SRI LANKA JOURNAL OF GEOGRAPHY AND ENVIRONMENTAL MANAGEMENT

SLJGEM (2026), Vol. 03 (01)

Journal homepage: www.sab.ac.lk/sljgem

SPATIOTEMPORAL DISTRIBUTION OF DENGUE INCIDENCE IN PUTTALAM DISTRICT FROM 2013 TO 2023: EPIDEMIOLOGICAL PERSPECTIVE

ARTICLE INFO

Article History:
Received 25 August 2025
Accepted 14 June 2026
Issue Published Online 30 July 2026

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SLJGEM (2026), Vol. 03, Issue (01), Pp. 67 - 94

KEYWORDS

Dengue incidence
Spatiotemporal assessment
GIS
Two-way ANOVA
IDW interpolation
Puttalam District
Sri Lanka

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ISSN 3051 5335X (Online)

Published by:

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ABSTRACT

This study examined the spatiotemporal distribution of dengue incidence in the Puttalam District, Sri Lanka, from 2013 to 2023. The study is novel because it integrates time series analysis, two-way ANOVA, and GIS-based Inverse Distance Weighting (IDW) interpolation to examine temporal and spatial variations in dengue incidence across all 14 Medical Officer of Health (MOH) divisions of the district. Secondary annual dengue incidence data (154 observations: 14 MOH divisions × 11 years) obtained from the Ministry of Health, Sri Lanka, were analysed. Time series analysis and linear trend analysis were used to assess temporal patterns, while two-way ANOVA was performed to evaluate the effects of year and MOH division on dengue incidence. Spatial distribution and hotspot areas were identified using IDW interpolation in ArcGIS 10.8. The findings revealed an overall increasing trend in dengue incidence during the study period. District-wide incidence increased substantially after 2016, reached its highest level with more than 5,600 reported cases in 2017, declined during 2018–2021, and increased again in 2022 and 2023. Two-way ANOVA showed that both year ($F = 8.166$, $p < 0.001$) and MOH division ($F = 5.073$, $p < 0.001$) had statistically significant effects on dengue incidence, indicating significant temporal and spatial variation. Spatial analysis identified persistent dengue hotspots in the Puttalam, Kalpitiya, Chilaw, Wennappuwa, and Dankotuwa MOH divisions, demonstrating the expansion and persistence of high-risk areas within the district. The findings indicate that dengue incidence exhibits clear spatial clustering and temporal variability in Puttalam District. Although environmental and socio-economic factors such as urbanisation, inadequate waste management, and favourable mosquito breeding conditions may contribute to the spatial distribution of dengue, these relationships were not statistically examined in the present study. Therefore, dengue prevention efforts should prioritise hotspot MOH divisions through GIS-based surveillance, pre-monsoon vector control, improved drainage and solid waste management, and community-based source reduction programmes. These findings provide evidence to support location-specific dengue control strategies and future research integrating climatic and environmental variables for improved disease prediction..

How to Cite this Article: *Mubashshira MAF, Pasima MM, Mafasa MB & Fareena Ruzaik (2026). Spatiotemporal Distribution of Dengue Incidence in Puttalam District from 2013 to 2023: Epidemiological Perspective. SLJGEM, 03 (01), Pp. 67 - 94.*

1. BACKGROUND

Dengue has become one of the fastest mosquito-borne viral infections (or fever) around the world. It is caused by a virus transmitted from person to person by biting Aedes mosquitoes, Aedes aegypti and secondary vector Aedes albopictus. It causes severe bleeding, vascular leak, elevated liver enzymes, abnormal bleeding and confusion. Dengue and other viral infections are climate-sensitive diseases. Because climate changes help diseases shift to new areas. Climate change, such as temperatures climbs, precipitation patterns change, and extreme weather events become more frequent. Such changes have dramatically altered the occurrence and severity of many infectious diseases and are having a disproportionate impact on vector-borne diseases such as dengue, malaria and filariasis. Warmer conditions provide ideal conditions for vectors such as mosquitoes; new areas are opened for their presence, breeding rates are higher and the pathogens they transmit spend more time infected, thereby increasing the transmission potential (Intergovernmental Panel on Climate Change [IPCC], 2022; World Health Organisation [WHO], 2021). Thereby, dengue viral infection incidence changes are happening based on climate change. Dengue vectors can adopt unfamiliar environments and climate change.

According to the World Health Organisation, dengue is the most significant health burden that has globally recorded a rapid increase in Dengue infection. Therefore, the World Health Organisation statistics suggest that about 390 million Dengue cases are reported every year worldwide, with 96 million infected showing clinical symptoms and about half of the population of the world at risk of the disease, whereas dengue has become endemic in over 100 countries (Bhatt et al., 2013; WHO, 2022). During 2024, an unexpected spike in dengue cases resulted in a historic high of over 14.6 million cases and more than 12, 000 dengue-related deaths reported (WHO, 2025).

Dengue is a major public health problem in Sri Lanka. Following notification in 1996, dengue cases have steadily increased. The cases peaked in 2017, recording 186,448 suspected dengue cases and three hundred deaths (Epidemiology Unit, 2018). Although a reduction was seen in 2022 with the recording of only about 44,000 cases (Ministry of Health, 2023), this is no comfort, given the fact that outbreaks can easily occur at any time of the year. There are many risk factors, such as rapid urbanisation and proliferation of slums, inadequate solid waste management explains the increasing trend of dengue as well as presence of conducive climatic factors, which are inherent to the tropical monsoon climate in Sri Lanka, that explain the increasing trend of dengue (Wijegunawardana et al., 2021). Although the Western Province accounts for the highest number of dengue cases, dengue has now started to spread to other districts as well, and in Puttalam district, there are several positive environmental and social factors that support mosquito breeding.

Puttalam District in the Northwestern Province of Sri Lanka falls within the dry and intermediate climatic zones. It occupies areas of the coastal lowland, lagoons, dunes and expanding urban areas. Having a bimodal rainfall pattern with peaks during the southwest and northeast monsoon seasons, this unique characteristic supports a high breeding density of Aedes mosquitoes (Department of Meteorology, 2023). In addition, the ever-increasing population, presence of seasonal migrant workforce, the practice of maintaining water reservoirs, and lack of proper drainage have further increased the risk of vector breeding in both the urban and rural sectors of the district (Fernando & Silva, 2020). Existing dengue incidence studies in Sri Lanka focus on Western, Central, and Southern provinces; these have a high distribution of dengue incidence. Therefore, there is limited knowledge regarding the temporal and spatial occurrence of dengue in Puttalam district. Our study aimed to examine the spatial and temporal distribution of dengue cases in the Puttalam District for the period of 2013 to 2023.

2. LITERATURE REVIEW

- ***Global Perspectives on Dengue Transmission***

Dengue transmission on a global scale is not caused by just one factor. It is the result of environmental, climate, and social issues all tangled together. Dengue fever is a problem in many places, and it is made worse by things like bad sanitation and not having clean water. Aedes mosquitoes love to breed in these kinds of conditions in cities that are growing fast (Nazhiifah et al., 2024). In some parts of the world, cities are growing quickly, so it is hard to keep up with the needs of all people, and this makes it easier for dengue fever to spread. The weather also plays a role in all of this. When it rains a lot or when it is hot and humid, mosquitoes can survive and reproduce easily, and the virus that causes dengue fever can develop more quickly. For example, in Delhi, heavy rain can lead to an increase in dengue cases, but it usually takes a couple of months for this to happen. This is probably because of the life cycle of mosquitoes. How long does it take for the virus to develop? Other places in Southeast Asia have seen similar things happen (Bisht et al., 2019). In Indonesia, things like how people throw trash and how they store water at home can affect whether there is a dengue outbreak in a particular area. Even the types of plants that are growing in an area can have an influence (Hariyanti, 2024). Both natural things, like the weather and human-made things like how we take care of our environment can contribute to the spread of dengue fever. To make things worse, climate change is making it easier for mosquitoes to thrive. When the weather is warmer, mosquitoes can develop quickly, and the virus that causes dengue fever can spread more easily (Yani, 2024).

In Kerala, scientists have found that rainfall and humidity are predictors of when a dengue outbreak will happen. In Karnataka, everyday things, like leaving containers uncovered or not throwing away trash, can give mosquitoes places to breed. Dengue mosquitoes can breed in these kinds of conditions, and dengue fever is able to spread easily (Varghese et al., 2025). But the climate connection is not always straightforward. In Yogyakarta, Indonesia, the connection between rain and dengue was not as clear, indicating that lifestyle, environmental features, and community practice can override or change the impact of weather (Kesetyaningsih et al., 2018). Home life and daily routines are a huge part of it. The risk of being bitten increases with high indoor humidity, the presence of mosquito larvae in water containers, or when drying clothes indoors (Raharjo, 2015). So, household-level fixes are just as critical as broad changes in environmental management. In the Americas, overcrowded living conditions, substandard housing and inequities in basic services have been driving dengue resurgence. In these places, vector-control strategies are most appropriate when widespread vaccines cannot be applied (Kouri et al., 2007). Social and economic conditions account for where dengue emerges even better than broad measures of the economy like Gross Domestic Product (GDP). Typically, the hazard accumulates in marginalised communities without robust public health systems or patchy environmental services. Climate change is shifting the map, too, as disasters and ecosystems in flux make everything more unpredictable (Watts et al., 2020). So, addressing dengue is purely about temperature and rain; it is also about ensuring we pay attention to social vulnerability. On the tech side, functions such as Geographical Information System (GIS), along with remote sensing and predictive modelling, have enabled us to notice changes or complexities of dengue in space-time. Early work in French Guiana demonstrated how spatial analysis can be used to help identify hot spots and target intervention (Tran et al., 2004). One of these studies, conducted in Brazil, identified significant correlations between changes in sea surface temperature and the occurrence of dengue cases and highlighted how local social disparities impact transmission (Ogashawara et al., 2019). Long-term studies from islands, meanwhile, illustrate how demographic shifts, environmental stress, and climate cycles such as La Niña intermix to fuel outbreaks (Roelofs et al., 2024). Dengue is merely a climate issue or an environmental one. It is determined, in part, by where people live, the climate and social disparities, and even day-to-day habits.

