 | Significant spatial variability |

Therefore, in order to further examine this spatial distribution, a humidity spatial distribution map was developed, as presented in Figure 5.


Humidity - Negombo DSD Coastal Area
2011
2012
2013
2014
2015
Kammalthurai
Palangathurai
Brown's Beach
Kudapaduwa North
Walla Weediya
Mutakkarai North
Mutakkarai
Pitipana South
Thalahena
Dungalpitiya Beach
Dungalpitiya
Beach
Kepunagoda
N


Humidity - Negombo DSD Coastal Area
2016
2017
2018
2019
2020
Kammalthurai
Palangathurai
Brown's Beach
Kudapaduwa North
Walla Weediya
Mutakkarai North
Mutakkarai
Pitipana South
Thalahena
Dungalpitiya Beach
Dungalpitiya
Legend
Beach
Kepunagoda
N

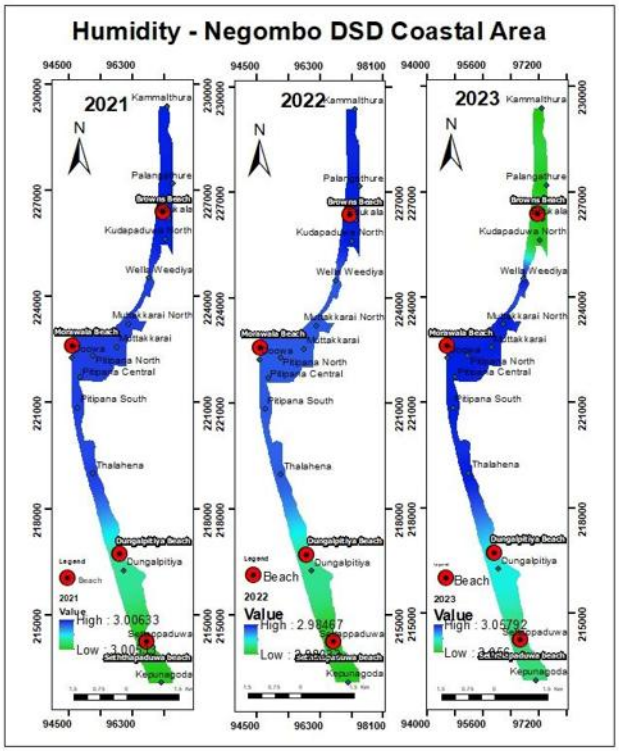



*Figure 5: Humidity Spatial Distribution Map*

According to the above humidity distribution map, it was identified that between 2011–2018 and during 2020 and 2023, the amount of water vapor in the atmosphere across the Negombo coastal tourism zone exhibited a uniform spatial pattern. The upper region of the study area contained a high amount of water vapor, the central region also recorded relatively high levels, while the lower region showed comparatively low water vapor content.

In 2019, 2021, and 2022, similar patterns were observed in the central region; however, the upper region recorded significantly higher humidity levels compared to the previous years. The lower region, particularly the Dungalpitiya and Kapungoda GN divisions, consistently showed the lowest humidity levels.

This indicates that there is both temporal and spatial variability in humidity levels within the study area. However, as revealed through interviews and questionnaire surveys, this variability does not have a direct impact on coastal tourism activities in Negombo.

### *3.2.4 Wind Variability*

To identify the temporal and spatial distribution of wind speed in the study area, a Two-Way ANOVA analysis was conducted, and the results are presented below.

