

Contribution of Rainfall Patterns for Increased Dengue Epidemic in Sri Lanka

G. Edirisinghe*

Senior Lecturer Department of Geography, University of Ruhuna, Matara , Sri Lanka

Email: olta.ruh@gmail.com, edi@geo.ruh.ac.lk

Abstract

Dengue epidemic has become a major health issue in Asian countries including Sri Lanka. According to the World Health Organization, dengue can be considered as a high burden tropical disease. In Sri Lanka, there has been oscillation pattern in terms of the risk dengue and the number of infected persons. During the period from 1990 to 2015 Sri Lanka experienced continuing growth in dengue disease. Among the geographical areas of the country, Western, Southern and Central provinces showed a significant growth. There was a rapid expansion of the disease especially in the urbanized areas with high population density. The main objective of this study was to analyze relationships of rainfall factors and spread of dengue disease in Sri Lanka during the period of year 2004- 2015. The study was conducted using secondary data from six districts of the country. The study revealed that the rainfall factors play a vital role for the spread of the disease especially in the Colombo district. However, relatively low relationships were identified between rainfall and the spreading of the disease in other parts of the country.

Keywords: climate; correlation; dengue epidemic; rainfall; Sri Lanka.

1. Introduction

Sri Lanka is an island surrounded by the Indian Ocean. The Island is a 65,610 square-kilometer teardrop off the southeast tip of the Indian subcontinent. Recent studies has concluded that “a significant change process has commenced in the village based rural society of Sri Lanka with the incorporation of the village into a broader societal system which is capitalist in nature and oriented towards western style of social institutions, governance systems, and cultural practices” [1] .

* Corresponding author.

These changes have contributed considerably on the various epidemics as well. Dengue fever can be considered as one such epidemic in the contemporary Sri Lankan society. As such high prevalence of dengue fever has been reported throughout the country in the recent past. Most evidence shows that Sri Lanka cannot be free from the diseases due to the inherent tropical climate conditions and natural environmental conditions that favour for the breeding of *Aedes aegypti* and *Aedes albopictus* mosquitoes which transmitted dengue fever. Therefore, it has been difficult to prevent, control or eliminate the entire negative health phenomenon such as disease, illness, deformity, injury and disabilities. Especially data from the year 2004- 2014 showed that significant variation of pattern of dengue occurrences in risk areas in the districts are urban and sub-urban areas in Sri Lanka [2].

2. Research Problem

In the year 2002 recorded the largest outbreak of dengue fever in the recent history of Sri Lanka with 8931 cases and 64 deaths. But in the following year 2003, was one of the relatively low with only 4,749 suspected cases and 32 deaths reported. However in the year 2004 there were 15,463 suspected cases and 88 deaths reported to the Epidemiological Unit of the Ministry of Health [3]. The year 2005, 5998 of suspected cases and 26 deaths of dengue fever and Dengue Hemorrhagic Fever were reported to the Epidemiological unit. The same report showed that dengue is the most prevalent in the Wet Zone districts in Sri Lanka. During the first 2 months of the year 2015, 7328 suspected dengue cases have been reported to the epidemiology unit, Colombo, [3] from all over the island. Approximately, 45.30% of dengue cases were reported from the Western province. Afterward, dengue continues to be a major health issue and affecting seven out of nine provinces of the country namely, Western, Southern, Central, Uva, North Central, Eastern and Sabaragamuwa. Recently, it was reported that the dengue is the most serious health problem in the country [4]. In recent times, dengue outbreaks in the country demonstrate with two trends. Annually increased of total number of dengue cases and increasing deaths. It was clear that the dengue epidemic had been a major health issue in Sri Lanka during last two decades [4].

Considering this situation, it is a dire need of the country to find out causes for large scale increased of dengue epidemic and find out possible corrective measures to control the spread of the disease in the country.

3. Literature Review

According to the WHO reports [5] high interaction between rainfall and temperature is the root cause for the transmission of dengue. Wet climatic conditions are also affected the survival of adult mosquitoes. This has been influenced towards the high transmission rates. In addition to that, temperature and rainfall may affected the feeding a reproduction pattern of mosquitoes. It leads the path way towards the high density of vector mosquitoes. Further, WHO has studied about a number of key factors that contribute in the outbreak of dengue epidemic, also point out due to the high population density, many people could be exposed although the mosquito abundance index shows a low density value in relation to low number of mosquitoes [5].

