

Evaluation of Prevalence Patterns of Dengue Fever in Lahore District through Geo-Spatial Techniques

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Abstract: Dengue and its impacts are growing environmental, economic and health concerns in Lahore. Disease pattern is important to know for better control and effective management, GIS is one of the tested tools and quite efficient for this purpose. In this study, firstly month-wise dengue cases mapping for seven consecutive years (2007-2013) is performed in order to reveal temporal or seasonal pattern of dengue disease in Lahore district. Then a composite analysis was conducted using Inverse Distance Weighted (IDW) technique in order to show dengue most affected locations (towns) and in this analysis, all cases of the study period (2007-2013) were appended and visualized by IDW. Temporally, September (6548 cases) was the most dengue affected month of all years whereas February (4 cases) was marked as least affected throughout the dengue incidence period. Endemic Foci is noticed in 2011 most affected months. This cluster of disease is agglomerated near Ravi River and Densely Populated Towns, which further aggravated the incidence of dengue in economically deprived areas. Data Gunj Baksh town was the most affected town and IDW results showed that this town is composite endemic foci where cases were agglomerated most frequently. The reason of prevalence in this town would possibly be due to its more density of population and proximity of Ravi River.

Keywords: GIS, Epidemiology, Disease Pattern, Mapping, Endemic Foci.

1. INTRODUCTION

Dengue Fever (DF) covers a large area in Pakistan just within 10 years similarly as its spread in many parts of the world. Particularly, it prevails in tropical and subtropical areas because of the suitable environment provided larger number of habitats for its pathogens. Therefore, Dengue Virus (DENV) as a mosquito-borne human viral pathogen has currently found as an important national health subject mainly in the tropical and subtropical areas of the world, particularly in the urban and peri-urban parts [1]. Dengue virus, belongs to the members of the genus *Flavivirus* of the family *Flaviviridae*. DENV has four distinct serotypes, DENV1-4, is maintained in a human-mosquito transmission cycle involving primarily *Aedes aegypti* and *Aedes albopictus*, and results in various clinical manifestations ranging from asymptomatic to dengue shock syndrome [2]. More than 2.5 billion people in over 112 countries of tropical and sub-tropical region of the world are now at risk from dengue virus infection [3]. Mahmood *et al.*, (2009) said that the very first epidemic of dengue disease was reported in 1779 in the continents of Asia, Africa, North America and it was occurred as pandemic after 2nd world war. In Pakistan, epidemic of DF was first reported in 1994 moreover in upper parts of Punjab Province in 2003 including Lahore city where it struck from 2006 to 2010 and even many other parts of

Pakistan including Karachi are also affected through DF [3-6]. Unfortunately, in 2011, Lahore became the worst victim of dengue virus and having many infected persons with high death toll [7], because still there is no available vaccine, control and prevention programs are found, which are used to reduce the prevalence of dengue Fever [8]. One of the most noticeable thing that Dengue cases were mainly reported in adult population not only in Pakistan but all parts of the world as well. Siqueira, *et al.*, (2005) reported in Brazil that DHF infected are mainly adults and in younger age groups [9]. Therefore, there is a severe need to curbing down the disease prevalence through control of their carrier habitats. For reducing the number of carriers (*Aedes aegypti* and *Aedes albopictus*) continuous monitoring of habitats is necessary. As observed Geographic Information System GIS plays a vital role in habitat studies. Government and Researchers of many countries are really interested to use GIS for controlling this disease. Khormi and Kumar (2011) studied dengue fever prevalence and modeled areas at risk in Jeddah, Saudi Arabia by using GIS and Remote Sensing (RS) data based on Socio-economic parameters. They compared dengue prevalence among Saudis and non-Saudis population (in 2006 to 2010) and found that dengue fever infected Saudis were higher in number in the years 2006 and 2007 but in 2008, 2009 and 2010, non-Saudis were infected more than the Saudis, they also found that adults were infected more than other age groups (they considered Adult age group from the age 16-60) [8]. Seng, *et al.*, (2005) described the relationship between dengue fever cases and density

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of population in the Johar state, Malaysia using GIS and found a very significant positive geographical relation ($R^2=0.87$) between density of population and DF prevalence [10]. Khormi, *et al.*, (2011) reported dengue fever (DF) on monthly basis in Jeddah, Saudi Arabia in order to monitor *Aedes aegypti* habitat using GIS. They noticed that monthly hotspots were mainly located in the center of the Jeddah district and the pattern of the disease was changed by time. They also found monthly DF pattern based on weekly frequency of mosquito vector [11].