Table 7. Results of Two-Way ANOVA for Wind Variability

| ***Summary*** | ***Count*** | ***Sum*** | ***Average*** | ***Variance*** |
|---|---|---|---|---|
| 2011 | 15 | 48.91675 | 3.261117 | 0.028073 |
| 2012 | 15 | 49.18806 | 3.279204 | 0.026918 |
| 2013 | 15 | 55.32258 | 3.688172 | 0.028785 |
| 2014 | 15 | 51.76513 | 3.451009 | 0.029742 |
| 2015 | 15 | 47.23172 | 3.148781 | 0.027202 |
| 2016 | 15 | 53.11986 | 3.541324 | 0.029603 |
| 2017 | 15 | 53.85623 | 3.590416 | 0.030349 |
| 2018 | 15 | 46.93683 | 3.129122 | 0.029554 |
| 2019 | 15 | 45.99275 | 3.066183 | 0.024181 |
| 2020 | 15 | 48.68708 | 3.245806 | 0.029375 |
| 2021 | 15 | 49.74785 | 3.316523 | 0.036467 |
| 2022 | 15 | 51.55942 | 3.437294 | 0.035309 |
| 2023 | 15 | 47.89248 | 3.192832 | 0.028426 |
| | | | | |
| Kammalthura | 13 | 42.12833 | 3.240641 | 0.034849 |
| Palangathure | 13 | 39.28167 | 3.021667 | 0.034949 |
| Ettukala | 13 | 39.28167 | 3.021667 | 0.034949 |
| Kudapaduwa North | 13 | 39.28167 | 3.021667 | 0.034949 |
| Wellaweeediya | 13 | 44.30167 | 3.407821 | 0.037528 |
| Muttakkarai | 13 | 44.30167 | 3.407821 | 0.037528 |
| Muttakkarai North | 13 | 44.30167 | 3.407821 | 0.037528 |
| Pitipana North | 13 | 44.30167 | 3.407821 | 0.037528 |
| Pitipana central | 13 | 44.30167 | 3.407821 | 0.037528 |
| Doowa | 13 | 44.30167 | 3.407821 | 0.037528 |
| Pitipana South | 13 | 44.30167 | 3.407821 | 0.037528 |
| Thalahena | 13 | 44.30167 | 3.407821 | 0.037528 |
| Dungalpitiya | 13 | 45.04175 | 3.46475 | 0.038221 |
| Seththapaduwa | 13 | 45.39417 | 3.491859 | 0.038599 |
| Kepungoda | 13 | 45.39417 | 3.491859 | 0.038599 |

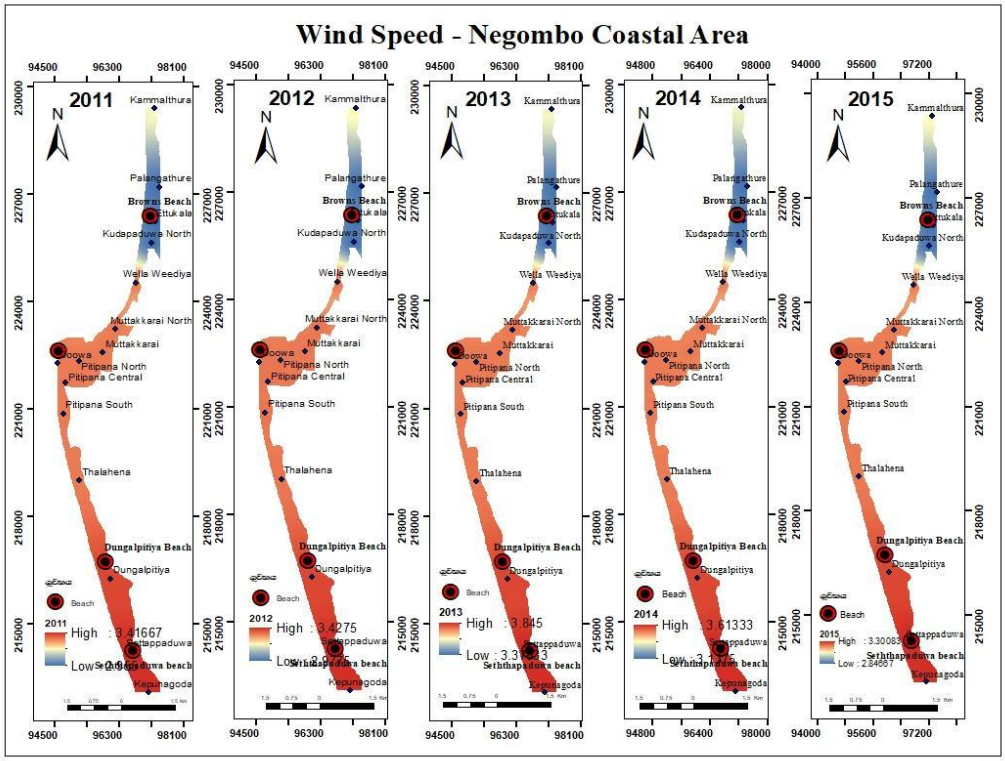
| **ANOVA** *Source of Variation* | *SS* | *df* | *MS* | *F* | *P-value* | *F crit* |
|---|---|---|---|---|---|---|
| **Rows** | 6.642925 | 12 | 0.553577 | 4409.426 | 4.4E-203 | 1.810189 |
| **Columns** | 5.354693 | 14 | 0.382478 | 3046.565 | 4.5E-194 | 1.751054 |
| **Error** | 0.021091 | 168 | 0.000126 | | | |
| **Total** | 12.01871 | 194 | | | | |

