



An investigation into spatial vulnerable factors for dengue epidemics using GIS in the Matara District in Sri Lanka

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Abstract

The main objective of this study is to analyse the geo-spatial pattern of dengue epidemic in Matara district in Sri Lanka. In the Matara district of Sri Lanka dengue epidemic has been a public health problem over the past fifteen years continuing as a major health hazard, particularly in urban as well as sub urban areas in the District. Municipal Council is the main town area of the District, which was led towards the urbanization. This was selected as study area since the area was recorded as the high risk area and majority of dengue cases during the period from the 1997-2013. The spatial distribution pattern of dengue are very few studies in Sri Lanka using the GIS technics. The use of GIS technology is very helpful to recognize the spatial and temporal distribution of dengue in the district it will be the most important in this way. GIS mapping the volume of dengue patients reported the most of the affected areas were located settlements and stagnating water loggings. The increasing of the number of dengue cases reported in the main city of the district. Dengue is restricted to a remarkably specific environmental factors in the district. Further, this study aim purpose to reach and result indicate the affected areas include low, moderate and high risk areas. GIS knowledge could be utilized for the mapping purposes of the area and it helps to identify the most risk areas in the eradication process of dengue menace. The research has been revealed that GIS knowledge is important to create operational maps which could be utilized for the dengue vector control agencies to identify that most hazard and risk areas in the eradication process of dengue. It was revealed that there was a high tendency of spreading dengue epidemic within the MMC limit once in three years since 1987. The study shown that there was a high trend spreading the dengue vectors especially during the rainy season. It was evidenced spread of the disease was mainly caused by the human factors as well as the environmental factors. Matara city which is administrated by MMC has a high population density, lack of a properly maintained drainage system has been identified as a major physical factor in the transmission of the disease rapidly. The main natural drainage system which flows via Hittatiya releases its water to the Nilwala River. But due to the different circumstances water remains in certain areas. A proper flowing process could not be seen there because of garbage collection. Therefore, the researcher was compelled to name, Hittatiya West, Fort, Isadeen Town and Kotuwegoda GNDs as dengue hotspot through GIS analysis.

Keywords: Dengue Epidemic, Geo-spatial pattern, Hotspot, Risk area.

Introduction

Dengue, is one of the main epidemics which is reported in various Districts of Sri Lanka. It is spread as a virus disease by *Aedes Aegypti* and *Aedes Albopictus mosquitoes*. Dengue, the deadly disease is raising its head once again health experts alarming that it may appear as an epidemic in the coming months claiming more innocent lives particularly in 2011, 185 deaths and 28,138 suspected dengue cases were reported to the Epidemiology Unit of the Health Ministry¹. In the recent time high prevalent of dengue has been reported everywhere in Sri Lanka. Most evidence shows that Sri Lanka cannot free itself from the diseases due to the inherent tropical climate conditions and natural environmental conditions that favour the breeding of dengue vector. Therefore, it has been identified that it is difficult to prevent, control or eliminate the entire negative health phenomenon such as disease, illness, deformity, injury and

disabilities. The data significant difference pattern of dengue incidences 2004-2014².

It was recorded the highest outbreak in the recent past with 64 deaths and 8931 suspected cases. The following year 2003, was one of the relatively low endemic 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. During the year 2005, 5211 of suspected cases of Dengue Fever and Dengue Hemorrhagic Fever 26 deaths were reported to the Epidemiological unit.

The year 2009 has created devastating effected highest mortality so far 348 death cases. The highest number of dengue cases have been reported 47,000 cases in 2016 with 78 deaths. The disease has been continuously increased 2009-2014¹.

It is clear that the dengue epidemic has been a crucial health issue in Sri Lanka during the last two decades. Dengue is an epidemic disease contributes a major role in the development process of the same. There is a popular saying called health is wealth. Human factor of the country plays a vital role in the development process of the same. Therefore, it is essential to build a healthy nation. Health factor should be given priority when implementing development policies. It should be aimed at mitigating deadly epidemic diseases such as dengue. As a result of that government has to spent large sum of money with the intention of eradicating dengue menace from the land forever. On the other hand it reduces the investments flowing towards the development process of the country.