In Pakistan, Mahmood, *et al.*, (2009) Analyzed DHF in local population of Lahore during October to December in 2008 and observed that the prevalence of DHF was 37.8% in old age as compared to children (1-15 years old) where it is only 7.1% [3]. Tahir, *et al.*, (2010) investigated spatial and demographic profile of DF cases including its seasonal variation during 2008 in Lahore, researchers observed in 2010 that densely populated zones of Lahore were having more cases of dengue fever particularly from September to December 2010 [12]. Butt, *et al.*, (2013) presented a study on DF

in Lahore in which the data of dengue cases of 2011 was used and mapped in point format and as a result, gave spatial pattern and incidence levels of this disease which could be used to reduce the disease in future [13]. Shaikh, *et al.*, (2014) investigated spatial-temporal diversity of vector borne diseases including dengue and malaria in Karachi. They investigated the prevalence of these diseases and collected 1,156 mosquito samples from 50 ecologically different sites from January to December 2009 (on monthly basis). Then on the basis of taxonomical identification genus *Anopheles*, genus *Aedes* and genus *Culex* with their associated sub-genus were also identified. Through this study January was proved to be the best for vector mosquito breeding as it is colder month while, the slums are very vulnerable to the mosquito borne diseases as lack of awareness in public [14].

2. THE STUDY AREA

Lahore district is the area of interest for this study which is the 2nd largest City of Pakistan and capital of the Punjab Province. Lahore is having an extreme