Climate factors such as rainfall, humidity and temperature have been considered as stimulating factors of the disease [6, 7]. Moreover, tropical areas are potential high risk areas for mosquito-borne disease such as dengue and reveal that the internally acquired dengue outbreak in Northern Queensland in Australia [8]. Further,

revealed that the contribution of several conditions which favour of vector, density, distribution pattern, both survival and longevity [8]. They were in combined factors such as floods and heavy rainfall have caused in dengue menace throughout Australia. Moore & Carpenter, [9] observed that evaluation of spatial distribution pattern of dengue as a measure of risk factor may provide etiology perceptions [8]. Further, point out that the most serious form of the disease in dengue hemorrhagic fever which would be characterized, liver enlargement, bleeding and failure of the circulatory system [10]. Investigated movement population and vector borne disease. Distribution differentiating spatial and temporal diffusion pattern of both commuting and non-commuting dengue cases in Thailand. Also studied about dengue hemorrhagic fever in Thailand [12] have investigated spatial and temporal circulation of dengue virus serotypes, The study has been carried out selecting primary school children in Thailand [13].

Since monsoons are thought to influence dengue transmission, climate change can offset and weaken these monsoons through time by influencing local temperature variation and precipitation, and by extension affecting the transmission of the disease. Further, the positive temporal relationship between dengue incidence and rainfall ("dengue season") in Malasia. Similarly, research focuses on Costa Rica, [14] point out the relationship between vector density and viral transmission. Dengue morbidity is positively linked with rainfall since the dengue vector proliferates more during the rainy season. When the relative humidity is high, even if water containers in and around households are not exposed to rainfall. Two vector-related groups of factors were identified as factors. They were based on two factors, accessibility of appropriate water sources for breeding and accessibility of blood for feeding [15]. Climate factors influences the dengue and vector population both directly and indirectly. Temperature affects rates vector development mortality and behavior. Fluctuation in precipitation affects creating the suitable habitats Agypt albopictus larva and pupa. Temperature influences vector development rates, mortality, and behavior [16] and controls viral recurrent falls within the mosquito [17]. Variability in precipitation influences habitat availability for *Ae. aegypti* and *Ae. albopictus* larvae and pupae. Temperature further interacts with rainfall as the main regulator of evaporation, thereby also affecting the availability of water habitats. Indirectly, rainfall, temperature, and humidity influence in land cover and land use, which can promote or impede the growth of vector populations [18].

Climate changes also contribute a lot to alter human interaction towards the land use. The above alternation leads to increase the mosquito population rapidly and serious [19]. Moreover, inter-annual climate-variation range, climatic information and changes identified habitat of the mosquito of *Ae. albopictus* utilizing a geographic information system (GIS) in Hawaii. They determined that mosquito range spread during La Niña conditions (generally wetter) and decrease during El Niño conditions (generally drier). This could develop future risk of dengue fever given projected changes of El Niño Southern Oscillation (ENSO) cycles [20]. In addition to that changes pattern of land use especially, irregularly expansion of urbanization with insufficient housing and infrastructure. The outbreak of dengue is predictable to increase due to causes such as climate changes, globalization, and socioeconomic including urbanization and irregular settlement and also viral evolution [21]. In recent years study of the vector borne disease has received increased concentration together with new concern about climate change and the accessibility of a variety of research tools. Specially, in GIS technics [15] endemic urbanized areas.