Dengue is the most prevalent disease in the Southern region of the country. Currently, Matara Municipal Council is faced so many environmental health issues in the district, due to the rapid expansion of dengue epidemic at present. There are natural environmental factors and human factors that create favourable background for the conveyance in the area. Because of the dengue has become a major health issue in Matara district within the last 15 years. There are two significant trends related to dengue outbreak in the district as well as a whole of the district seemed the epidemic levels. In the Matara district of Sri Lanka dengue epidemic has been a public health problem over the past fifteen years continuing as a major health hazard, particularly in the urban areas as well as sub urban areas in the District. MMC is the main town area of the District, which consists of mostly urbanized area³. Then the above area was selected as the study area since the area recorded highest rate of dengue cases during the period from the 1997-2014¹.

Geographical Information System (GIS) has provided effective tools to solve any vector borne disease in world problems. The number of dengue cases increased significantly and it became the worst epidemic in the nation's history. Today GIS technology and the remote sensing have paved the way towards the alternatives and potential tool for infectious diseases such as dengue and to control vector borne diseases of many types. Mapping tools are utilized to identify the spatial and distribution of dengue cases help a lot to achieve towards the task. Health authorities are given opportunity both to identify source of outbreak and the spatial pattern of high risk areas. In addition, to that using GIS technology preventing the disease health involvement towards these areas⁴. The geographical information system (GIS) can provide paths or patterns, relationships and trends that are not tabular data³. In addition to that using GIS technology in preventing the disease. Not only will it encourage the improvement of the spatial epidemiology which has theoretical and practical values. This will further facilitate to increase the global awareness of the infectious diseases significantly⁵. High population density⁶. GIS knowledge has been used in epidemiological public health survey for many years alarming spatial risk for dengue^{7,8}. Applying GIS to map and envisage diseases patterns and changes overtime⁹. Bangladesh GIS knowledge has been applied in epidemiological

public health studies for many years defining spatial risk for dengue.

In Sri Lanka GIS techniques have been already applied to investigate the spatial relation between dengue risk factors by so many researches. The usage of GIS to control and prevent dengue outbreak should be explored extensively and put under serious consideration¹⁰. Remote sensing applied to the analysis of spatial and temporal patterns of dengue incidence based on ecological and socioeconomic and demographic factors in Sri Lanka¹¹. This research revealed that the consolidation environmental factors derived from remote sensing data and socio-economic and demographic factors are vital for a forecasting spatial and temporal patterns of distribution of dengue. They revealed dengue is an endemic epidemic in Sri Lanka in town areas overlay operations and buffering techniques were applied. In Sri Lanka¹². They point out dengue is hyper endemic in Sri Lanka with detected co-circulation of multiple serotypes. Dengue spread is affected by biological and environmental factors, socio-economic and factors that vary over time and space. According to that the spatial and temporal relationships between the above factors dengue combined with mosquito breeding grounds and native places in the northern part of Sri Lanka. Similarly, studied with GIS used at the field of environmental health with location and spatially to detect disease cluster spatial distribution pattern. GIS technologies have the competence to integrate many types of data and to analyze spatial and temporal data to produce new models. From the public health perspective, GIS is essentially used to govern the health situation of an area, generating and analyzing diseases hypotheses, identify high risk disease affected areas, arrange areas for mitigation and surveillance programs, monitor the occurrence and visualize and analysis or map that information in a more interactive manner for better empathetic.

Objectives of the study: The aim of this study was to analyses geographical aspect. The utmost aim of this study is to investigate the spatial vulnerable factors of dengue epidemic in Matara District.

Specific objectives: i. To identify the ecological risk factors of dengue epidemic, ii. To investigate causes that influenced the spatial pattern in 2014, iii. Prepare dengue risky areas and map using the analyses factors.

Study area: This study was carried in Municipal Council in Matara District, Southern province of Sri Lanka. It possesses a striking land containing about 1282.5 km², or 128,250 hectares. Matara district falls in between 5.8-6.4 North latitude and 80.4-80.7 longitude. The district is divided into 16 administrative sub divisions. Each sub division is under a Divisional Secretariat. District is demarcated in North by the Rathnapura District, South by the Indian Ocean East by the Hambantota District, West by the Galle District. Length of the beautiful coast belt from Dickwella to Midigama in Matara district is 55 km. Mean width from east to west is 35 km. Figure 1 shows, the study area

Matara district total land extend 1.96 belongs to Southern Province, it is 23.14% of land cover extend in Sri Lanka. The elevation from the coast up to Kukulegala is 3880 feet. When the situation of land of the district is considered land extent of about 10%- 20% are hilly areas between 300m-750 m. The highest point of the Heenatigala peak which 1,170 m from the sea level and the minimum height is 90 m.