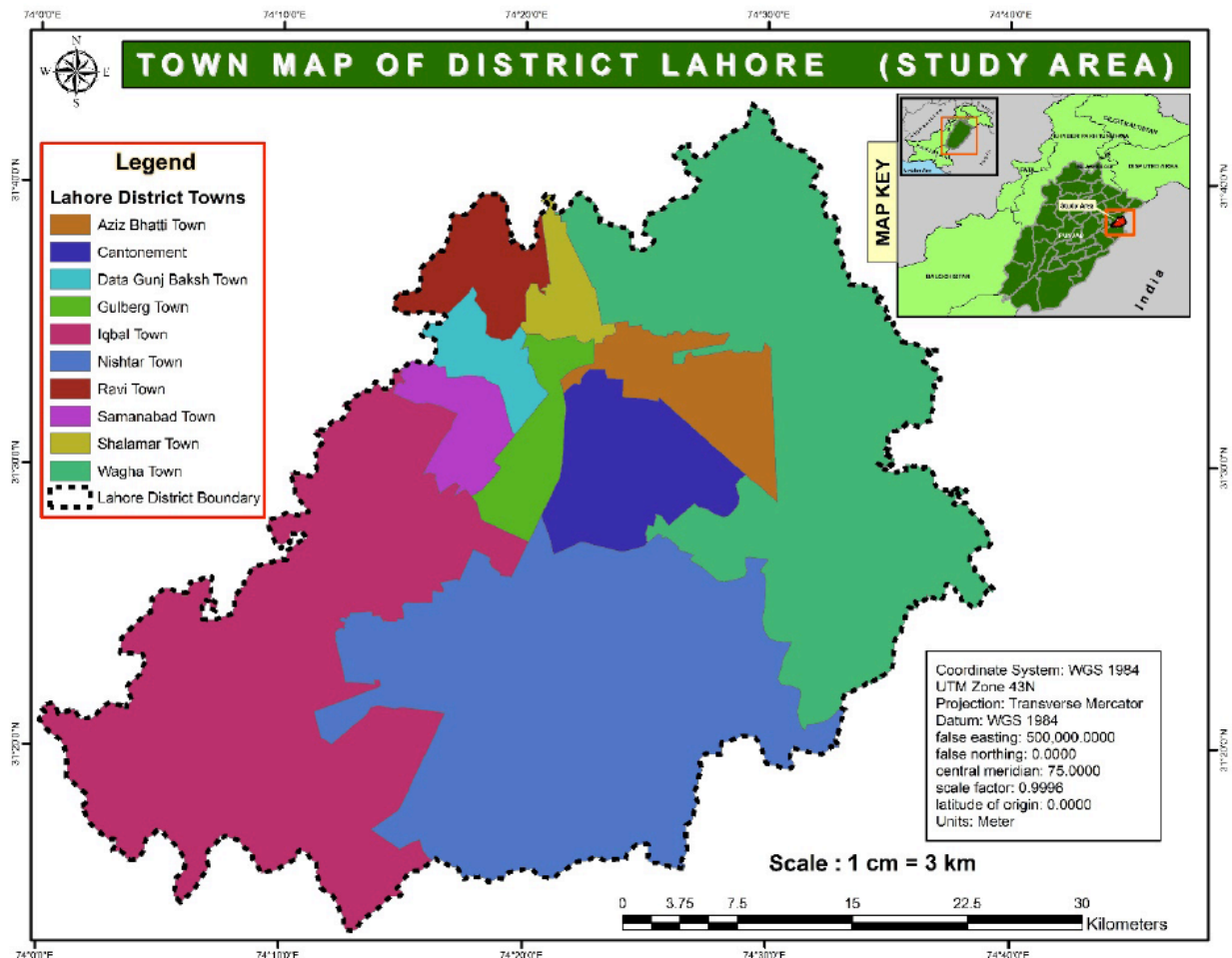


Figure 1: Lahore Administrative Towns.

climate with both warm and cold effects and located in monsoon region of South Asia. Usually summer is lengthy and most of the time with sporadic rainfall, in fact winter is also designated with cool to cold therefore, low pressure persists in summer and high in winter [15]. The rainfall and humidity are ideal to nurture the habitat of dengue and malaria. The geographical coordinates of Lahore are $31^{\circ} 13'$ and $31^{\circ} 43'$ N latitude and $74^{\circ} 0'$ and $74^{\circ} 39.5'$ E longitude. Administratively, Lahore is divided into nine towns and one cantonment (Figure 1):

Lahore is hub of economic activities and therefore a place of interaction of people from all across the country. The mobility of parasite from Karachi to Lahore led to the severe incidence of dengue.

3. DATA AND METHODOLOGY

In this study, there are two section, first is relatively larger section in which monthly spatial-temporal pattern

and prevalence of Dengue in Lahore have been evaluated with the help of monthly temporal maps and second section discusses town based dengue incidence in which all cases of all years (2007 to 2013) have been appended and shown via Inverse Distance Weighted (IDW). For achieving these objectives, dengue cases for the years of 2007 to 2013 were acquired from the Directorate General Health Services, Punjab (DGHSP). This data (In the form of MS Excel sheets) comprises mainly dengue patients and basic details with house addresses. When any researcher wants to demarcate the prevalence pattern of any disease it is better to have the GPS (Global Positioning System) coordinates for this purpose. But the data provided by the DGHSP was not having the GPS coordinates of the Patients houses. Therefore, the addresses of patients were used to create point data with the help of Google Earth in Kml and Kmz file formats. Following that the Lahore Towns and UC's maps with real estate and guide maps of Lahore towns were also used to demarcate the correct location of