4. Study Area

Sri Lanka has been traditionally divided into two climatic Zones both of which are based on rainfall patterns. The Wet Zones covers south west lowlands and the western slope of the Central Highlands while the Dry Zone compasses the rest of Sri Lanka. Basically, the Dry Zone is demarcated by a comparatively lower rainfall than what the Wet Zone receives. Different scholars have defined the boundary between the Dry Zone and the Wet Zone in various ways. In the first approach, the Wet Zone and Dry Zone were identified by a total of the 50 inch (1905mm) Isohyets of the mean annual rainfall and the Arid Zone Extends along the east Mannar on the North West coast. And the Hambantota on the South East coast. Climate of Sri Lanka is mainly determined by the tropical monsoon regimes. Sri Lanka belongs to the South Asian monsoon regime [22]. The Wet Zone of Sri Lanka receives its more rainfall from the South West monsoon (May- September). It gets a major precipitation from the South West monsoon and average rainfall is between 2000-2500 mm. The South West monsoon is accompanied by very air moist air masses, which lead to heavy rainfall, due to its rejection over the tropical Indian Ocean [22]. The tropical location of most part of Sri Lanka uniformly high temperature throughout the year. The mean temperature in the district ranges from 25-27C°. The climatic conditions of Sri Lanka with the exception of the high mountain regions above 500 m, are favorable for the breeding dengue mosquito of the suitable environment. The present study area was selected based on the climatic zones, representing Wet Zone districts of Colombo, Galle, Rathnapura and Nuwara Eliya. Hambantota district was selected to represent the Dry Zone and Kurunagala district represents the intermediate climatic zones. Figure -01 illustrate the study locations.

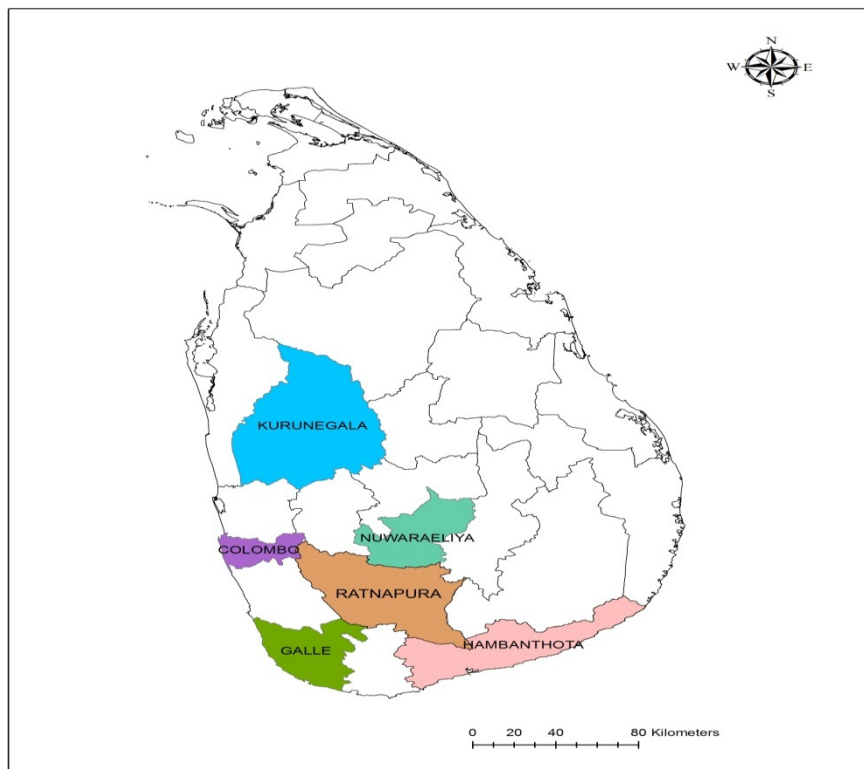


Figure 1: Locations of the Study

5. Objectives of the Study

The main objective of this study is to analyze contribution of rainfall patterns to increase the dengue epidemic in Sri Lanka. In order to achieve this broader objective, two specific objectives were formulated as follows: To identify relationships of seasonal and temporal pattern and dengue in selected geographical areas. To identify links between the monthly and intra monthly rainfall patterns and dengue in the study areas.

6. Materials and Methods

Data was collected in order to analyses both monthly and annual rainfall pattern of the selected districts from 1989 to 2014. Monthly data was gathered from 2010 to 2014 with the intention of identifying the seasonal distribution pattern of the disease. Both monthly and annual data was collected in relation to the dengue patients. Monthly and annual data collected from respective districts were also used to analyze the same. Data relevant to rainfall was gathered from the Meteorology Department and data regarding dengue patients was collected from the epidemic disease unit in Ministry of Health. Therefore, this study was mainly based on secondary data.

Time serious analysis, correlation and coefficient analysis were used in the analytical process. This study paved the way to understand the relationship between rainfall factor and the dengue epidemic in Sri Lanka.