- ***Regional Evidence from Asia***

In Asia, where dengue has established itself as a cyclical disease of some seasonal type, spatiotemporal studies have proven indispensable for diagnosing geographic clustering and time-space dynamics in both endemic and epidemic outbreaks. Transmission of dengue in the region is highly seasonal but has a strong localised clustering tendency, suggesting that it is driven by climatic variability acting on population density/environmental factors. This has been particularly true for GIS-based analyses in Thailand. In Chachoengsao and Khon Kaen provinces, persistent dengue hotspots tightly correlated with environmental factors such as precipitation patterns, temperature variation, and areas of high-density population (Jeefoo et al., 2019). The same dynamics have played out in other parts of Asia. Dengue incidence was strongly seasonal in Timor-Leste, with increased numbers of cases occurring during the wetter, warmer months. The burden was higher in children and females, reflecting the demographic vulnerability as well as climatic determinants (Wangdi et al., 2018). In Taiwan, spatiotemporal analysis showed that areas with high hotspot index were significantly correlated with higher concentrations of dengue hemorrhagic fever cases (Wen et al., 2010), thereby suggesting that the early detection of hotspots is important not just in terms of controlling transmission but also in preventing severe disease outcomes. These findings, coupled with previous results, argue for the hypothesis that dengue dynamics across Asia are influenced by predictable seasonal cycles and by spatial persistence. Not only have placebo studies focused on the dynamics of dengue transmission regionally, but also to an increasing extent revealed the significant economic and social burden that the disease is inflicting.

Suaya et al. conducted a ground-breaking multi-country study (2009) that provides measures beyond standard epidemiological parameters to estimate direct and indirect costs of dengue illness in diverse health care and economic environments across Asia and the Americas. The study also indicated that while the disease can be a financial burden to households, particularly by way of medical fees and costs associated with transportation and loss of income due to time taken away from work or long-term work stoppages, countries like Vietnam, Thailand and Cambodia shoulder high costs for treatments as well as losses caused by unproductive labour. These findings highlight that dengue represents not only a public health problem but also an important socio-economic issue, particularly in low- and middle-income countries. National-scale syntheses indicating the severity and persistence of dengue in Asia are also increasingly being reported. A systematic review by Khattak et al. (2024) of dengue in Pakistan over the last 20 years shows that the dengue epidemic has been increasing in terms of both spatial distribution and intensity of outbreaks owing to lack of robust surveillance, rapid urbanisation, and changing climate. This indicates a switch from dengue being an occasional epidemic to a persistent and therefore significant public health problem and is therefore in need of initiative-taking rather than reactive control measures.

Disease severity and immunological dynamics are another key factor affecting Dengue outcome in the South and East Asia Region. Recent studies in India have demonstrated that a multi-centre sero-survey of dengue cases across the entire country showed significant geographical variation regarding primary versus secondary Dengue infections (Rao et al., 2019). Many secondary infections in a particular area of India are a major worry; secondary infections to different dengue serotypes have an increased risk of developing severe forms of dengue such as Dengue Haemorrhagic Fever (DHF) and Dengue Shock Syndrome (DSS). A region-by-region risk assessment, coupled with information on host immunological status along with other environmental and climatic variables, is necessary for understanding its effects and severity. Prior work has focused on the long-term effects of global warming on dengue dynamics. However, recent research is beginning to uncover the role of short-term climate variability and discrete weather events that can lead to a dengue outbreak. A regional analysis found that heatwaves, heavy rainfall, drought, and cold spells led to increased dengue cases, with some variations in time lags depending on the climate event (Ith et al., 2025). Thus, short-term climatic events can pose considerable risks to dengue infection, and early warning systems of discrete climatic and entomological indices combined with real-time surveillance would be extremely useful.

Beyond their infectious disease impact, Chikungunya and dengue epidemics are also showing their socio-political face in conflict-affected countries. In Yemen, a retrospective cross-sectional study conducted in Hajjah Governorate found a clear seasonal pattern of dengue infection activity and an increasing trend in a country with a weakened health system and almost no active surveillance activities (Abdullah et al., 2025). The epidemics are occurring in a context where health infrastructure has been severely degraded following years of conflict, accompanied by a disrupted health system, population movements, and a significant reduction in vector control activities. Far from being a few isolated cases occurring in a research vacuum, Yemen and other conflict-affected countries in the region are already providing valuable insights into the impact of epidemics in fragile socio-political contexts, a reality that is also observed in other parts of the world where conflict and instability persist. In Yemen, for example, retrospective analysis of dengue cases from all health facilities in Hajjah Governorate found a clear seasonal pattern of dengue infection activity and an increasing trend, many years after the first reported outbreak of dengue in Yemen, and in a context where the health system has been severely weakened, almost no active surveillance activities are in place, health infrastructure has been severely degraded following years of conflict, population movements have taken place and there has been significant reduction in vector control activities.

Studies from Asia show that dengue spread is affected by changes in climate, location patterns, social and economic conditions, and the strength of healthcare systems. This shows the importance of combining data on place, time, economy, and climate to develop effective, data-based control strategies.

- ***Sri Lanka-Based Dengue Evidence***

Dengue cases are being reported in large numbers in Sri Lanka now and then, and it has become one of the major dengue-affected countries in South Asia (Sirisena & Noordeen, 2014). It is said that the dengue dynamics in the country have undergone changes due to genotype shifts of the dengue virus, changes in the distribution of vectors and drastic changes in the environment due to rapid urbanisation. Moreover, spatiotemporal analysis done on the Dengue cases in Sri Lanka revealed that Dengue has been showing a highly seasonal and clustered pattern across space and time, which is strongly correlated with the known bioclimatic factors associated with the South-West and North-East monsoons, namely heavy rainfall and high temperatures (Prabodanie et al., 2020).

The GIS studies that are conducted in our country have revealed that population density is a major factor in the transmission of dengue. As suggested in research, the urban and peri-urban areas in the country, especially in Colombo and Gampaha districts, have higher rates of dengue cases compared to the rural sector due to factors such as high population density, poor housing conditions, and increased man-vector contact. Thus, Environmental factors like rainfall, temperature and relative humidity are the major factors which determine the exact timing and magnitude of dengue epidemics in Sri Lanka (Faruk et al., 2022). Moreover doing a more detailed study using GIS to identify the mosquito breeding sites in the districts of Kurunegala, Gampaha, Kegalle and Kandy it was revealed that even though the country has a wide distribution of vector species, the transmission of dengue is highly concentrated within specific areas known as the focal mosquito population and thus it is recommended that area specific vector control measures be implemented instead of implementing national level measures to control the vector population.

Analytical and modelling methodologies are rapidly evolving with new improvements and applications which aid in strengthening dengue surveillance and prediction in Sri Lanka. According to Piyatilake and Perera (2020), “Fuzzy multidimensional clustering (FDMC) approach along with various environmental and socio-demographic factors identified the high-risk dengue-infected areas in Sri Lanka”. Moreover, Li et al. (2022) integrated big geospatial data with a machine learning algorithm, where long short-term memory (LSTM) is implemented to strengthen the forecasting accuracy of the dengue outbreak.

We aimed to identify environmental and spatial determinants as well as virological factors influencing viral transmission and thereby understand the factors influencing epidemic behaviour of dengue virus (DENV) in Sri Lanka. We undertook systematic reviews to assess the prevalence and distribution of dengue infections in Sri Lanka in recent years. Results showed that all four DENV serotypes are present and circulating all over the country, with DENV-2 being the prevalent one since 2017. National epidemics of dengue occurred in 2017 and 2019. The case fatality rate has varied between 0.11% and 1.0% over time, indicating variable disease virulence and capacity of the health system to manage cases, implying that the present trends of dengue epidemiology in Sri Lanka cannot be fully explained by alone or in combination with environmental and spatial factors, implying a need to understand the role of other virological factors influencing epidemic behavior of DENV in Sri Lanka.

Recent molecular surveillance results that shed some light on the present dynamics of the dengue virus in Sri Lanka have been available at the time of publishing this document. A recent molecular epidemiology study on dengue outbreaks in Sri Lanka between the years 2022 and 2024 provided information on the prevalence of different dengue virus serotypes and genotypes, the source and time to spread to different parts of the country, as well as the genetic mutations present in the strains currently circulating in the country and possible impacts on the transmission as well as the disease severity, thereby confirming the role of viral genetics in the epidemiology of epidemics. Integration of molecular surveillance with the traditional spatiotemporal surveillance has contributed to improved epidemiological predictions of an impending epidemic. Climatic factors affecting dengue transmission have been confirmed at the national level by more recent studies. A retrospective time-series study examining dengue cases reported from 2020 to 2024 showed lagged relationships between dengue and climatic factors such as rainfall, temperature, and humidity (Wanasinghe et al., 2025). Therefore, the short-term climatic fluctuations, rather than the long-term average, which can function as a trigger for dengue outbreaks, are the factors that need to be considered when designing an early warning system that is climate-based.

A systematic review on Sri Lankan literature concluded that dengue infection is influenced by a variety of climatic, environmental, socio-demographic, viral and urban factors. Therefore, this study aims to integrate spatiotemporal analysis of dengue outbreaks with molecular and climate-based approaches to investigate the determinants of dengue infections and to evaluate the major risk factors in high transmission districts in Sri Lanka.

- ***Research Gap***

Although considerable research has been conducted on dengue in Sri Lanka and other Asian countries, several gaps remain, particularly in relation to Puttalam district. Although studies have assessed dengue in Colombo, Gampaha and other high-risk districts, no comprehensive research has been conducted specifically focusing on Puttalam.

No specific dengue research for Puttalam district – Existing dengue studies focus on Western, Central, and Southern provinces. But dengue distributions are affected by climate change. Our study focused on Puttalam District. Puttalam District often faced floods and high rainfall because of climate change. This was caused by dengue incidence in Puttalam. But there is a significant gap in knowledge about Puttalam, despite dengue incidence distribution. **No time series assessment using advanced statistical methods** – Although national and provincial studies have examined broad temporal patterns of dengue, time series analysis has not been systematically used to assess seasonal cycles, long-term trends, or inter-annual variations within Puttalam district. Similarly, methods such as two-way ANOVA, which allow for simultaneous examination of temporal and spatial variations, have not been used in this district. **No spatial analysis using GIS Inverse Distance Weighting (IDW) interpolation** – GIS methods such as disease spatial clustering have been used in Sri Lanka; IDW-based interpolation for dengue incidence has not been used in Puttalam. This limits the understanding of spatial variations.