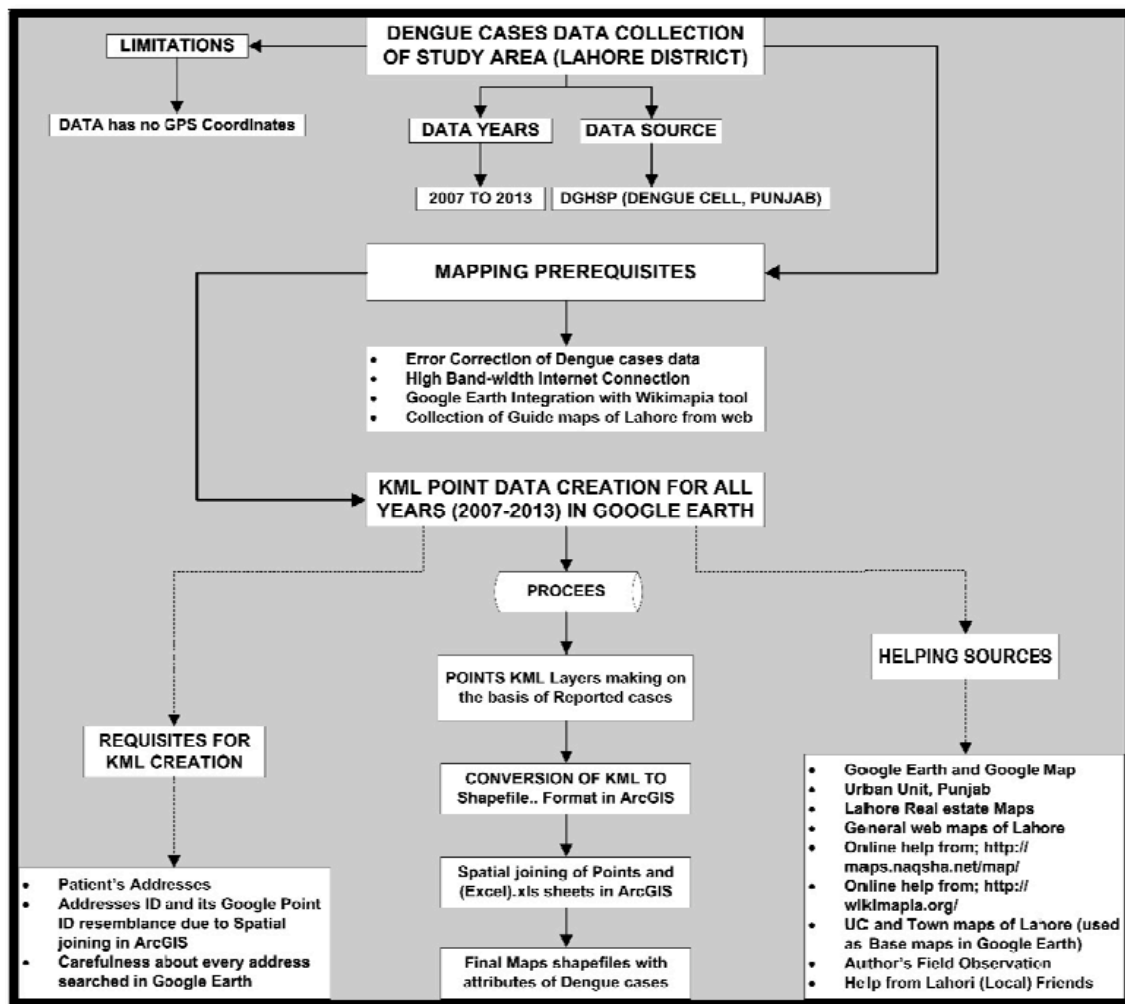


Figure 2: Methodological Framework.

patients, furthermore, the help was also derived from some online mapping projects like wikimapia.org, Naqsha.net, Bing maps and Google maps etc. Consequently, point based Kml and Kmz layers from 2007 to 2013 of reported patients were prepared but the chances of errors is still present and the data layers are not 100% error free. After this long process, those Kml point layers of years 2007 to 2013 were converted into Shapefiles (.shp) using ArcGIS Desktop 10.1 of the ESRI, and then monthly DF cases of all years were also extracted from those Shapefiles. In the end, the spatial-temporal distribution in all towns of DF cases from 2007 to 2013 was mapped to identify the monthly prevalence pattern of Dengue Fever in Lahore that surely help to curb down the Dengue Fever in future. A short Methodological framework for point data making process is designed which is shown in Figure 2.

After the creation of point layers of dengue cases and their usage in first section, IDW analysis was performed to show dengue incidence in the second section using the centroid points of all towns. Those centroid points had all cases of their respective towns so every town was having its all cases in this manner.

4. RESULTS AND DISCUSSIONS

Dengue is ecologically a special disease and environmental parameters played key role in its transmission in Lahore. Therefore, there is a dire need to study this menace through Geospatial techniques. This study is divided into two sections:

4.1. Section – 1

Maps have been developed for entire dengue affected months of the reported years (2007 to 2013). These seven maps show seven spatial results of dengue prevalence and pattern on the basis of month wise points of all seven years. For showing these points, town map of Lahore district was used for spatial overview and “Figure 1” is recommended to be used as key for town names and other compulsory detail. In this analysis, dengue disease affected months are visualized for example, in 2007 out of all 12 months dengue was occurred only in the months of January, February, March, May, June, July, August, October, November and December. The month of November was the most affected month of the year 2007 (see Figure 3) when 149 dengue cases were reported and