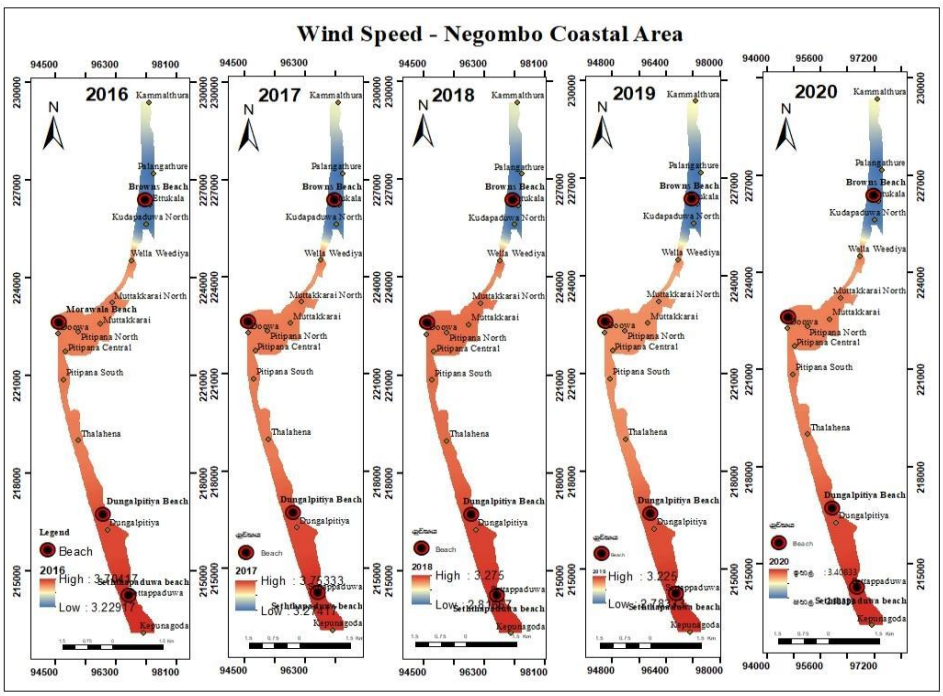
A Two-Way Analysis of Variance (ANOVA) was performed to examine the temporal and spatial variability in wind speed across the fifteen coastal Grama Niladhari Divisions between 2011 and 2023. The analysis demonstrated statistically significant temporal variation among years ($F(12,168) = 4409.43$, $p < 0.001$), indicating inter-annual variability in wind speed. Similarly, wind speed varied significantly among the fifteen Grama Niladhari Divisions ($F(14,168) = 3046.57$, $p < 0.001$), confirming significant spatial variability within the study area.

Table 8. Summary of Two-Way ANOVA Results for Wind Variability

| *Source of Variation* | *df* | *F* | *P-value* | *Interpretation* |
|---|---|---|---|---|
| Year | 12 | 4409.426 | <0.001 | Significant temporal variability |
| GN Division | 14 | 3046.565 | <0.001 | Significant spatial variability |

A more detailed explanation of this spatial distribution of wind speed can be observed through the wind speed spatial distribution map presented in Figure 6.