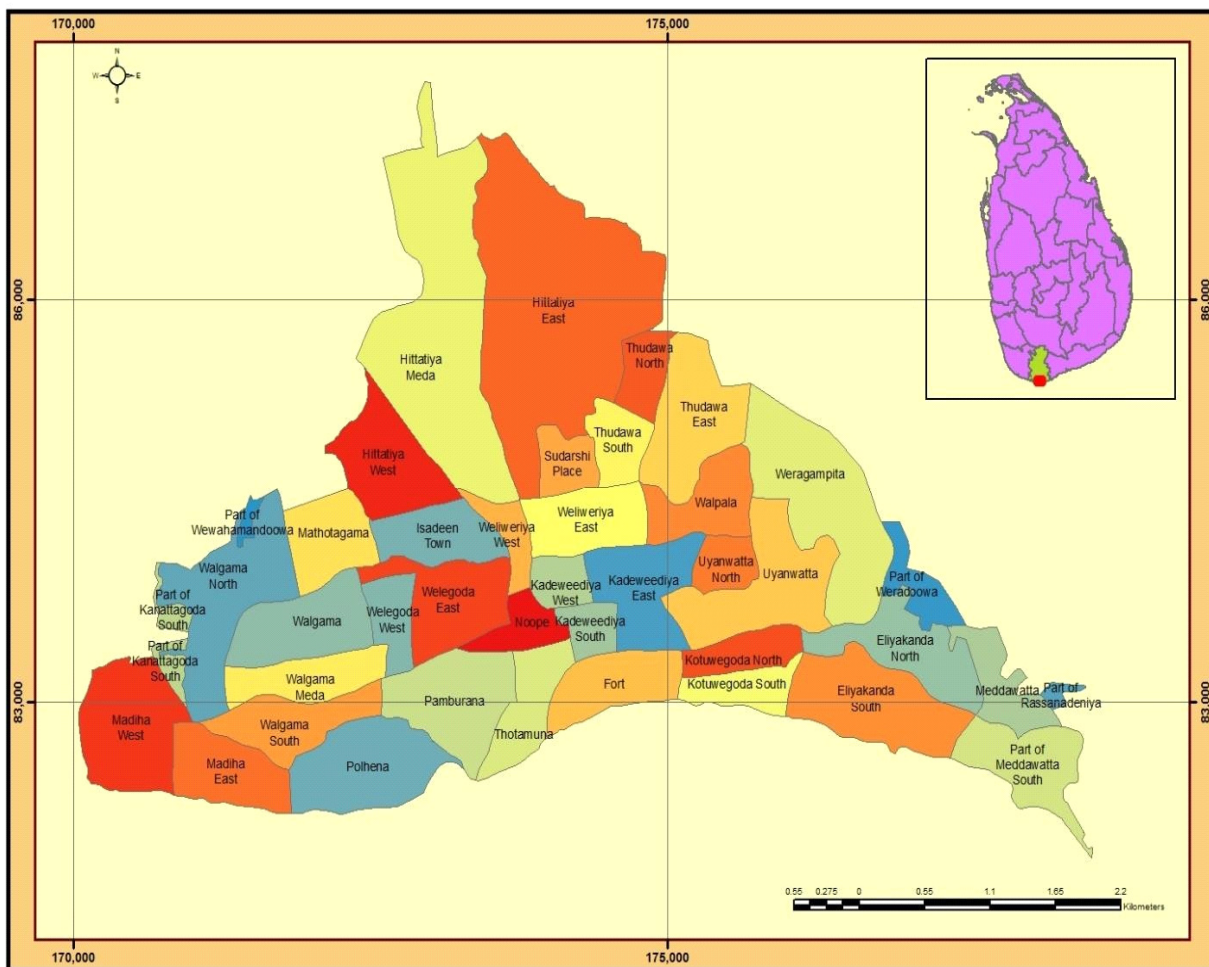
Climate of Sri Lanka is mainly determined by the tropical monsoon regimes. Sri Lanka belongs to the South Asian monsoon regime¹³. The Wet Zone of Sri Lanka receives its more 2000-2500 mm. The South West monsoon is accompanied by very air moist air masses, which lead to heavy rainfall, due to its rejection over the tropical Indian Ocean¹³.