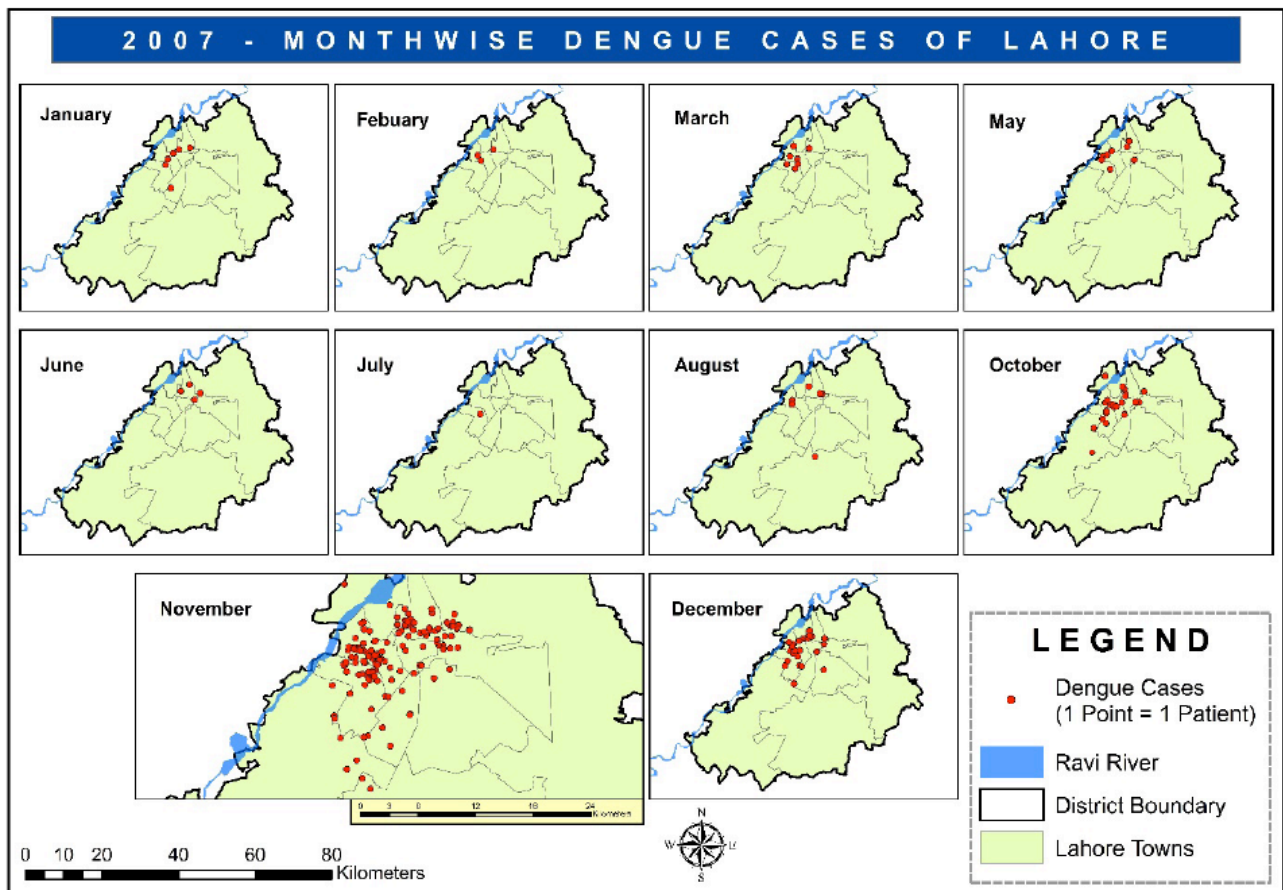


Figure 3: Dengue Disease Spatial Pattern of 2007.

the month of July received only 1 case as it was the least affected Month of 2007 but in April and September, there was no case reported that's why these two months are not shown in Figure 3. Prior to the remaining results, it is compulsory to know that the total yearly cases of 2007 were 267 in number but after some errors like Duplication of Addresses, Fake Addresses, and Null fields etc. only 241 cases remained that could be used for mapping so they were considered for this studies.

Looking inside map of 2007 (Figure 3), in the month of November couple of point Clusters are seemed to be appeared; First cluster is appeared in Samanabad and Data Gunj Baksh Towns then second relatively smaller cluster in Shalimar town. These clusters of cases have appeared in one of densely populated towns on some distance near Ravi River.

In year 2008 (see Figure 4) total 1332 dengue cases were reported but due to above mentioned errors 1180 cases were considered useful. Affected months were July, September, October, November and December. Maximum number of 894 cases were reported during the month of November however

minimum cases were reported in July when only 3 cases were documented. No case was reported during the months of January, February, March, April, May, June and August. Figure 4 visualizes the results of 2008 incidence.