7. Data analysis and Discussion

Figure 02 shows the number of dengue cases in Sri Lanka from the year 1989 to 2014. The data given in this figure shows that the number of dengue cases have been extremely fluctuating.

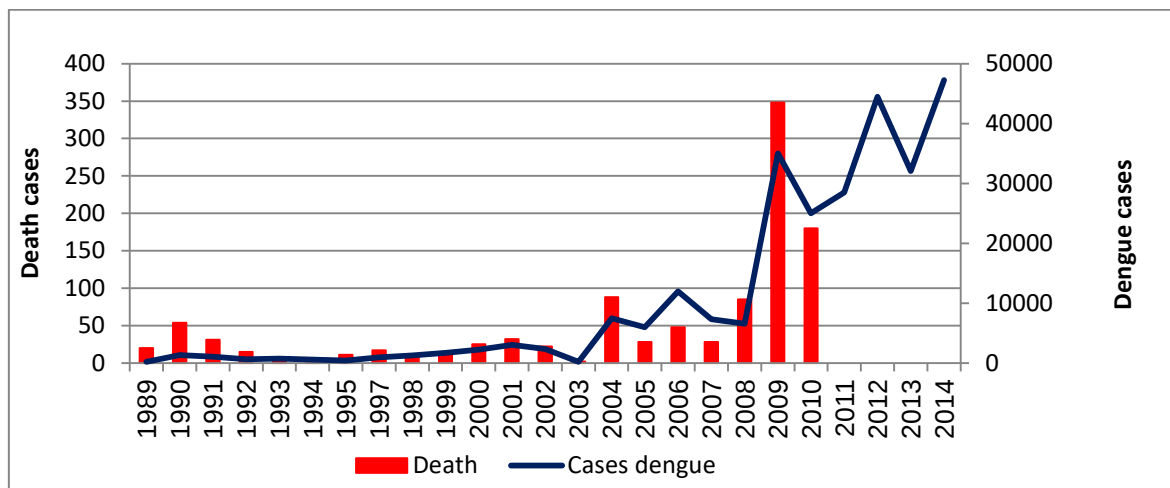


Figure 2: Annual Dengue epidemic and death cases in Sri Lanka 1989-2014

As per the data, it is clear that the year 2009 has created devastating effected highest mortality so far with 348 death cases. The disease has been continuously increased since 2009 to 2014.

7.1. Time series analysis

The plot of the annual dengue patients in Colombo shows an increasing trend since 2008 than other selected districts. In overall, a gradual increasing pattern of dengue patients can be identified in all selected districts since 2008. It shows that there is clearly a positive nearly linear trend in dengue patients in Colombo district. However, there were no clear relationships between the dengue and rainfall patterns in other districts of the study. Moreover, it predicts the future movement of an increasing trend based on previous data in Sri Lanka.