Therefore, this study attempts to address these gaps by conducting a spatiotemporal assessment of dengue incidence in Puttalam district (2013–2023) by combining time series analysis, two-way ANOVA and GIS IDW interpolation. It aims to identify seasonal patterns, trends, and local disease hotspots. This will enable more evidence-based dengue control interventions tailored to the specific context of the district.

3. MATERIALS AND METHODS

3.1 Study Area

The administrative district of Puttalam is situated in the Northwestern Province of Sri Lanka and surrounded on the North by Modaragam Aru, bordering Mannar district; east by Kurunegala and Anuradhapura districts; south by 'Ma Oya', bordering Gampaha district; and West by the Indian Ocean. The district has a land area of 3013 square kilometres, including inland water bodies and a coastal belt of 288 kilometres in length (District Secretariat Puttalam, n.d.). There are two kinds of climate zones in the district. They are the wet zone and dry zone. Puttalam District has mild weather conditions without extremes throughout the entire year. The maximum temperature is about 31 degrees Celsius (88 degrees Fahrenheit) during the months of March and April, and the minimum temperature is about 22 degrees Celsius (72 degrees Fahrenheit). The monsoon seasons are from March to August and from October to January, during which very heavy thunder showers can be expected. The annual rainfall is about 2400 mm. In 2023, the district recorded an average temperature of 27.9°C, a total rainfall of 1,608.8 mm and an average relative humidity of 81.8% (Weatherspark, 2023). As of 2024, its estimated population was approximately 818,816, and the population density in Puttalam District was 266.5 persons / km^2 (Census of Population and Housing, 2024).

This study selected 14th MOH's in Puttalam District based on secondary data availability. Figure 1 shows the MOH locations.

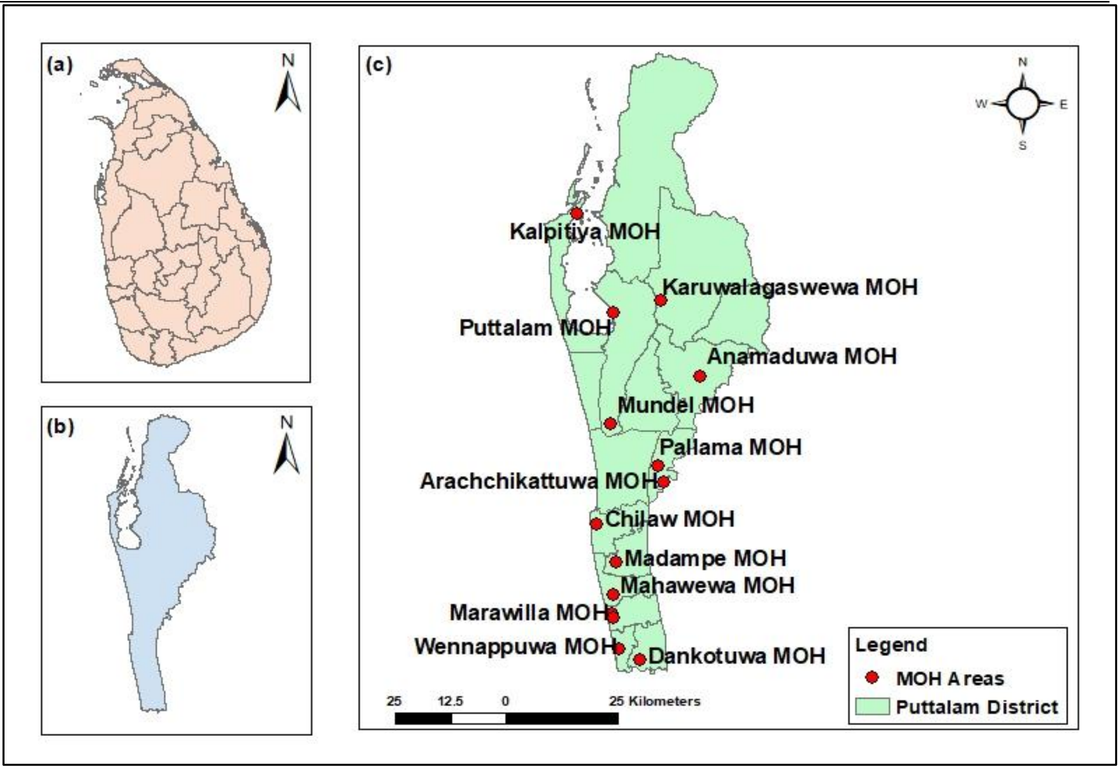

Figure 1: Study Area (a) Sri Lanka, (b) Puttalam District, and (c) 14th Medical Officer of Health [MOH] in Puttalam District;
Source: Prepared by the researchers using the software ArcGIS version 10.8, 2026.

3.2 Data Collection Method

This study used secondary data on reported dengue cases from the Ministry of Health of Sri Lanka. This included weekly and annual counts for case numbers by each Ministry of Health Division over the 11 years (2013-2023).

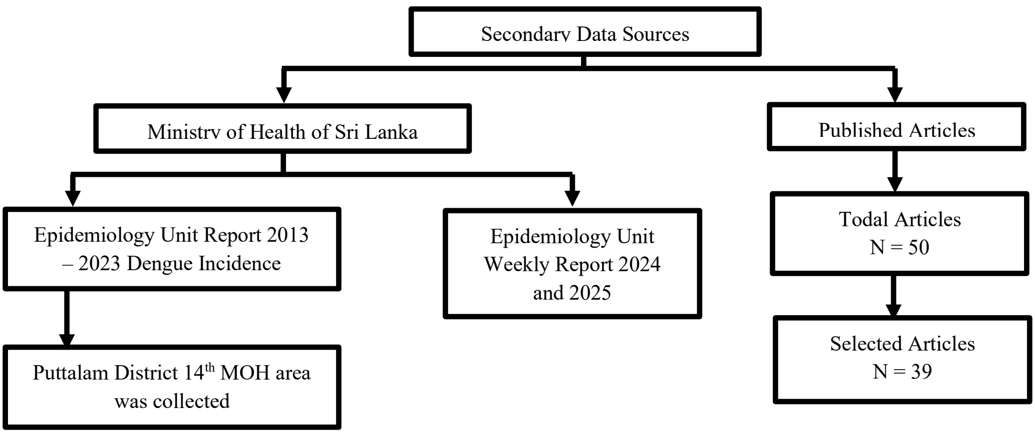

Figure 2: Data Collection Method

Moreover, this study used some secondary data obtained from the official online databases and websites of authorised government departments and institutions.

3.4 Data Analysis

The data were collected from secondary sources and entered excel sheet using Microsoft Excel 2016. Using analysis methods showed dengue case trends over time, mapping the shapes of geographic distributions by area.

- ***Inferential Statistical Analysis***

(1) Time Series analysis: This approach was employed to analyse annual trends, seasonal patterns, and variations of dengue cases according to division under the Ministry of Health. This gave valuable information about the years when the disease incidence rose.

(2) Linear trend analysis: Linear trend analysis was performed to evaluate long-term changes in annual dengue cases for each Medical Officer of Health (MOH) division during 2013–2023. A simple linear regression model was fitted to the annual case data, where year was treated as the independent variable and dengue cases as the dependent variable. The resulting linear trend equation (y = mx + c) was used to estimate the annual rate of change in dengue incidence, where the slope (m) represents the average increase or decrease in cases per year. The coefficient of determination (R^2) was calculated to assess the goodness of fit of the linear model, with higher R^2 values indicating that a greater proportion of the variation in dengue cases was explained by the linear trend.

(3) Two-way ANOVA: This statistical analysis was employed to determine the simultaneous effects of time (year) and space (MOH Division) factors or variables in the dissemination of dengue cases. This allowed us to identify statistically significant differences in case numbers across years and locations.

- ***Spatial Distribution Analysis***

The spatial distribution of dengue cases was assessed using software Arc GIS version 10.8. Inverse distance weighting (IDW) interpolation was employed to produce detailed maps of the variations in dengue density. With this approach, both highly affected areas as well as regions with a small number of cases were distinguished.

4. RESULTS AND DISCUSSION

- ***Time Series Findings:***

Temporal Pattern of Dengue Cases by MOH Divisions in Puttalam District (2013-2023)

Across the 14 MOH divisions in Puttalam District from 2013 to 2023, varying trends in dengue cases have been observed:

The highest case count was 139 in 2023, with a low of 8 in 2015, showing a positive trend and rapid growth in Anamaduwa MOH. *(Figure 3)*

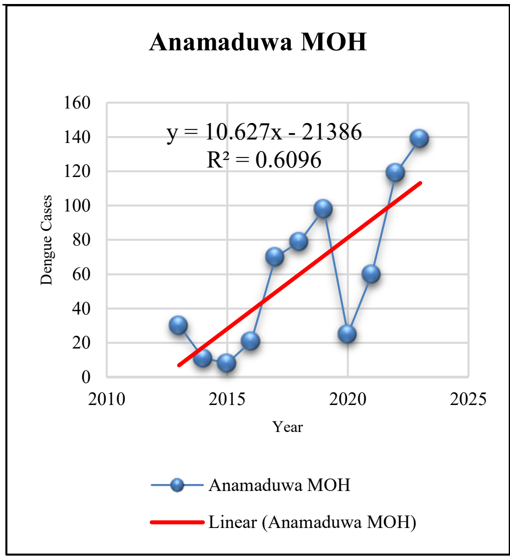

Figure 3: Temporal Pattern of Dengue Cases in Anamaduwa MOH
Source: Data collected from the Ministry of Health, Sri Lanka (2013 – 2023)

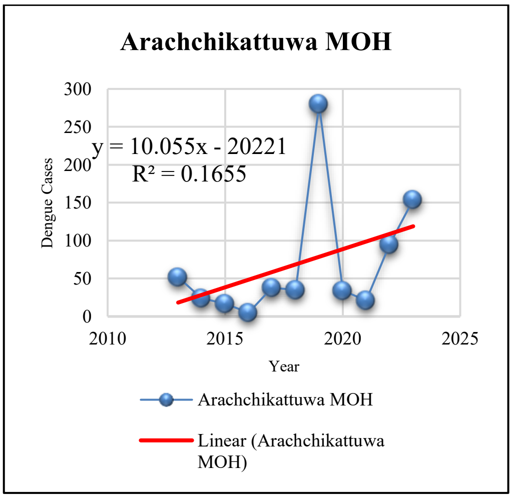

Figure 4: Temporal Pattern of Dengue Cases in Arachchikattuwa MOH
Source: Data collected from the Ministry of Health, Sri Lanka (2013 – 2023)

Figure 4 shows that the peak was 280 cases in 2019, with a low of 5 in 2016, showing a positive trend with moderate growth in Arachchikattuwa MOH.