In 2008 map (Figure 4), in the month of October clusters are under development in the same area as in 2007 previously. In the month of November 2008 in comparison to November 2007, clusters are agglomerated over same area of 2007 but this time the agglomeration spreads toward Ravi town, Allama Iqbal town and Cantonment near Ravi River.

In the year 2009, total number of dengue cases were 89. Whole twelve months (January-December) of 2009 remained disease affected while maximum number of cases (22 cases) were reported during the month of October and minimum (1 Case) occurred during February. Figure 5 illustrates the incidence of the year 2009.

In 2009, though dengue incidence was the lowest but interestingly it emerged in rural areas also which was always less concern with respect to its prevalence.

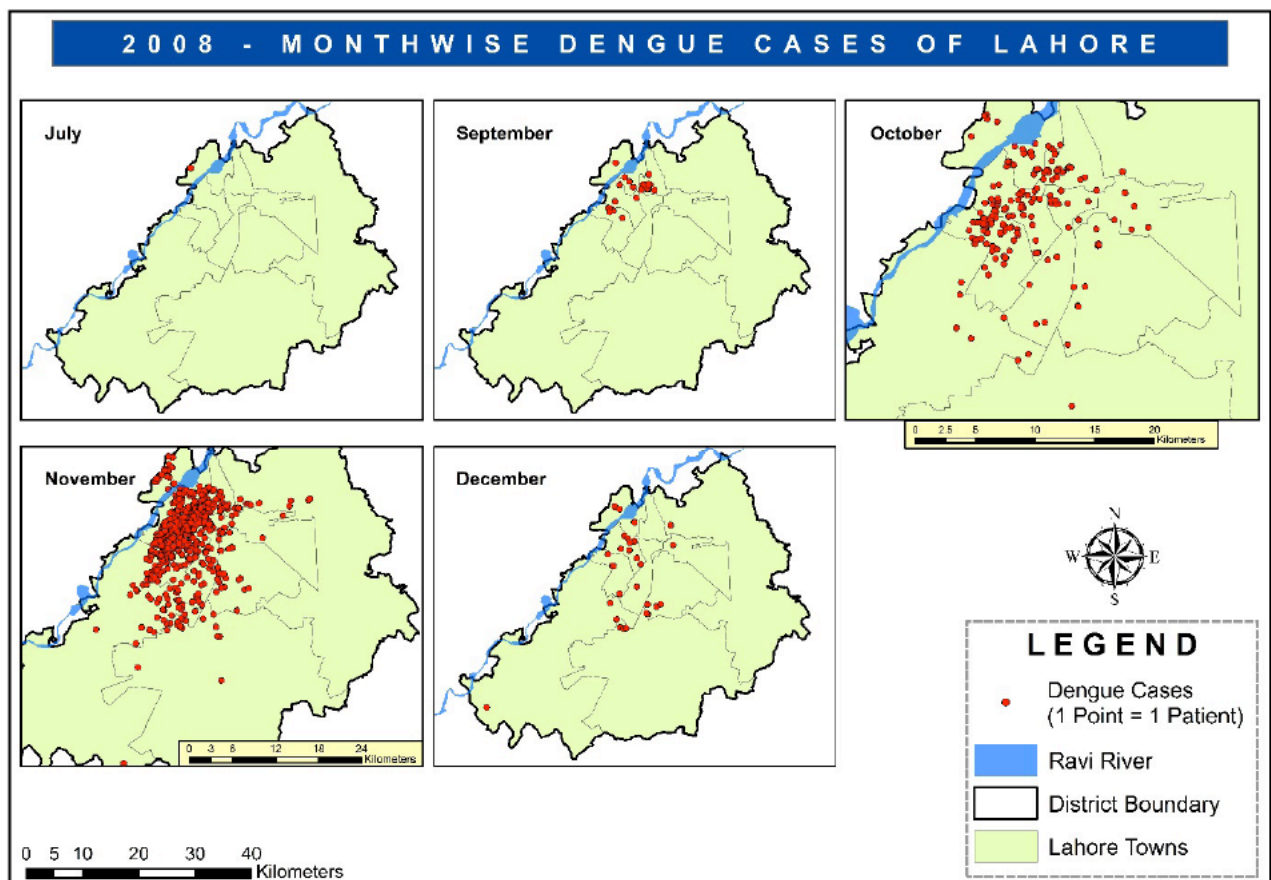


Figure 4: Dengue Disease Spatial Pattern of 2008.