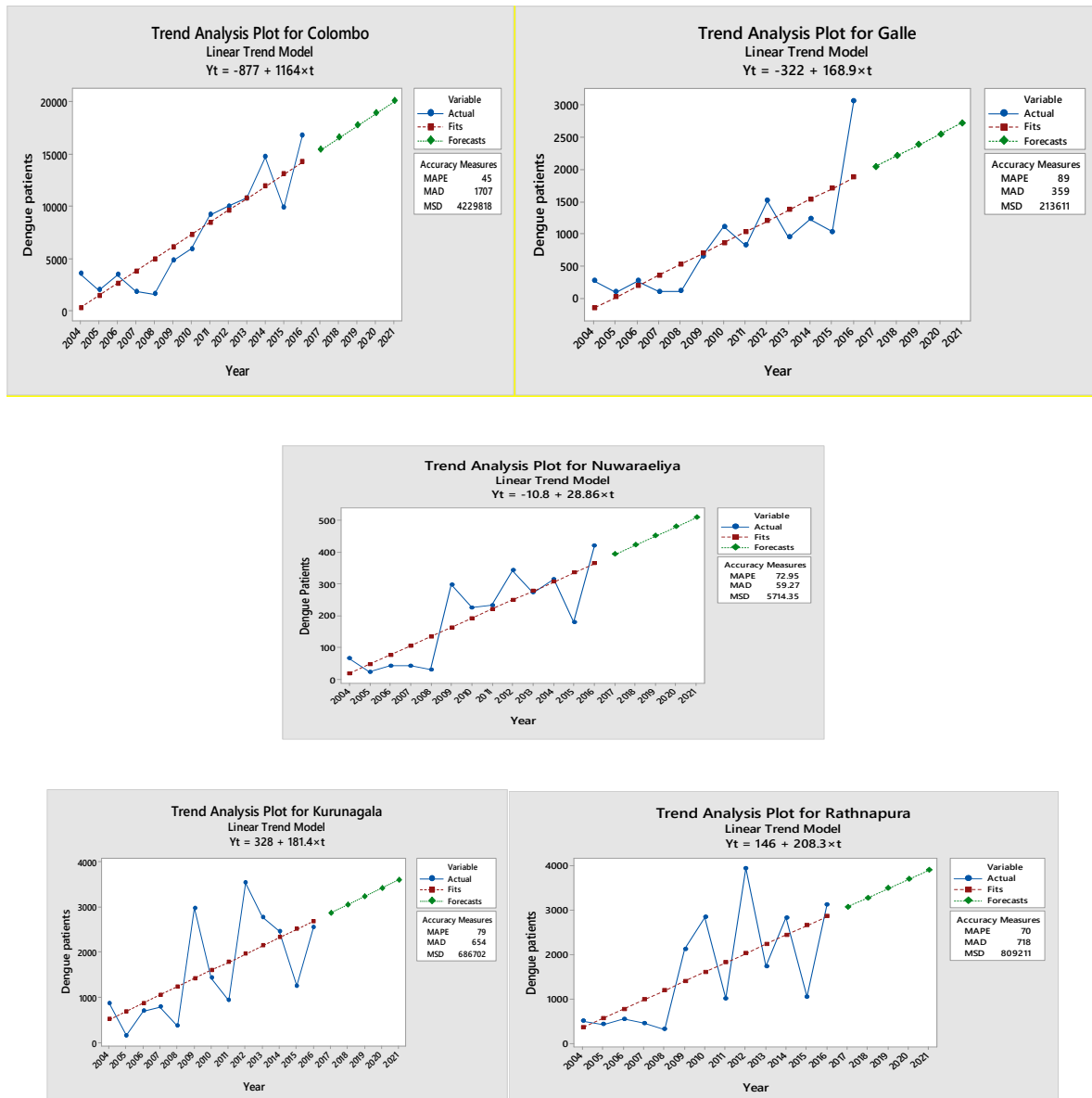


Figure 3: Time series dengue trend in selected district in Sri Lanka during 2004-2014

7.2. Relationship between annual rainfall and annual dengue cases

The inter annual variability of rainfall and the total number of dengue cases in Sri Lanka during the period 2004-2014 were investigated for studying impact of rainfall on the incidence of dengue. Figures 4,5,6,7,8 and 9 show Colombo, Galle, Rathnapura, Nuwara Eliya, Kurunegala and Hambantota districts that annual totals of rainfall varies district to district respectively. High rainfall received with low amount of dengue cases in Sri Lanka. It

can be seen 2004-2014 there was high rainfall and the low amount of the dengue cases were reported in every district.

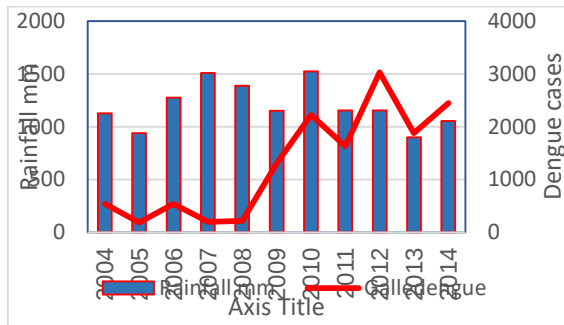


Figure 4: Relationship between mean annual rainfall and dengue in Colombo district 2004-2014