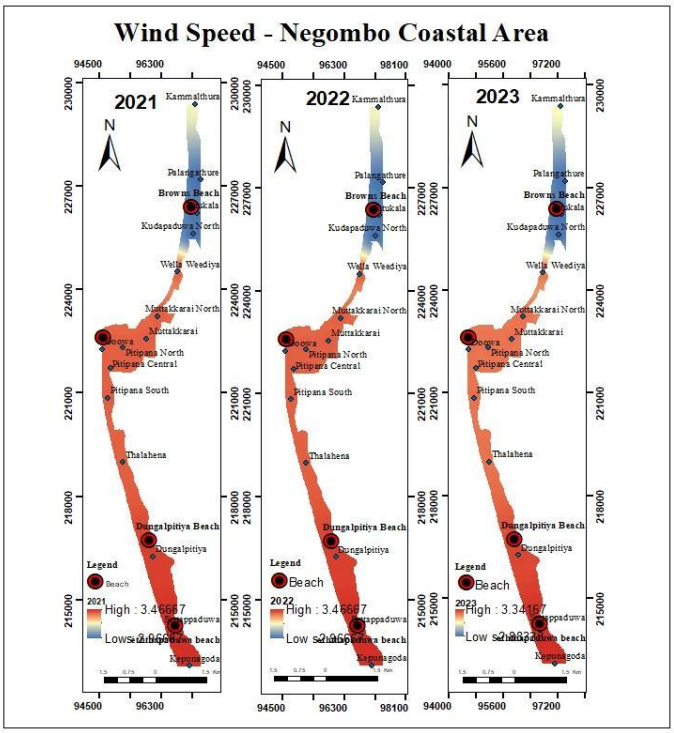



*Figure 6 : Wind Speed Spatial Distribution Map*

According to Figure 6, a relatively uniform pattern of wind speed could be observed across the study area during the period 2011–2023. While the temporal analysis indicated a very slight variability in wind speed, the spatial analysis did not reveal any significant spatial variations. It was identified that wind speeds are lowest in the upper boundary of the study area, whereas relatively higher wind speeds were recorded in the lower boundary.

Therefore, similar to temperature and humidity, wind speed does not exert a strong influence on tourism activities in the Negombo coastal tourism zone.

Based on these findings, it can be concluded that rainfall variability is the most significant climate variability factor affecting tourism in this region. This conclusion is further supported by the analysis of secondary data on rainfall, temperature, wind, and humidity, which confirmed that, although there are both temporal and spatial variations in all-weather factors, rainfall has the most prominent and direct impact on

tourism activities in the Negombo coastal area, at a statistically significant confidence level.

It was identified that during the years 2020, 2021, and 2022, the Etthukala area—where the majority of tourism activities in the Negombo coastal tourism zone are concentrated—experienced the lowest recorded rainfall. However, in 2023, the same area reported significantly higher levels of rainfall. This revealed that unpredictable rainfall patterns had a noticeable impact on tourism activities in the region. Among the weather factors, rainfall emerged as the most influential, as periods of heavy or unpredictable rainfall tended to discourage tourists from visiting coastal destinations. This finding is consistent with the research of Farkhwan and Winandi (2018), which highlighted the negative effects of uncertain rainfall on tourist arrivals.

The analysis further showed that the primary impact of rainfall variability was caused by short-term intense rainfall events. In addition, unexpected weather conditions resulting from seasonal transitions also affected tourism activities. Flash floods triggered by sudden rainfall were identified as another consequence within the Negombo coastal tourism zone. However, it was also observed that rainfall can exert a positive influence on tourism, aligning with the findings of Kule et al. (2013). In particular, tourists from warmer regions such as the Middle East and Africa tended to prefer visiting during rainy periods, indicating a more favorable perception of rainfall compared to tourists from other regions.

The thematic analysis conducted through literature review and interviews revealed that not only rainfall variability but also other weather factors such as temperature, wind speed, and humidity influenced tourism activities (Arabadzyan, 2020; Farkhwan & Winandi, 2018; Siddiqui & Imran, 2018; Kule et al., 2013; Camelia et al., 2011). The results of the variability analysis indicated the existence of temporal and spatial variations in these weather variables. However, the analysis also confirmed that these variations were not abrupt or extreme and therefore did not exert a direct impact on tourism activities.

In summary, rainfall plays a significant role in influencing tourism planning and outdoor activities in the Negombo coastal tourism zone, and in some cases, it has a positive influence as well. In contrast, other weather variables such as temperature, wind, and humidity were found to have less pronounced impacts compared to rainfall.

## 4. Conclusion

This study examined the impacts of climate variability on coastal tourism in the Negombo Coastal Tourism Zone, Sri Lanka, by integrating qualitative data collected from tourists, tourism service providers, and experts with quantitative weather data obtained from Google Climate Engine 2.1. The findings indicate that rainfall variability is the most significant weather factor affecting coastal tourism in the study area. Heavy and unexpected rainfall was found to disrupt outdoor recreational activities, reduce tourist satisfaction, and negatively affect tourism-related businesses. Rainfall variability was also associated with flash flooding, which further limited tourism activities. In contrast, although temporal and spatial variability was observed in temperature, humidity, and wind speed, these factors did not have a substantial direct impact on tourism activities during the study period.

The study also identified several adaptation measures currently adopted by tourism stakeholders to minimise the impacts of climate variability and enhance the resilience of the tourism sector. These findings demonstrate the importance of incorporating climate adaptation strategies into tourism planning and destination management to ensure the long-term sustainability of coastal tourism in Sri Lanka.

Overall, the objectives of this study were successfully achieved by examining the impacts of climate variability on coastal tourism, analysing the spatial and temporal variability of major weather factors, understanding the experiences of tourists and tourism service providers, and identifying adaptation strategies to improve tourism resilience. Future research should consider broader geographical coverage and larger sample sizes while examining tourists' seasonal travel preferences and long-term adaptation responses to climate variability.