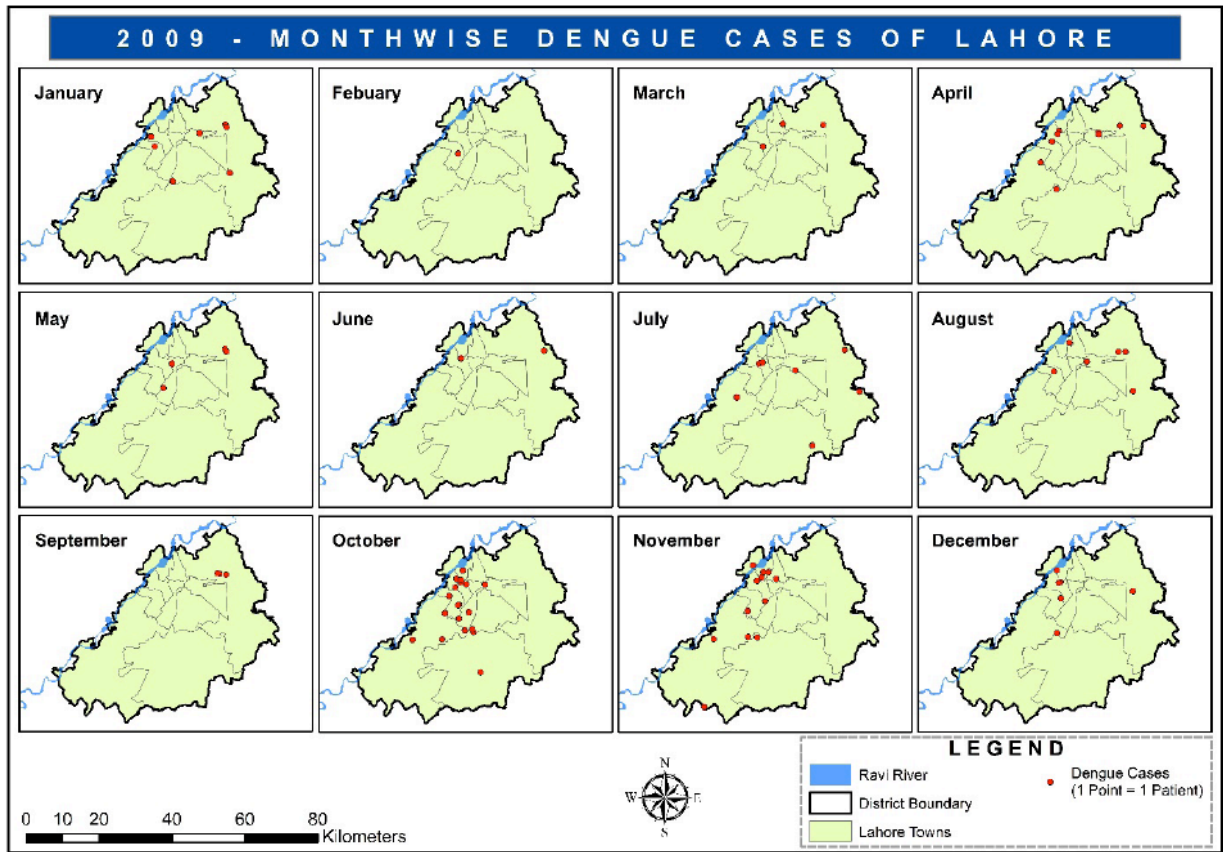


Figure 5: Dengue Disease Spatial Pattern of 2009.