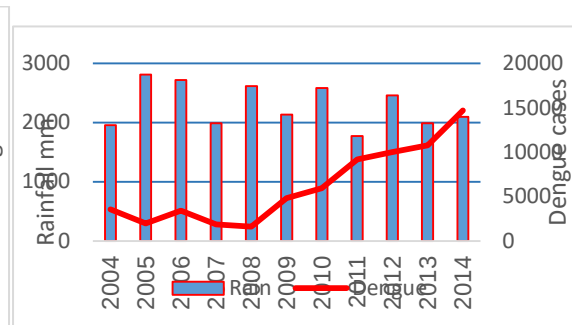


Figure 5: Relationship between mean annual rainfall and dengue in Galle district 2004-2014

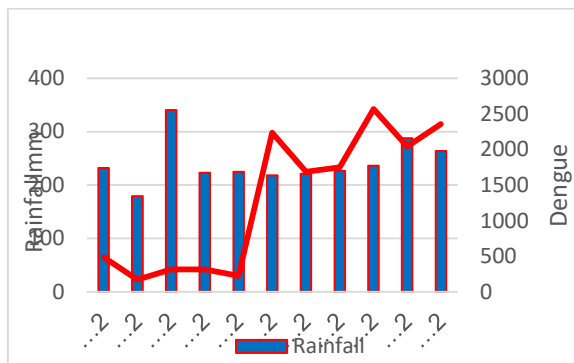


Figure 6: Relationship between mean annual rainfall and dengue in Rathnapura district 2004-2014

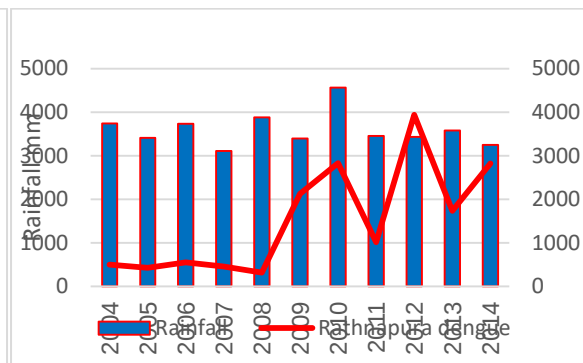


Figure 7: Relationship between mean annual rainfall and dengue in Nuwara Eliya district 2004-2014

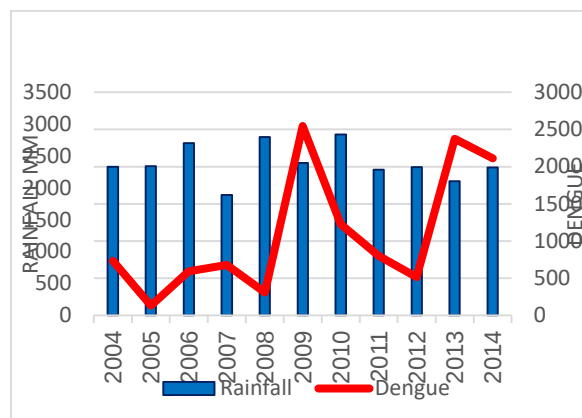


Figure 8: Relationship between mean annual rainfall and dengue in Kurunegala district 2004-2014

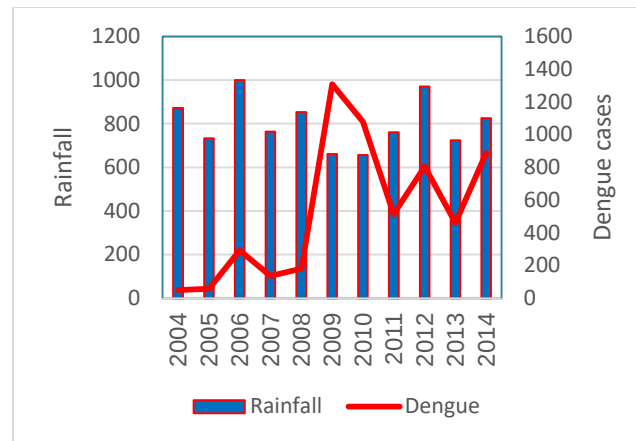


Figure 9: Relationship between mean annual rainfall and dengue in Hambantota district 2004-2014

7.3. Intra-monthly pattern of dengue

Identifying the intra-monthly pattern of dengue affecting to each month covering the period from 2012-2015 were collected for the whole country. It was recorded the disease throughout the year. Table 01 identify the intra-monthly patterns dengue cases as June, July, August and October to February. Especially in the years from 2012-2015, 50% patients of the entire cases have been recorded within three months starting from December to February in 2015. This shows that temperature makes warm environment that is appropriate for mosquitoes. During this period low amount of dengue incidence has been reported during the months from March to May. There is an outstanding increase in the number of dengue occurrence in the months of June, July and January.