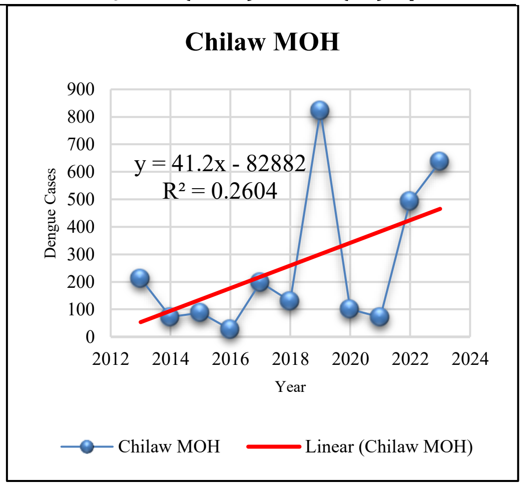

Figure 5: Temporal Pattern of Dengue Cases in Chilaw MOH
Source: Data collected from the Ministry of Health, Sri Lanka (2013 – 2023)

According to *Figure 5,* the highest count was 823 cases in 2019, with the lowest at 27 in 2016, showing steady growth in Chilaw MOH.

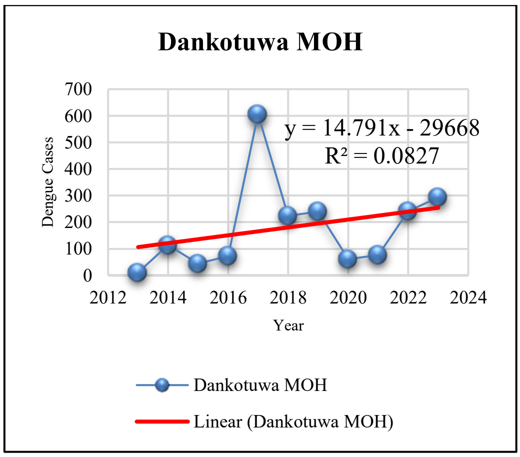

Figure 6: Temporal Pattern of Dengue Cases in Dankotuwa MOH
Source: Data collected from the Ministry of Health, Sri Lanka (2013 – 2023)

The peak was 606 cases in 2017, with eleven cases in 2013 as the low point, indicating slow growth in Dankotuwa MOH. *(Figure 6)*

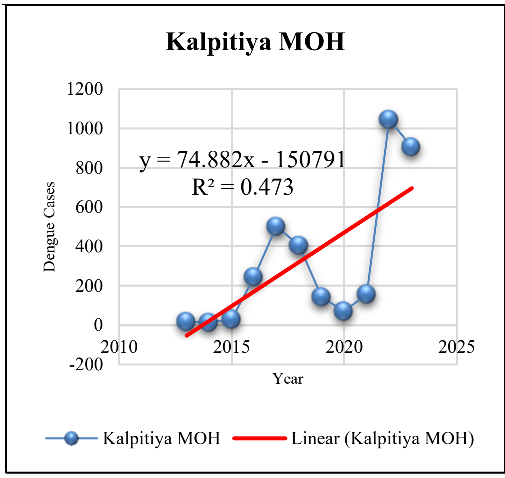

Figure 7: Temporal Pattern of Dengue Cases in Kalpitiya MOH
Source: Data collected from the Ministry of Health, Sri Lanka (2013 – 2023)

According to *Figure 7,* a peak of 1,045 cases in 2022, with only fourteen cases in 2014, showing rapid growth in Kalpitiya MOH.

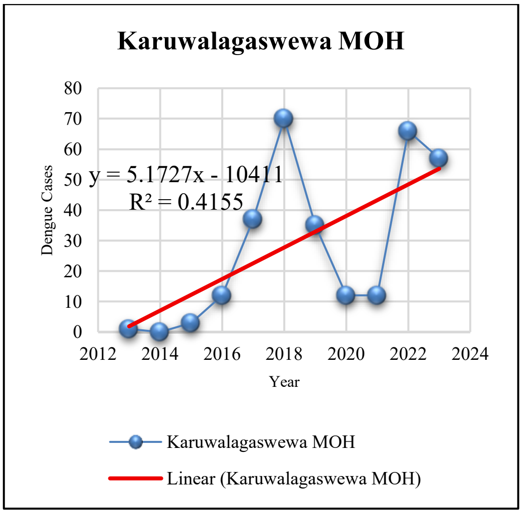

Figure 8: Temporal Pattern of Dengue Cases in Karuwalagaswewa MOH
Source: Data collected from the Ministry of Health, Sri Lanka (2013 – 2023)

The highest count was seventy cases in 2018, with no cases in 2014, showing rapid growth in Karuwalagaswewa MOH. *(Figure 8)*

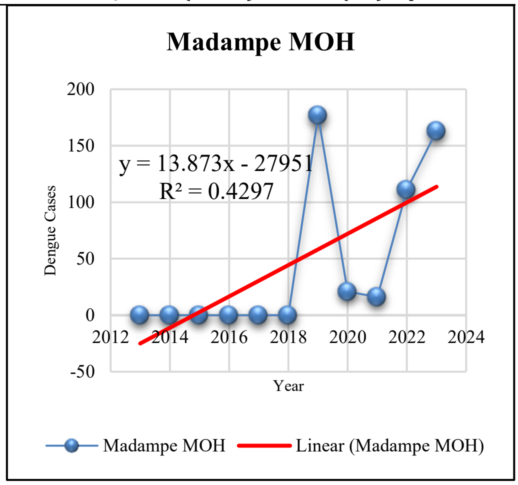

Figure 9: Temporal Pattern of Dengue Cases in Madampe MOH
Source: Data collected from the Ministry of Health, Sri Lanka (2013 – 2023)

The peak was 177 cases in 2019, with no cases from 2013 to 2018, showing rapid growth in Madampe MOH. (*Figure 9)*

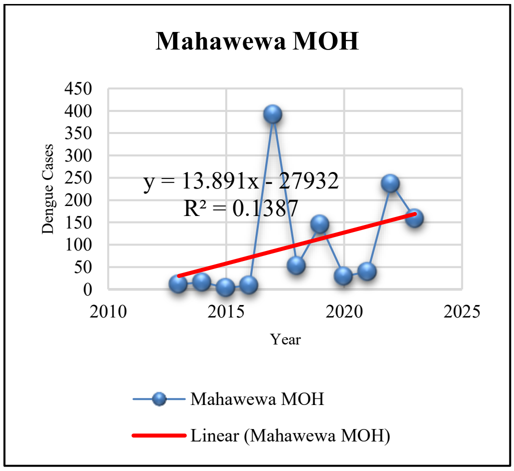

Figure 10: Temporal Pattern of Dengue Cases in Mahawewa MOH
Source: Data collected from the Ministry of Health, Sri Lanka (2013 – 2023)

According to *Figure 10*, a total of 392 cases in 2017 was the highest and three cases in 2015 were the lowest, showing slow growth in Mahawewa MOH.

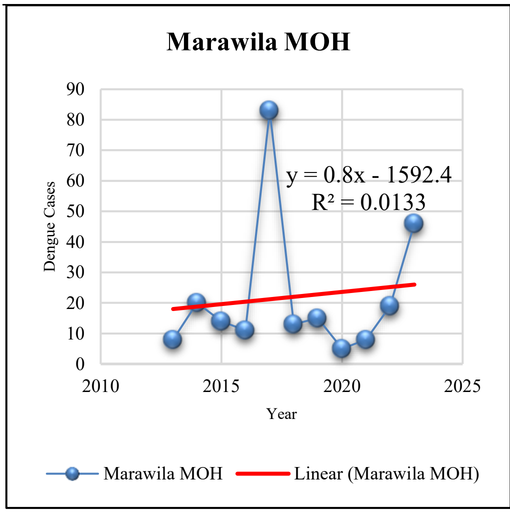

Figure 11: Temporal Pattern of Dengue Cases in Marawilla MOH
Source: Data collected from the Ministry of Health, Sri Lanka (2013 – 2023)

The highest case count was 83 in 2017, with a low of 5 in 2020, indicating slow growth in Marawilla MOH. (*Figure 11)*

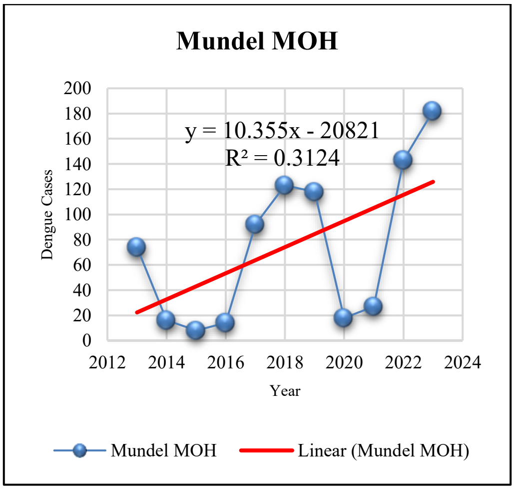

Figure 12: Temporal Pattern of Dengue Cases in Mundel MOH
Source: Data collected from the Ministry of Health, Sri Lanka (2013 – 2023)

Figure 12 shows that the peak was 182 cases in 2023, with a low of 8 in 2015, showing steady growth in Mundel MOH.