The tropical location of most part of Sri Lanka has a uniformly high temperature throughout the year. The mean temperature in the district ranges from 25-27°C. The climatic conditions of Sri Lanka with the exception of the high consolidation of climate topography and geology, are favourable for the breeding of dengue mosquito of the appropriate environment. Combination

of climate, topography and geologic history has caused in species-rich natural and environmental situations in the district³.

Methodology

Research for this study was carried out in order to find out how far natural and human environmental factors have influenced the distribution of dengue with geospatial analysis used in GIS techniques. This study confined to the Municipal Council in the Matara district which recorded the highest number of dengue cases which were 122 in 2014. According to the available data Matara Medical Health Office (MOH) is identified as highly affected dengue area. Therefore to get a better understanding in the study area particularly that the Matara MC is selected and for collection of data from the dengue affected families. Visiting affected 24 GNDs, of the MMC in Matara district. Spatial distribution of the people living conditions, behavioral patterns as far as being exposed to dengue were revealed. In obtaining primary data a questionnaire was circulated among the affected dengue families.



Source: Data: Ministry of Health, 2014.

Figure-1: Location of study area.

Primary data was obtained by direct interviews with the dengue affected families at community level so as to get very trustworthy and correct information. The following data collection methods were used. The selected dengue affected families with Stratified Sampling Method and given interviews using the detail questionnaires. In addition to that secondary data was collected in 1989-2014 from the Matara district. For this study all 122 cases affected persons who were registered in hospitals were interviewed. The sources of secondary data for this study, collected from the records available at the MOH office of the Matara district. Mainly to identify the distribution of dengue patients location that address of patients is collected from dengue in the MOH in Matara Data concerned with the incidence and treatment of dengue and other related information collected from various government institutes such as Ministry of health, Department of meteorology, department of survey and MOH office of the district.

Therefore, temporal and spatial outbreak of geographical aspects of dengue epidemic in the Matara district is analyzed Arc GIS 10.1 is the used for software mapping. The information utilized to map the habitats of each dengue case applying one of the Global National Navigation Systems (GNNS). Collected data analyzed by GIS analyses software and geographical methods. GPS locations were taken and basic survey was carried out for the addresses of the dengue fever cases provided by the General Hospital (Matara MOH Office) unaware of the reason for the year 2014. During the survey it was noticed that the most of the people were unaware of the causes for the occurrence of dengue fever. By using these GPS locations hot spot analysis was carried out for the study area.

Results and discussion

It is revealed that Matara district is seriously affected. There are 40 GNDS within the area of Matara MC 29. GNDs out of 40 can be considered as highly affected areas. Therefore researcher expects to identify the geo spatial pattern in relation to the distribution of dengue. Dengue disease shows that it is the most critical public health problem in the Matara District. During the period from 1997 to 2014, it is important to note that Matara district has never been free from dengue³.

There is high tendency of spreading dengue disease in Matara. Dengue is the most prevalent in the urban and sub-urban areas in the district. Urbanized areas seemed to be favourable for a mosquitoes with a copiousness supply of plastic containers, discarded bottles, tins, tires, water coolers, house plants, air conditioners and places where rain water stuck or stored providing the suitable mosquitoes breeding grounds. Matara district also high density population with dengue spread as well as population moment throughout the district transport development activities, economic activities and the changes in climatic factors, after considering the distribution of annual dengue cases in 2014 there has been extremely spatial pattern of the district.

Risk factors analysis: The first stage consists in preparing data obtained the information system. A digital elevation of the model (DEM) was created as well as a three dimensional view of the territory obtained by contour layer 1:10000 metric map. Surface analysis was done using the DEM in spatial analysis tool.