## References

Ahrens, C. D., & Henson, R. (2019). *Meteorology today: An introduction to weather, climate, and the environment* (12th ed.). Cengage Learning.

Arabadzhyan, A., Figini, P., García, C., González, M. M., Lam-González, Y. E., & León, C. J. (2021). Climate change, coastal tourism, and impact chains: A literature review. *Current Issues in Tourism, 24*(16), 2233–2268. https://doi.org/10.1080/13683500.2020.1825351

Athulathmudali, S., Balasooriya, A., & Fernando, K. (2011). *An exploratory study on adapting to climate change in coastal areas of Sri Lanka.*

Barry, R. G., & Chorley, R. J. (2010). *Atmosphere, weather and climate* (9th ed.). Routledge.

Camelia, S., Breda, Z., & Surugiu, M.-R. (2014). *Climate change impact on seaside tourism: Portugal and Romania: Two different case studies with strong particularities.*

City Population. (2024). *Negombo (Divisional Secretariat, Sri Lanka): Population statistics, charts, map and location.* https://www.citypopulation.de/en/srilanka/admin/gampaha/1203__negombo/

Climate-Data.org. (2025). *Climate: Negombo.* https://en.climate-data.org/asia/sri-lanka/western-province/negombo-764251/

Department of Census and Statistics Sri Lanka. (2012). *Census of population and housing 2012.* https://www.statistics.gov.lk/

Furqan, A., & Winandi, F. I. (2018). The impact of climate change on coastal tourism destination: Case of Kuta Beach, Bali, Indonesia. *ASEAN Journal on Hospitality and Tourism, 16*(2), 84–94. https://doi.org/10.5614/ajht.2018.16.2

Hall, C. M. (2001). Trends in ocean and coastal tourism: The end of the last frontier? *Ocean & Coastal Management, 44*(9–10), 601–618. https://doi.org/10.1016/S0964-5691(01)00071-0

Kūle, L., Haller, I., Varjopuro, R., & Alberth, J. (2013). *Sectoral impact assessments for the Baltic Sea region: Climate change impacts on biodiversity, fisheries, coastal infrastructure and tourism. Coastline Reports, 21.*

Mahanama, P. K. S., Jayasinghe, A., & Abenayake, C. (2011). *Cities and climate change initiative: Negombo, Sri Lanka: Climate change vulnerability assessment.* UN-Habitat.

Nianthi, R., Shaw, R., & Nianthi, K. W. G. R. (n.d.). *Climate change and its impact on coastal economy of Sri Lanka.*

Pan, S. L., Wu, L., & Morrison, A. M. (2024). *A review of studies on tourism and climate change from 2007–2021.*

Pathmanandakumar, V., Chenoli, S. N., & Goh, H. C. (2021). Linkages between climate change and coastal tourism: A bibliometric analysis. *Sustainability, 13*(19), 10830. https://doi.org/10.3390/su131910830

Samarasinghe, J. T., Wickramarachchi, C. P., Makumbura, R. K., Meddage, P., Gunathilake, M. B., Muttil, N., & Rathnayake, U. (2023). Performances of Holiday Climate Index (HCI) for urban and beach destinations in Sri Lanka under changing climate. *Climate, 11*(3), 48. https://doi.org/10.3390/cli11030048

Siddiqui, S., & Imran, M. (2018). Impact of climate change on tourism. In *Handbook of research on climate change impact on health and environmental sustainability* (pp. 68–83). IGI Global. https://doi.org/10.4018/978-1-5225-5843-9.ch004

Sri Lanka Tourism Development Authority. (2024). *Tourist arrivals from all countries.* https://sltda.gov.lk/en/tourist-arrivals-from-all-countries

Sun, F., Xu, M., Li, Z., Zhang, W., & Yang, Y. (2024). Spatial distribution, accessibility, and influencing factors of the tourism and leisure industry in Qingdao, China. *Sustainability, 16*(16), 6961. https://doi.org/10.3390/su16166961

Tam, S. (2019). *Sounding the alarm: Is the Sri Lankan tourism sector prepared for climate change?*

United Nations Environment Programme. (2009). *Sustainable coastal tourism: An integrated planning and management approach.* https://www.unep.org/resources/report/sustainable-coastal-tourism-integrated-planning-and-management-approach

University of Moratuwa. (2010). *Batticaloa City and Negombo City, Sri Lanka: Cities and climate change initiative.*