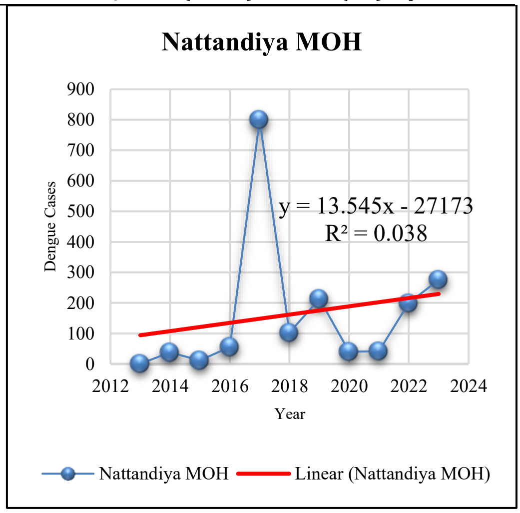

Figure 13: Temporal Pattern of Dengue Cases in Nattandiya MOH
Source: Data collected from the Ministry of Health, Sri Lanka (2013 – 2023)

According to *Figure 13,* the highest recorded cases were 800 in 2017, with the lowest at 1 case in 2013, indicating slow growth in Nattandiya MOH.

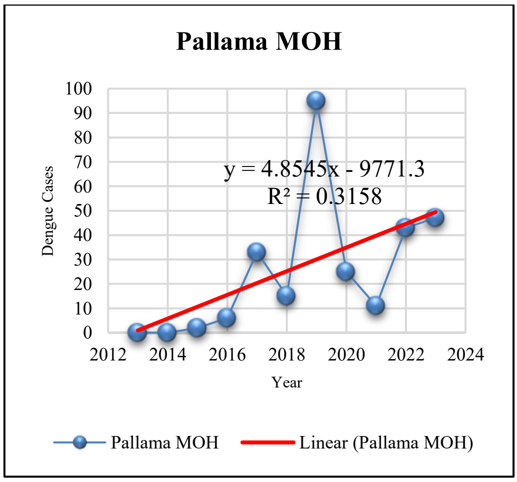

Figure 14: Temporal Pattern of Dengue Cases in Pallama MOH
Source: Data collected from the Ministry of Health, Sri Lanka (2013 – 2023)

The peak was ninety-five cases in 2019, with no cases in 2013 and 2014, indicating rapid growth in Pallama MOH. (*Figure 14)*

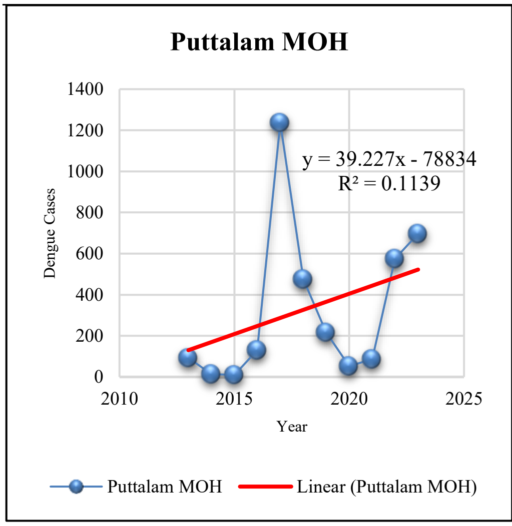

Figure 15: Temporal Pattern of Dengue Cases in Puttalam MOH

Source: Data collected from the Ministry of Health, Sri Lanka (2013 – 2023)

The highest case count was 1,237 in 2017, with a low of 10 in 2015, showing steady growth in Puttalam MOH. (*Figure 15)*

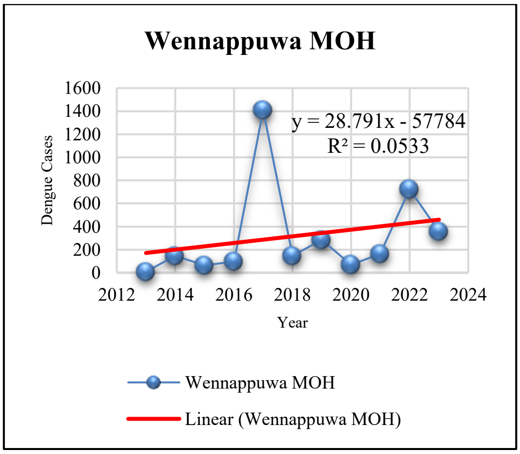

Figure 16: Temporal Pattern of Dengue Cases in Wennappuwa MOH

Source: Data collected from the Ministry of Health, Sri Lanka (2013 – 2023)

The peak was 1,409 cases in 2017, with nine cases as the lowest in 2013, indicating slow growth in Wennappuwa MOH. (Figure 16)

The district-wide outbreak observed in 2017 coincided with Sri Lanka's largest recorded dengue epidemic. Although climatic conditions such as rainfall and temperature influence the seasonal abundance of *Aedes* mosquitoes, evidence from Sri Lanka indicates that the exceptional magnitude of the 2017 epidemic was not explained by climate alone. Other contributing factors included changes in circulating dengue virus serotypes, a large susceptible population, and increased human movement.

Following a decline in reported cases during 2020–2021, dengue incidence increased sharply again in 2022 and remained high in 2023. This resurgence is consistent with national trends and may reflect the combined effects of the restoration of routine surveillance after the COVID-19 pandemic, interruptions to vector control activities during the pandemic period, favourable monsoon rainfall and temperature conditions that increased mosquito breeding sites, and ongoing urbanisation and environmental changes.

Table 1: Table: Temporal trend (cases per year) and goodness-of-fit (R^2) for reported cases across MOH divisions

MOH	TREND SLOPE (CASES/YEAR)	R^2	INTERPRETATION
Anamaduwa	10.6	0.6096	Strong linear trend
Arachchikattuwa	10.1	0.1655	Weak linear trend
Chilaw	41.2	0.2604	Weak linear trend
Dankotuwa	14.8	0.0827	Very weak linear trend
Kalpitiya	74.9	0.473	Moderate linear trend
Karuwalagaswewa	5.17	0.4155	Moderate linear trend
Madampe	13.9	0.4297	Moderate linear trend
Mahawewa	13.9	0.1387	Weak linear trend
Marawila	0.8	0.0133	Very weak linear trend
Mundel	10.4	0.3124	Moderate linear trend
Nattandiya	13.6	0.038	Very weak linear trend
Pallama	4.9	0.3158	Moderate linear trend
Puttalam	39.2	0.1139	Weak linear trend
Wennappuwa	28.8	0.0533	Very weak linear trend

R^2 = coefficient

Source: Analysis conducted using Microsoft Excel based on data obtained from the Ministry of Health, Sri Lanka (2013–2023)

The results show clear variation in disease trend patterns across MOH areas based on trend slope (cases per year) and R^2 values. Chilaw (41.2) and Kalpitiya (74.9) show the highest increasing trends in cases, indicating strong and rapid growth in disease occurrence, especially in Kalpitiya where the slope is remarkably high, but the trend fit is only moderate (R^2 = 0.473). Anamaduwa (10.6, R^2 = 0.6096) shows a strong and dependable upward linear trend compared to other areas.

Several MOH areas such as Karuwalagaswewa, Madampe, and Mundel show moderate linear trends, suggesting steady but less pronounced increases in cases. In contrast, Arachchikattuwa, Dankotuwa, Marawila, and Wennappuwa show weak to very weak linear trends, indicated by low R^2 values (as low as 0.0133). Overall, the findings indicate that while some areas show strong and consistent increases in cases, many locations exhibit weak or irregular trends, suggesting that other factors beyond time may be influencing disease variation.

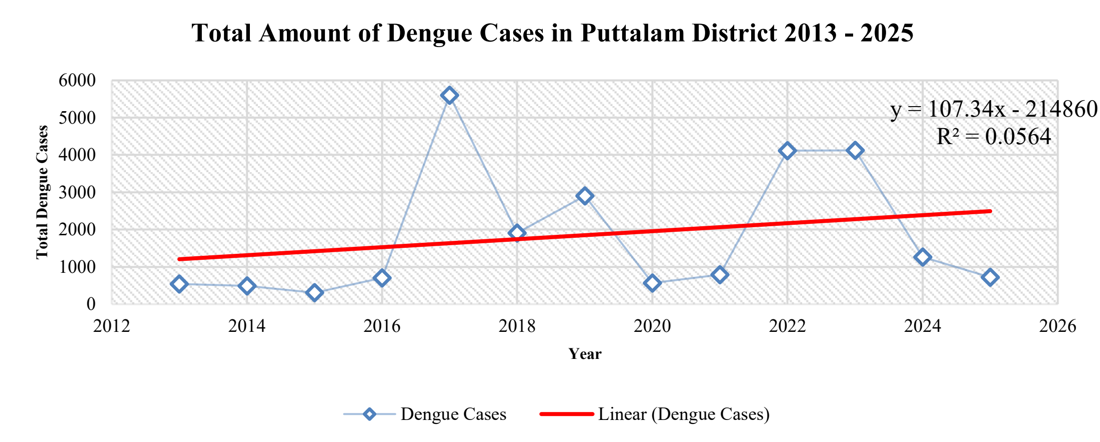

Figure 17: Temporal Pattern - Total Amount of Dengue Cases in Puttalam District; Source: Data collected from the Ministry of Health, Sri Lanka (2013 – 2025)

The seasonal trends in cases shown in Figure 17 and the Time Series Analysis indicate that fewer than one thousand cases were documented across years, averaging around 0.5 or less for a certain period per year (Puttalam District; 2013 - 2016). But afterwards, post - 2016, that leapt up. In fact, in 2017 there were over 5,603 reported cases of dengue. This led to a decline in cases, with only about

2,000 new diseases reported in 2018, but there were peaks and valleys in subsequent seasons. The total cases had bumped up again in 2023, exceeding 4,126. In both 2022 and 2023, reported above 4,000. Also, reported dengue cases between 2013 and 2025 were 24,049. Dengue incidence numbers show a positive trajectory overall but are variable over the 11 years. Recently, the Epidemiology Department reported 786 dengue incidence at Puttalam district by 2026 January to June.