Table 1: Monthly dengue cases in Sri Lanka (2012-2015)

Month	2012	%	2013	%	2014	%	2015	%
Jan	3986	8.2	3462	10.8	3610	7.6	6345	21.6
Feb	3145	7.0	3258	10.1	2011	4.2	3731	12.5
Mar	2628	6.0	2996	9.3	1648	3.4	1962	6.5
Apr	2028	4.5	2109	6.5	1682	3.5	1293	4.3
May	2550	5.7	2614	8.1	4292	9.0	1625	5.5
June	5955	13.4	2427	7.5	6736	14.1	1477	5.0
July	5193	11.7	2924	9.1	5721	12.0	2125	7.0
Aug	5266	12.0	3282	10.2	4022	8.5	1604	5.4
Sep	2857	6.3	1912	6.0	2640	6.0	1099	3.7
Oct	3181	7.1	1636	5.1	4297	9.0	2066	7.0
Nov	4034	9.0	2611	8.1	5452	11.4	2762	9.3
Dec	3638	8.1	2832	8.8	5391	11.3	3688	12.2
Total	44461	100	32063	100	47502	100	29777	100

Source: Data from the Ministry of Health, Sri Lanka- 2015

7.4. Seasonal pattern of dengue

As per the data in table 01, there were some 21840 cases or 73.4% dengue has been reported during the North East (NE) monsoon season from October to April and South West (SW) monsoon reported 7937 or 26.6% of dengue cases. Monsoon seasonal variances could be seen relevant to the patients population 25%- 49% were recorded during the SW monsoon. Dengue patient density was high during the NE monsoon season variances of the area. It has been evidenced that when experiencing high rainfall it shows a dramatic reduction of the dengue while less rainfall result high tendency of the distribution pattern in the country.

Table 2: Seasonal pattern of dengue 2010-2015

Year	SW monsoon May-Sep	%	NE Monsoon Oct-Apr	%	Total cases
2010	17531	51.4	16574	48.6	34105
2011	14875	59.0	10032	41.0	24907
2012	16272	36.5	28189	63.5	44461
2013	13159	41.0	18904	59.0	32063
2014	23411	49.2	24091	50.8	47502
2015	7937	26.6	21840	73.4	29777

Further, the data in table 2 shows that it has been recorded high amount of cases during the Inter monsoon and South west monsoon season in Sri Lanka. During the first inter monsoon(FIM) season there has been a dramatic reduction of dengue cases.

Table 3: Four Seasonal rainfall variability and dengue fever (2010-2015)

year	FIM March-mid May	%	SW Mid May- Sep	%	SIM Oct- Nov	%	NE Dec- Feb	%	Total
2010	5482	16.5	15681	47.2	2773	5.3	10169	31	34105
2011	3812		12171		2772		6242		24907
2012	6206	14.0	20271	45.6	7215	16.2	10769	24.2	44461
2013	6719	21.0	11545	36.0	4247	13.2	9552	29.8	32063
2014	5622	12.0	21119	44.4	9749	20.5	11012	23.1	47502
2015	3880	13.0	7305	24.6	4828	16.2	13764	46.2	29777

8. Conclusion

This study reveals that there is a direct relationship between the rainfall patterns and widespread increased of the dengue epidemic. It was revealed that the rainfall factors played a vital role to spread of the disease especially in the Colombo district when compared with other study locations. It showed a strong relationship between rainfall and the spreading of the disease in the urbanized areas than rural locations. It can be concluded that generally the dengue epidemic is activated significantly after around 3-4 weeks of commencements of the rainfall. As per

the findings of the study, number of patients reported in the months of June, July January and February are highest annually irrespective of the geographical locations of the country. Therefore, it can be concluded that there was a high tendency of spreading dengue menace during the rainy season. Among the studied locations, Western, Southern and Central provinces of Sri Lanka showed a significant expansion of the disease. These findings of the study lead to conclude that in addition to the rainfall patterns, there is considerable impact from the urbanization and high population density to spread the dengue diseases.

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