Relation urbanization: Hotspots (high-high values) were demonstrated by combining the values over the space (using Kernel Density Estimation as interpolation method), as shown in Figure-2. The above maps exhibit show clear spatial patterns of dengue hotspots. Figure-2 shows the results for 2014. All clusters detected were significant (p -value < 0.01). The dengue epidemic in Matara MC spread rapidly in all the study area during the six month and the wide spatial dengue distribution was conserved during the peak of the epidemic, at May to September. A dengue cases map was built from the cumulative number of cases for each month during the complete epidemic, and confirmed that dengue cases were spread all around the Matara MC showing a hotspot with red colored points in the west and middle of the study area. This apparent cluster was due to a notification effect in the near city village, where spatial resolution of cases was lower. Once public health services were notified of the outbreak in the district, a faster expansion of the dengue was observed compared to the disease expansion in district areas.

The maps of local spatial correlation indices were used to display the hotspots with purple zonation (high surrounded by high, respectively).

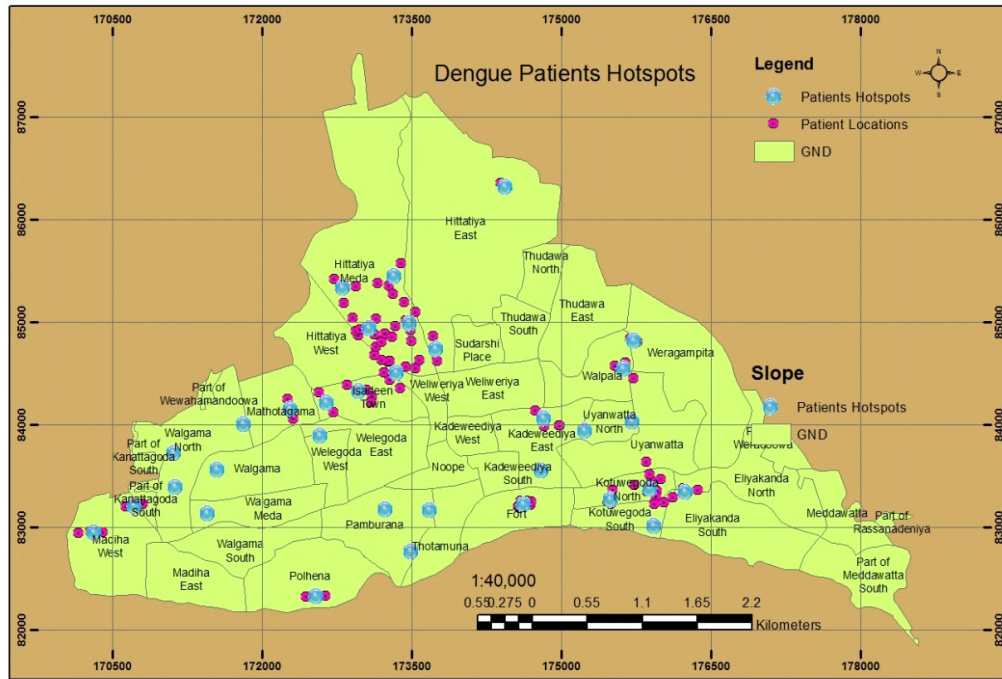
It was clear that the above map shows spatial patterns of dengue epidemic in the area of Hittatiya west. It can be considered as a high risk area. Middle (Town areas) of the study area 2014 they were determined in the southern part (Kotuwa GND) of the Matara MC. Hotspot with the highest density have been identified within the urban areas such as Kotuwegoda and Kotuwa Matara MC in the district.

Hotspot analyses which was carried out in relation to the distribution of dengue revealed that the following areas were badly affected Fort, Kotuwegoda, Hittatiya West and Isadeen Town were the areas in GNDs. Hotspot recorded a high density of dengue epidemic, human activities directly play a major role in creating mosquitoes breeding places in the above areas. Environmental conditions are ideal for breeding of the mosquitoes. On the other hand high population density and urbanization are the other factors caused severely. Although, Hittatiya West is a semi urban area, it's contribution towards the problem is remarkable. Further in the proper drainage system, canals and also garbage dumping grounds are abundant in the areas.