Temporal Patterns of Annual Dengue Cases in Puttalam District (2013-2023)

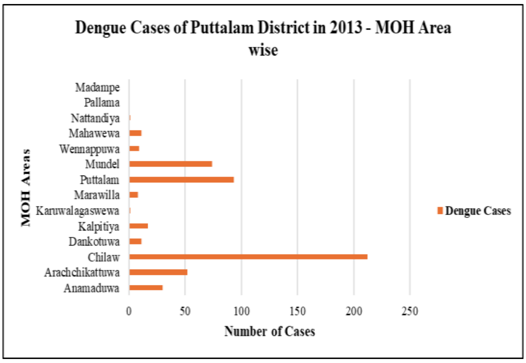

Figure 18: Temporal Pattern of Dengue Cases in 2013
Source: Data collected from the Ministry of Health, Sri Lanka (2013 – 2023)

In 2013, the Chilaw MOH division reported the highest number of dengue cases, while the lowest cases were recorded in Nattandiya and Karuwalagaswewa. No cases were reported in the Madampe and Pallama MOH divisions. (Figure 18)

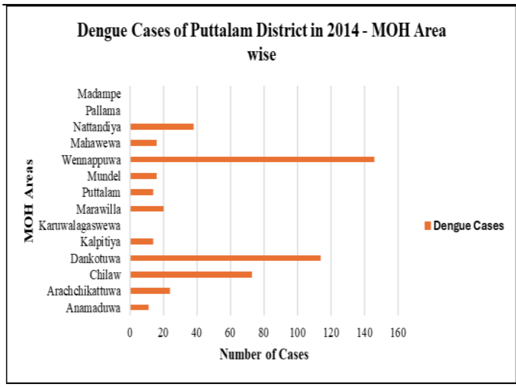

Figure 19: Temporal Pattern of Dengue Cases in 2014

Source: Data collected from the Ministry of Health, Sri Lanka (2013 – 2023)

In 2014, the Wennappuwa MOH division reported the highest number of dengue cases. Very few cases were recorded in Anamaduwa, Puttalam, and Kalpitiya, while Madampe, Pallama, and Karuwalagaswewa reported no cases. (Figure 19)

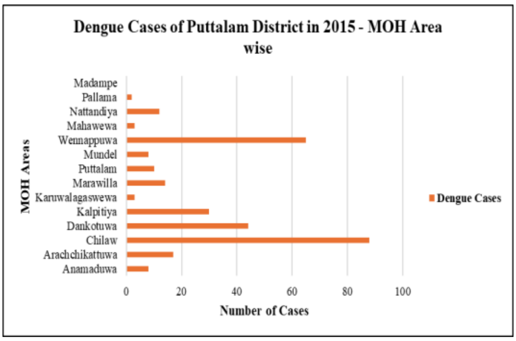

Figure 20: Temporal Pattern of Dengue Cases in 2015

Source: Data collected from the Ministry of Health, Sri Lanka (2013 – 2023)

In 2015, Chilaw again reported the highest number of dengue cases, with a very low number recorded in Pallama, Mahawewa, and Karuwalagaswewa. Madampe reported no cases. (Figure 20)

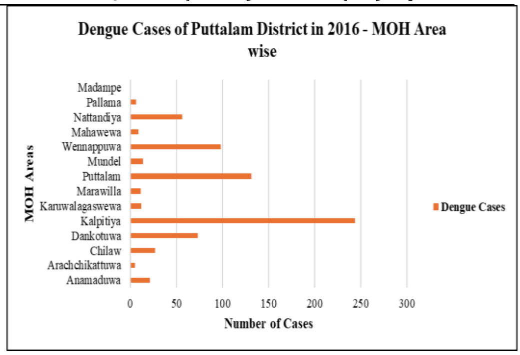

Figure 21: Temporal Pattern of Dengue Cases in 2016

Source: Data collected from the Ministry of Health, Sri Lanka (2013 – 2023)

In 2016, Kalpitiya reported the highest number of dengue cases, with a few cases in Arachchikkattuwa, Pallama, and Mahawewa, and none in Madampe. (Figure 21)

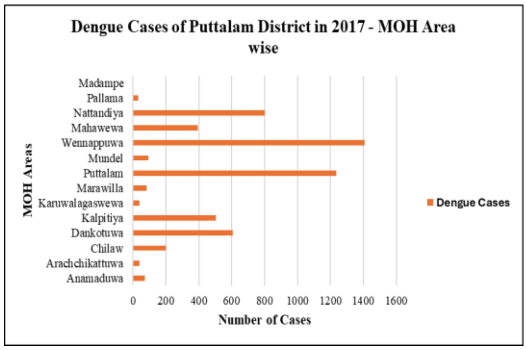

Figure 22: Temporal Pattern of Dengue Cases in 2017

Source: Data collected from the Ministry of Health, Sri Lanka (2013 – 2023)

In 2017, Wennappuwa had the highest number of dengue cases, while the lowest was recorded in Pallama. Madampe reported no cases. (Figure 22)

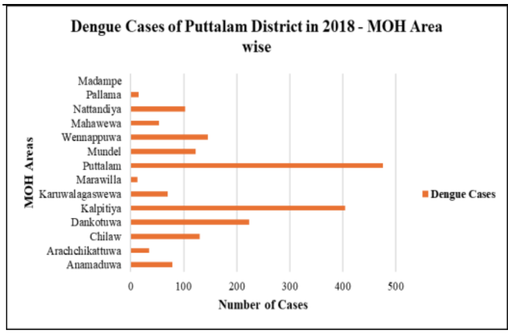

Figure 23: Temporal Pattern of Dengue Cases in 2018

Source: Data collected from the Ministry of Health, Sri Lanka (2013 – 2023)

In 2018, the Puttalam MOH division recorded the highest number of cases, with Marawilla reporting the fewest. Madampe again had no reported cases. (Figure 23)

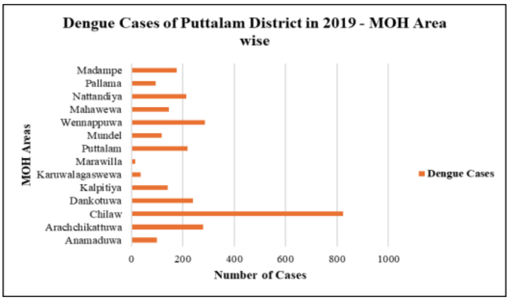

Figure 24: Temporal Pattern of Dengue Cases in 2019

Source: Data collected from the Ministry of Health, Sri Lanka (2013 – 2023)

In 2019, Chilaw recorded the highest number of cases, with Marawilla reporting the fewest. (Figure 24)

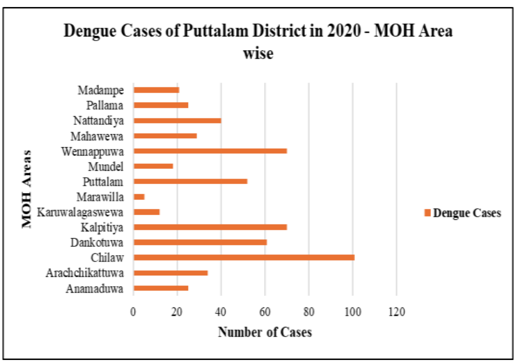

Figure 25: Temporal Pattern of Dengue Cases in 2020

Source: Data collected from the Ministry of Health, Sri Lanka (2013 – 2023)

In 2020, Chilaw reported the highest cases, with Marawilla recording the lowest. (Figure 25)

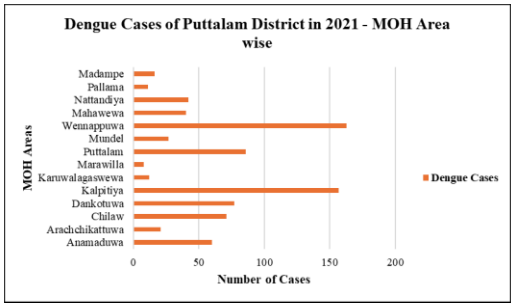

Figure 26: Temporal Pattern of Dengue Cases in 2021

Source: Data collected from the Ministry of Health, Sri Lanka (2013 – 2023)

In 2021, Wennappuwa reported the highest number of cases, followed by Kalpitiya, with Marawilla reporting the fewest. (Figure 26)

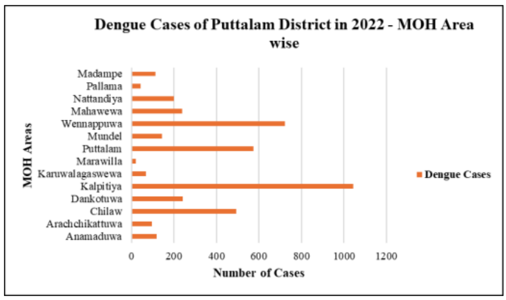

Figure 27: Temporal Pattern of Dengue Cases in 2022

Source: Data collected from the Ministry of Health, Sri Lanka (2013 – 2023)

In 2022, Kalpitiya reported the highest cases, while Marawilla had the fewest. (Figure 27)

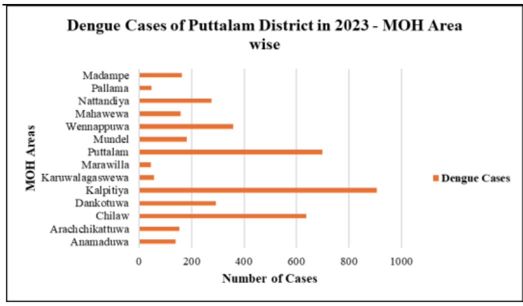

Figure 28: Temporal Pattern of Dengue Cases in 2023
Source: Data collected from the Ministry of Health, Sri Lanka (2013 – 2023)

In 2023, Kalpitiya recorded the highest cases, and Marawilla reported the lowest. (Figure 28)

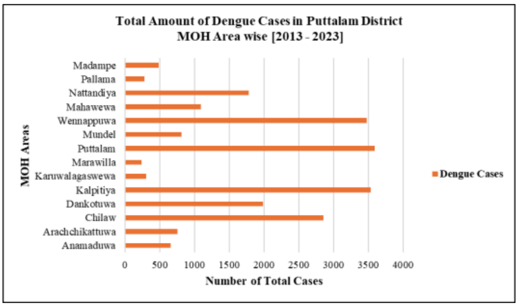

Figure 29: Temporal Pattern - Total Number of Dengue Cases in Puttalam District MOH Area-wise (2013 – 2023)
Source: Data collected from the Ministry of Health, Sri Lanka (2013 – 2023)

(From 2013 to 2023, the Puttalam MOH division reported about 3589 cases, which is the highest in terms of analysing dengue case data by the MOH division in Puttalam District.) Kalpitiya, Wennappuwa and Chilaw MOH divisions followed Puttalam with high case numbers. In contrast, the Marawilla MOH division showed the least number of infections with just 242 cases. The Pallama, Karuwalagaswewa and Madampe MOH divisions reported low case counts, whereas other MOH divisions had moderate case counts.