Patient's location and slope: The rate of changes of the surface in the horizontal and vertical directions from the center of a cell determines the slope. Slope is a critical factor in determining the

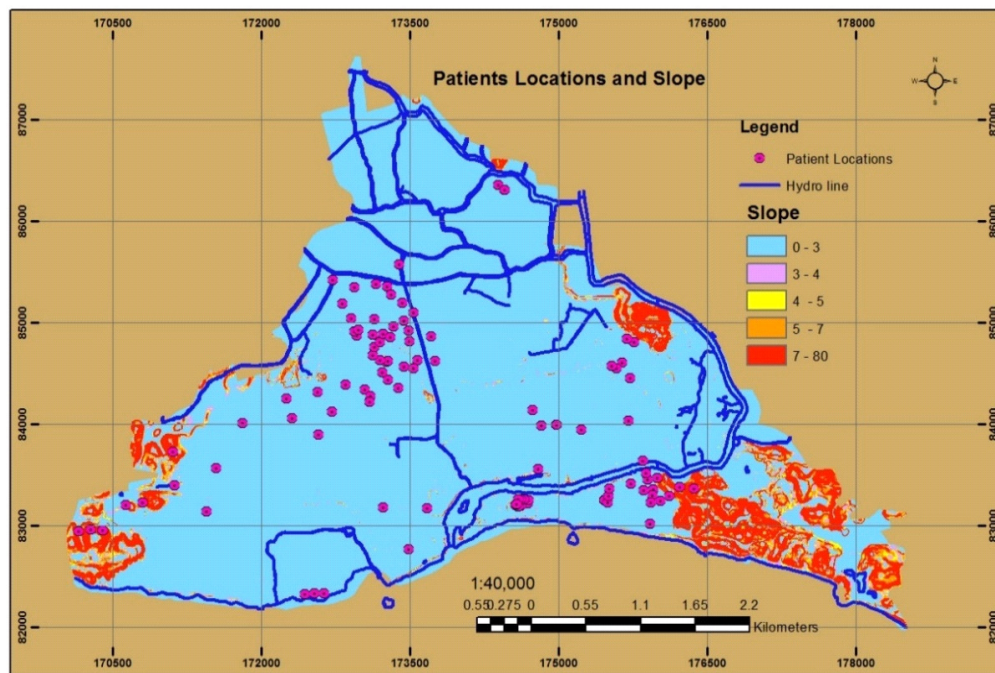
availability of the dengue epidemics in the area, shows Figure-3. Fair slope areas are low amount of patients than low slope areas in the Matara MC. Slope was derived utilizing the DEM in spatial analysis tool using surface analysis surface/slope module. After that the slope raster layer was further reclassified in to creating five sub groups on the basis of predefined slope

class. Then the sub groups reclassified slope raster layer sub groups were ranked according to the degree of suitability for dengue outbreaks in the area. It helped to determine that steeper slope areas have lesser hazard and the areas having the gentler slope have high susceptible for dengue outbreaks.



Source: Data: Ministry of Health, 2014.

Figure-2: Dengue hotspot in the Matara MC 2014.



Source: Data: Ministry of Health, 2014.

Figure-3: Relationship between patients' location and Slope.

GIS analyses reveals many factors are caused in spreading dengue epidemic both physical environmental and human involvements are identified. The average height of the land within Matara MC limit in below 100m mean sea level. It is clear that the water flowing pattern in such area is usually slow, due to the low level of the area. Even rain water remains in the area for a long time. This creates breeding places for mosquitoes. That means physical location of the area creates a favourable atmosphere for mosquitoes.

Unavailability of proper drainage system: The study area has been identified evident that there is no properly maintained drainage system within the Matara MC area. Drainage system is a very important factor for Dengue occurrences as these streams act as natural barrier for water collection that leads to mosquitoes breeding.

The Nilwala River is the only river flowing through the Matara district and somewhat pollution from the city has left it not more than a large size drain. Breeding sites in the Matara MC arise from the neglected features of the construction sites, stagnant drain water collections, tanks, of rain water collections.

There are evidences of water pockets in low lying areas of the town due to receding of flood in the year 2003. Waste items such as plastic containers, polythens bags, and leaf axils are spread in the entire environment. Gutters and low lands areas are automatically filled with the waste items during the rainy season.

Finally it creates the ideal habitats for mosquitoes density of the area. It shows a high percentage. Therefore to get rid of mosquitoes breeding sites in and around Matara MC it is necessary to maintain proper garbage disposal system. Unavailability of such system has created a mosquito paradise in the area. Even existing drainage system is not properly maintained at present. It is not a hard job to destroy mosquito grounds which are a common sight in our environment. It is sole responsibility of the relevant authorities and the public to get rid of this menace.