- ***Two-way ANOVA Findings:***

Two-way ANOVA is a statistical technique which is used to determine the effect of two predictors on the outcome variable. In this, it assists in inspecting how the cases of dengue vary with time and space within Puttalam District. As seen in Table 1, this output p-value is less than 0.05, so we found that there is a significant association between the two categorical variables, time and location of MOH areas related to dengue case incidence for both factors.

Table 1: Results of two-way ANOVA on annual dengue incidence by year and MOH area in Puttalam District (2013–2023).

SUMMARY	*Count*	*Sum*	*Average*	*Variance*
2013	14	519	37.07	3393.148
2014	14	486	34.71	2016.527
2015	14	304	21.71	698.6813
2016	14	707	50.50	4679.654
2017	14	5497	392.64	217950.4
2018	14	1870	133.57	20712.73
2019	14	2884	206.00	38451.08
2020	14	563	40.21	735.8736
2021	14	791	56.50	2585.5
2022	14	4109	293.50	92216.12
2023	14	4114	293.86	71440.29
Anamaduwa	11	660	60.00	2037.8
Arachchikattuwa	11	755	68.64	6718.055
Chilaw	11	2854	259.45	71703.07
Dankotuwa	11	1983	180.27	29104.62
Kalpitiya	11	3530	320.91	130409.5
Karuwalagaswewa	11	305	27.73	708.4182
Marawilla	11	242	22.00	530.6
Puttalam	11	3589	326.27	148591.6
Mundel	11	815	74.09	3775.091
Wennappuwa	11	3472	315.64	170952.1
Mahawewa	11	1094	99.45	15305.27
Nattandiya	11	1780	161.82	53180.76
Pallama	11	277	25.18	820.7636
Madampe	11	488	44.36	4926.655

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	2464464.40	10	246446.44	8.1663	3.66836E-10	1.9042
Columns	1990261.53	13	153097.04	5.0731	3.29931E-07	1.7961
Error	3923178.32	130	30178.29			
Total	8377904.3	153				

Source: Analysis conducted using Microsoft Excel based on data obtained from the Ministry of Health, Sri Lanka (2013–2023)

A two-way ANOVA was performed to examine the effects of year and MOH division on the average number of dengue cases. The dependent variable was the number of dengue cases, while year and MOH division were treated as independent variables. The results showed that the main effect of year was statistically significant ($F = 8.166$, $p < 0.001$). This indicates that the mean number of dengue cases differed significantly among the study years. Therefore, temporal variation had a significant influence on dengue incidence.

The analysis also revealed a significant main effect of MOH division ($F = 5.073$, $p < 0.001$). This finding indicates that the mean number of dengue cases varied significantly among the MOH divisions, suggesting that the spatial distribution of dengue was not uniform across the study area. Because both p-values were less than 0.05, the null hypotheses for the main effects of year and MOH division were rejected. These findings demonstrate that both temporal and spatial factors significantly affected dengue incidence during the study period.

The descriptive statistics further support these findings. Dengue incidence reached its highest average in **2017,** 392.64 cases per month, indicating a period of intensified transmission, whereas **2015** recorded the lowest average incidence. Among the MOH divisions, Puttalam MOH division had the highest average number of cases with 326.27, indicating that it was the most affected area, while Marawilla MOH division reported only twenty-two cases during this period. These findings address the research objective by demonstrating that dengue incidence varied significantly across both time and geographical locations, highlighting the importance of implementing targeted dengue control strategies in high-risk years and MOH divisions.

- ***Spatial Distribution of Dengue Cases in Puttalam District (Interpolation and IDW Mapping)***

Continuously, the following maps show the spatial distribution of dengue cases between 2013 and 2023, created by Interpolation (more specifically, the Inverse Distance Weighting (IDW) method) using GIS software. This technique conveniently lets you visualize cases density in the region, displaying three levels of cases, with high and intermediate showing how the spatial configuration shifted over this time span.

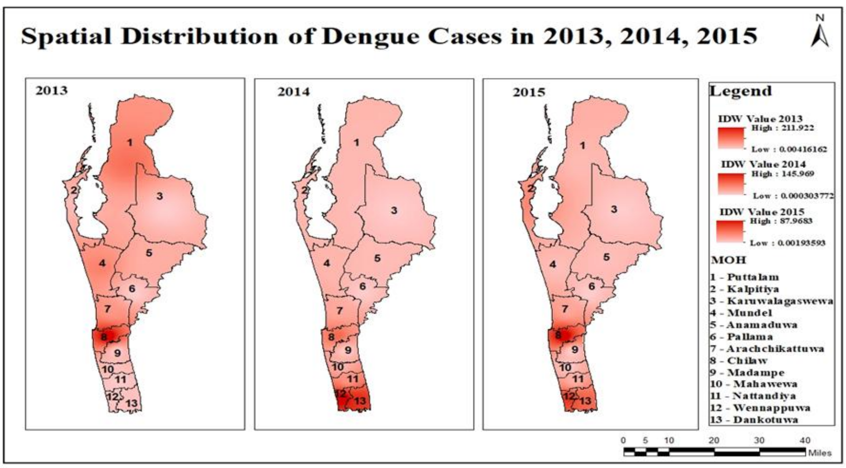

Figure 30: Spatial distribution of dengue incidence in Puttalam District (2013, 2014, and 2015) based on IDW interpolation;
Source: Spatial analysis conducted using ArcGIS 10.8 (IDW interpolation) based on dengue data obtained from the Ministry of Health, Sri Lanka.

Spatial distribution of dengue incidence from 2013- 2015 (fig. 30). Dengue cases were limited to one of the urban and semi-urban areas during that time. High incidence levels were also seen in the Chilaw MOH, Wennappuwa MOH and Dankotuwa MOH areas, which may be due to the high population density, urbanisation factors, and stagnant water sources that favour Aedes mosquito breeding. One reason is that both Wennappuwa and Dankotuwa experience slightly more rain than the rest of Puttalam District, and the clayey soil in the area retains water, creating a perfect breeding ground for mosquitoes. Elsewhere (i.e., Nattandiya and Puttalam MOH areas), transmission was recorded at a comparatively lower yet emerging level. The distribution pattern suggests that localised early outbreaks from viral transmission have not yet spread widely into the rural zones.

The spatial pattern observed from 2016 to 2018 (Figure 31) is worthy of note, as this was a time when the intensity and geographic extent of dengue spread rapidly. High transmission was also observed in 2017 (a known epidemic year of nationwide concern) in several MOH areas across the district. This shift is towards wider endemicity, as indicated by extreme clusters observed in Puttalam, Kalpitiya, Wennappuwa and Dankotuwa MOH areas. This is suggestive of an inland spread, with new clusters appearing in the MOH division Nattandiya that connect coastal urban centres to intermediate settlements.

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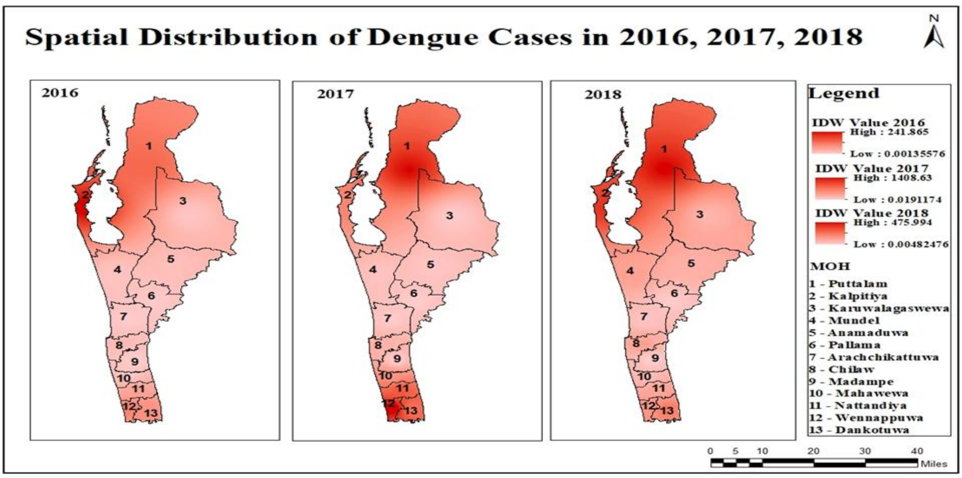

Figure 31: Spatial distribution of dengue incidence in Puttalam District (2016, 2017, and 2018) based on IDW interpolation;
Source: Spatial analysis conducted using ArcGIS 10.8 (IDW interpolation) based on dengue data obtained from the Ministry of Health, Sri Lanka

The dengue distribution from 2019 to 2021 is shown in Figure 32. In 2019, high incidence was again reported in the Chilaw MOH area. It is important to note, however, that a remarkable drop in dengue was seen throughout the district in 2020, presumably because of COVID-19 restrictive practices (like lockdowns, school closures, and prohibition of large gatherings), which had also led to reduced exposure to vectors. A moderate resurgence was seen by 2021, especially in the Madampe, Karuwalagaswewa and sections of MOH Kalpitiya (evidence for de novo risk in both coastal and inland environments)

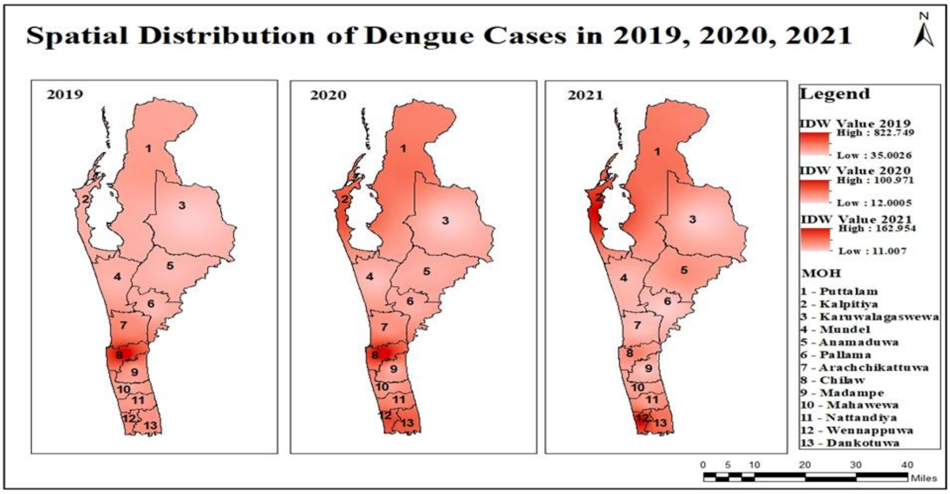

Figure 32: Spatial distribution of dengue incidence in Puttalam District (2019, 2020, and 2021) based on IDW interpolation;
Source: Spatial analysis conducted using ArcGIS 10.8 (IDW interpolation) based on dengue data obtained from the Ministry of Health, Sri Lanka.

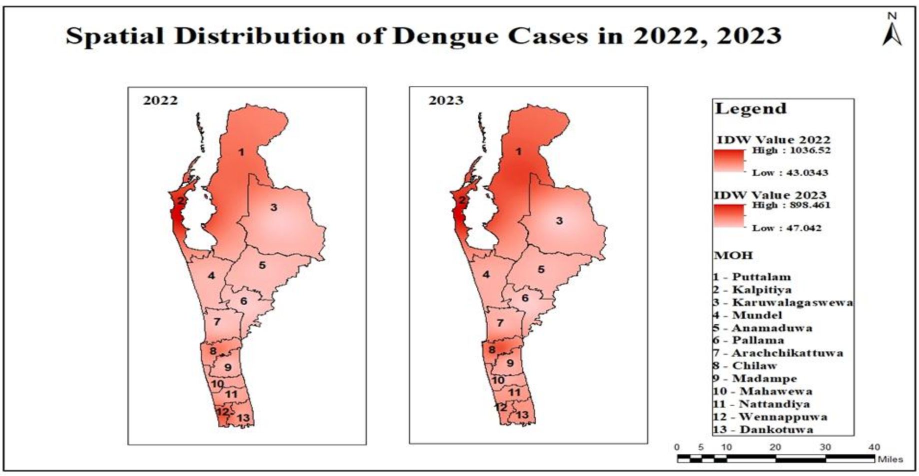

Figure 33: Spatial distribution of dengue incidence in Puttalam District (2022 and 2023) based on IDW interpolation.
Source: Spatial analysis conducted using ArcGIS 10.8 (IDW interpolation) based on dengue data obtained from the Ministry of Health, Sri Lanka.

The full spatial pattern in 2022 and 2023 is shown in Figure 33. Several MOH areas are witnessing a steep rise in dengue incidence, with Puttalam, Kalpitiya, Chilaw and Wennappuwa reopening as major hotspots. In addition, high-risk areas spread into the Kalpitiya Peninsula, indicating a wider geographical dispersion of disease. The reemergence of dengue clusters at such a large scale indicates that transmission is now more entrenched in both urbanised and peri-urban MOH divisions. The spatial patterns show localised endemicity and gradual geographic expansion of dengue in specific areas of Puttalam District over the 11 years. Still-persistent hotspots in MOH areas like Puttalam, Kalpitiya, Wennappuwa, Chilaw and Dankotuwa indicate that there are structural and environmental drivers for vector proliferation due to urban growth, poor waste management, and stagnating water bodies. Our results highlight the need for localised, MOH-area-focused vector control strategies and public health interventions that reflect the underlying spatial dynamics of risk.

The analysis of dengue fever trends in the Puttalam District from 2013-2023 indicates an upward propagation of the disease. In those years when there were only a few cases of dengue fever, fewer than 1,000 in any one year. There was a significant increase in the number of cases (2017), and this was similar nationwide. That year was the highest ever for Sri Lanka in terms of dengue fever cases, with more than 186,000 people falling ill. This large spike occurred because a strain of dengue virus that had been absent for some time returned. Such a virus is termed dengue virus serotype 2, or DENV-2. Dengue virus serotype two was not the type of dengue virus at play in the country for a decade. So, when it returned, they discovered that many people were not immune to it. That caused more people to get sick and for the disease to spread widely. In 2018, the number of reported cases dropped significantly following an outbreak in 2017. This was not only in the Puttalam District but all over the country. You may wonder why this might have happened. One reason is that people were more aware of the disease and took measures to stop its spread. The government also took additional steps to suppress the mosquitoes that transmit the disease.

Another explanation for the decline in cases could be that many people had already become ill with dengue fever and were thus immune to it. If enough of a community is immune to a disease, the disease finds it more difficult to spread. The cases of dengue fever continued to drop every year for several years after that. This indicates that dengue fever is now an endemic disease in Puttalam District and is affected by numerous factors, including weather and human behaviours. One year in particular that is notable is 2020, which saw a very substantial decrease in cases. It was the year when the COVID-19 pandemic started, and countries worldwide, including Sri Lanka, took measures to contain the spread. Measures such as staying home and avoiding places also slowed the spread of dengue fever. This is because when people are all at home, the mosquitoes that carry dengue fever are less likely to meet them.

The study also examined the visitations of dengue fever cases in the Puttalam District. It was found that some areas such as Puttalam, Kalpitiya and Chilaw had a lot of infections. These typically tend to be more dense and populated areas. There is a lot of construction and not so good waste management. All of this can allow mosquitoes to breed and transmit disease more easily. While all the districts had recorded instances of dengue fever, some areas, such as Marawila and Pallama, had recorded few cases. These territories tend to be more rural and less densely populated.

They also have trees and plants that can inhibit the breeding of mosquitoes. Even in these areas, there were some years when case numbers rose. This is indicative of dengue fever moving into places and not only a concern in the urban centres. Weather also contributes to the dissemination of dengue fever. In the Puttalam District, Rain is fall two seasons, and these seasons can influence breeding mosquitoes. Heavy rains can create breeding grounds for mosquitoes. That can lead to cases of dengue fever. The inhabitants of the Puttalam District also tend to have habits that make them more susceptible to dengue infection. For instance, a lot of people wear clothes that expose their skin and make them more susceptible to mosquito bites. They also tend to leave the windows and doors open, which can facilitate entry into their homes.

In general, the research states that dengue fever is a public health challenge in the Puttalam District, and many factors such as climate conditions, human behaviour, and surroundings influence it. Special attention must be given to these factors to curtail the spread of the disease. This can include efforts such as improving waste management, reducing mosquitoes, and educating people on prevention of the disease. Dengue fever is strongly associated with environmental factors like temperature, rainfall, and humidity. These changes can create ideal breeding conditions and make it easier for mosquitoes to transmit the disease. In the Puttalam District, for example, cases often surge post-season in cities where drainage is poor, and waste management is lacklustre. That could mean that climate change may exacerbate the problem with dengue fever, resulting in new regions where the disease can spread. The data also shows that dengue fever in Puttalam District from 2013 to 2023 [needs to be seen] as an issue. The disease is spreading increasingly. Weather, people's behaviour, and the environment affect many things. The factors below must be understood and actioned to prevent the spread of the disease. This includes improving waste management, reducing the number of mosquitoes, and educating people on how to prevent the disease. So, by taking these measures, we can avoid cases of dengue fever. Train and educate to make the Puttalam District a happy place.

5. CONCLUSION

This study examined the spatiotemporal distribution of dengue incidence in Puttalam District from 2013 to 2023 using time series analysis, two-way ANOVA, and GIS-based IDW spatial interpolation. The time series analysis revealed a clear overall increasing trend in dengue incidence across the study period, although considerable year-to-year variation was observed. A major outbreak occurred in 2017, followed by a decline during 2018–2021, and a marked resurgence in 2022 and 2023. Trend analysis further showed that MOH divisions such as Kalpitiya, Chilaw, Puttalam, and Wennappuwa experienced the greatest increases in dengue incidence, while several other divisions showed weaker or irregular temporal trends.

The two-way ANOVA demonstrated that both year and MOH division had statistically significant effects on dengue incidence ($p < 0.001$). These findings indicate that dengue incidence varied significantly over time and across geographical locations. The results also suggest that temporal and spatial factors jointly influenced the distribution of dengue cases in Puttalam District. Furthermore, the interaction effect between year and MOH division indicates that temporal changes in dengue incidence were not uniform across all MOH divisions, with some areas experiencing much greater increases than others over the study period.

The spatial analysis using IDW interpolation identified persistent dengue hotspots in the Puttalam, Kalpitiya, Chilaw, Wennappuwa, and Dankotuwa MOH divisions. The spatial distribution also showed that dengue gradually expanded from localised urban and peri-urban areas into surrounding regions, demonstrating an increasing geographical spread of the disease during the eleven-year study period. Overall, the findings confirm that dengue incidence in Puttalam District exhibits significant temporal variation and distinct spatial clustering. The persistence of high-risk hotspots highlights the need for area-specific vector control, continuous surveillance, improved environmental management, and targeted public health interventions in high-risk MOH divisions. Future research should integrate climatic variables, socioeconomic factors, and entomological data to improve dengue prediction models and strengthen evidence-based disease control strategies in Sri Lanka.

6. ACKNOWLEDGEMENTS

We thank the Ministry of Health, Sri Lanka, and the Dengue Control Unit for supplying the dengue case data from 2013 to 2023 (attained in 2024) across fourteen Medical Officer of Health (MOH) divisions. We are also grateful to the doctors and Staff of the Dengue Control Unit for their assistance and the Department of Geography, University of Colombo, Sri Lanka for co-operating and giving us guidance in this study.

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