Relationship built with human behavior: Poverty creates numerous problems in the society. So long as poverty is there it is difficult to create a friendly environment. Their family background doesn't allow them to maintain a healthy environment. That is mainly because of lack of income, lack of education, unawareness of disease and attribute insufficient house facilities and lack of resources also contribute in a wider range towards the problem. All these factors are directly aimed towards the mosquito density of the area.

A large number of families are confined to a limited land area. Due to that water facilities and sanitary facilities are not sufficient and properly maintained. They are not compelled to keep their environment clean and they don't have time even to think of them. So long as this situation prevails it is hard to

eradicate dengue menace from our land. United Nation organization report reveals that the 25% of total families of Sri Lanka, 2009. These areas have suitable environmental conditions that are ideal for breaking of the main dengue vector mosquitoes.

Dengue fever occurrence is mapped by depending on some of the environmental factors which contribute for the survival of *Aedes aegypti* mosquitoes. For the purpose of identifying areas of dengue fever susceptible to areas, this study focused on slope, land use land cover pattern, rainfall distribution, drainage pattern and locations of the dengue fever occurrences as the factors of incidence in this study area. The occurrences and transmission of dengue fever needs the environment with gently slope abundance of wet lands, occurrence of gentle slopes, availability of wet lands stagnating water pools around area and, surrounding having lower drainage system³.

Areas with settlement are at high risk for the dengue fever occurrences due to the probabilities of crowded town area. Therefore, higher population density and interconnection of houses could lead to more effective transmission of the virus and thus increased exposure to infection. The transmission of the disease is normally limited by the flying distance of *Aedes aegypti* during its lifetime.

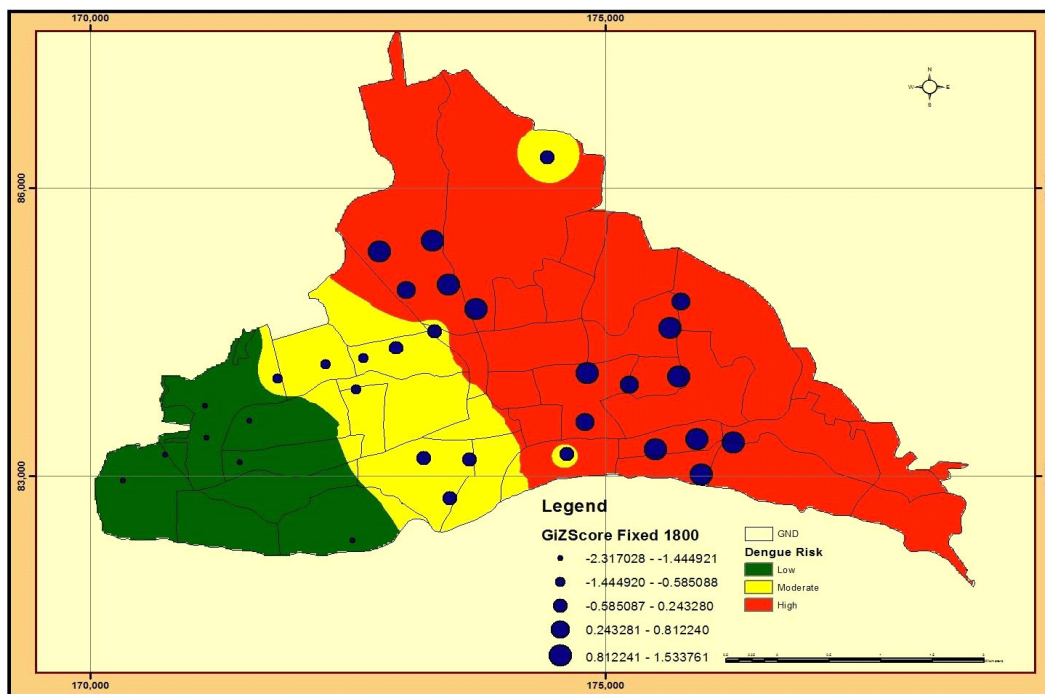
The flight distance of *Aedes aegypti* ranges from a few meters to more than 50 meters in a closed urban environment¹⁴. Whereas in urban environment where interconnections are not very common, the independent nature of houses limits the flight range of *Aedes aegypti* and reduces the transmission of the disease.

Lack of Knowledge dengue disease: Lack of awareness creates many health problems. This has become a root cause for the distribution of dengue. There is a direct relationship between during the poor community and the dengue menace. Dengue fever spreads via bite the day time. It can spread fast in urban areas. Most people engage in their during the day time. So they become victims of dengue epidemics. They are not interested in paying their attention on epidemic such as dengue. They only pay their utmost attention to earn their way of examines day to day living. It is reported that not only the poor community of urban area. Suffer from the disease but also rich people in the area. However majority of patients are recorded from the less income earned families. This factor is to be concerned.

According to the Figure-4 higher regional differences in the number of dengue cases can be observed, the highest amount recorded from the center of the MMC and the lowest number recorded from the eastern part of the study area. Data manipulation and GIS presentation and spatial statistics were used to map the distribution of the dengue occurrence in the study area. Spatial relationship between the incidences of dengue with the environmental factors that were related for the breeding of mosquitoes. They can be classified into three risk areas.

Table-2: Dengue risk areas in MMC 2014.

| High risk GNDs | Moderate Risk GNDs | Low risk GNDs |
|--|---|---|
| Hittatiya West, Isdeen Town, Kotuwegoda South, Fort, Kotuwegoda North Uyanwatta, Walpola, Kadeweediya East | Walgama, Paburana, Totamuna, Polhena, Walgama North, Eliyakanda North | Madiha West, Sudarshi Place Welegoda west, Walgama South, Tudawa, Welegoda East |



Source: Data: Ministry of Health, 2014.

Figure-4: Dengue Risk areas in the MMC in area.

Conclusion

It was led towards certain conclusions according to the information gained through the study carried out using GIS technique in relation to the distribution and root causes for the dengue epidemic within the Matara MC limit of the Matara district. The field survey and the secondary data collected from MOH office revealed that the contribution of both physical environmental factors and human factors towards the problem is remarkable.

The dengue epidemic had originated in the urban sector and later crept into rural and remote areas in the country. No proper medicine or vaccine or medicine have so far been found to treat dengue patients. There is a famous saying called “prevention is better than cure” destroying mosquitoes grounds is the best way to be free of the disease. It was identified preventive measures and strategies to be adopted within the MMC limit through GIS analysis and the maps already prepared. This will help to control and mitigate the risk in the respective areas. This will enable the work of decision makers in health division to plan the strategy for a awareness plan to combat the emergence of the dengue epidemic and ensure safer living conditions to people without the fear of diseases.

Risk maps are vital for the dengue evaluation and estimation the risk. Therefore the resources are needed in combating the dengue epidemic from the land forever.

Field survey carried out within the areas evidenced that the human factor has played a major role in strengthening the physical factors. The areas identified as hotspots according to the research revels poverty and the unawareness of people have influenced severely for the spreading of dengue epidemic. People are not interested in keeping their environment clean and tidy. Collecting garbage, polluting waterways, blocking gutters, throwing waste everywhere, were familiar sights of the area. There were many habitats for vector mosquitoes within the city limit. There were large buildings houses shops and garages. These areas were identified as hotspots. Business premises of the areas usually release waste items such as polythien products plastic container and yogurt cups into the atmosphere. As a result of that many problems were created. Proper garbage removal system has not been launched within the area of Fort, Kotuwegoda South and the West. So long as this situation is prevailed it is difficult to get rid of dengue menace. Therefore there should be an attitude change in people. It is necessary to improve their dedications towards the effort of eradicating the

menace. Without their active participation in this process it is difficult to achieve set goals. Plus attitude and motivation play a major role in combating dengue menace from our land. It is essential to launch public awareness programmes among community continuously. Healthy environment creates a healthy nation. It is the responsibility of the authorities to encourage the community and educate them in a regular manner. It was true that at the initial stage they were compelled to control the disease. But after achieving their targets once again they give up their effort and neglect the same. Therefore this process is needed regular attention. Most countries have identified that the root causes for the diseases are lack of knowledge and negligent of the affected parties. It is essential to pay the attention towards hotspots area and the interference of the respective parties such as government and relevant authorities.

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