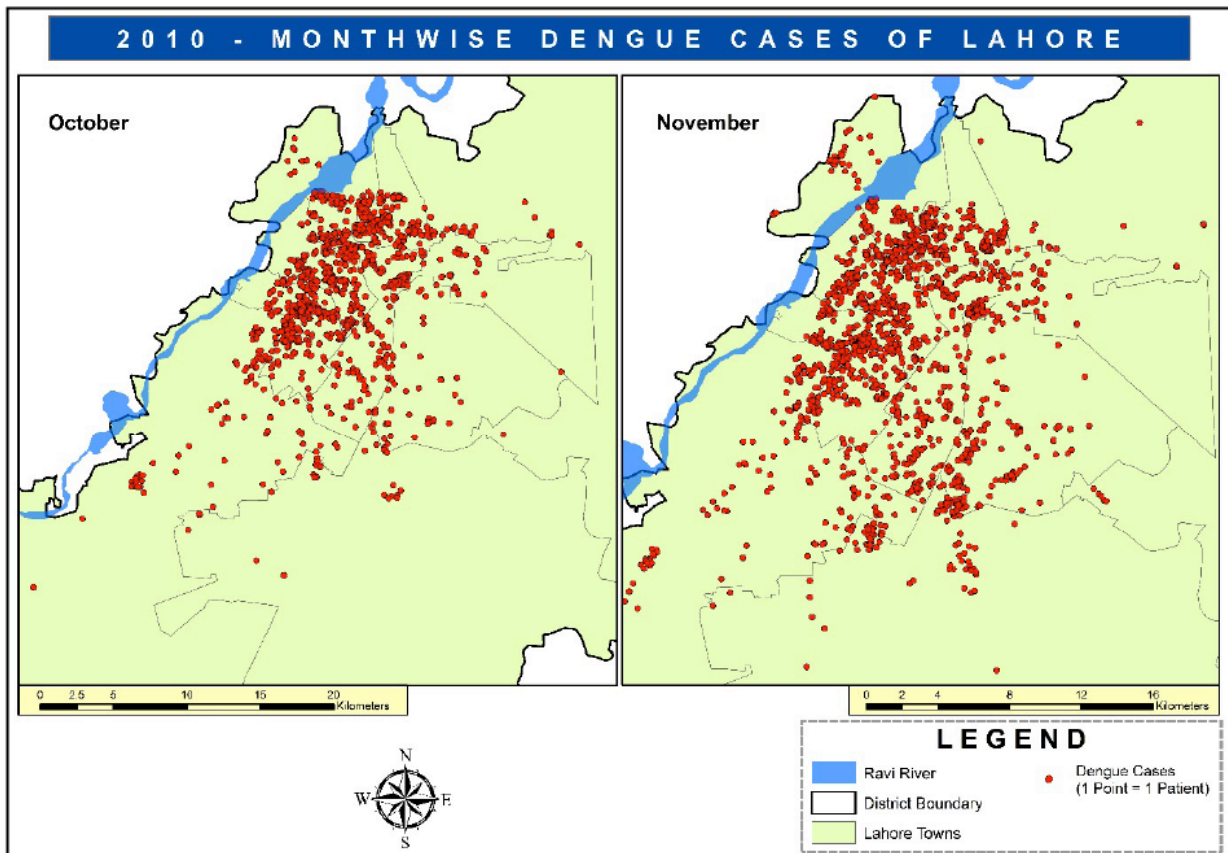


Figure 6: Dengue Disease Spatial Pattern of 2010.

The year 2010 had 4494 dengue cases but due to many errors mentioned above only 3580 cases were considered suitable for this study after correction and removing the redundant data. Only two months of 2010 were dengue affected. These months were October and November but November received Maximum number of Patients which were 2067 and remaining 1513 cases were reported during the month of October.

While looking in 2010 map (Figure 6), we see clusters and minor agglomeration mostly in Samanabad town, Data Gunj Baksh town, and lower part of Ravi town then extends towards Shalimar. Interestingly in this year the Cantonment area and Shalimar Town are having less clusters relatively had in 2008 and Ravi River is again close to the clustering.

2011 (as shown in Figure 7) was the most disastrous and dreadful year among all others when 11,283 cases were reported. In month wise pattern, dengue was occurred during the months of March, April, May, June, July, August, September, October, November and December. Maximum number of cases (6314 cases) were reported during the month of

September and minimum number of cases were reported during the month of June when only 2 patients were infected. The months of January and February received no case of dengue. The most calamitous thing about this year was that total number of 296 patients died. These deaths made the year 2011 a dengue disaster because of its attention taking attack.

Map of 2011 (Figure 7) presents disastrous picture of dengue prevalence. Dengue cases agglomerated massively in the months of August, November but especially in September and October have become Endemic Foci. This Endemic Foci is located in densely populated area of Lahore mainly Data Gunj Baksh town, Samanabad town, Cantonment area, Ravi Town, Shalimar town, Allama Iqbal Town, Aziz Bhatti Town and upper parts of Nishtar town. Viewing all previous years except 2009, Ravi River is always nearby clustering and agglomeration process which makes it very important factor for dengue incidence increase while other factor is densely populated towns. These two factors played possibly an important role in creation of Endemic foci in 2011.

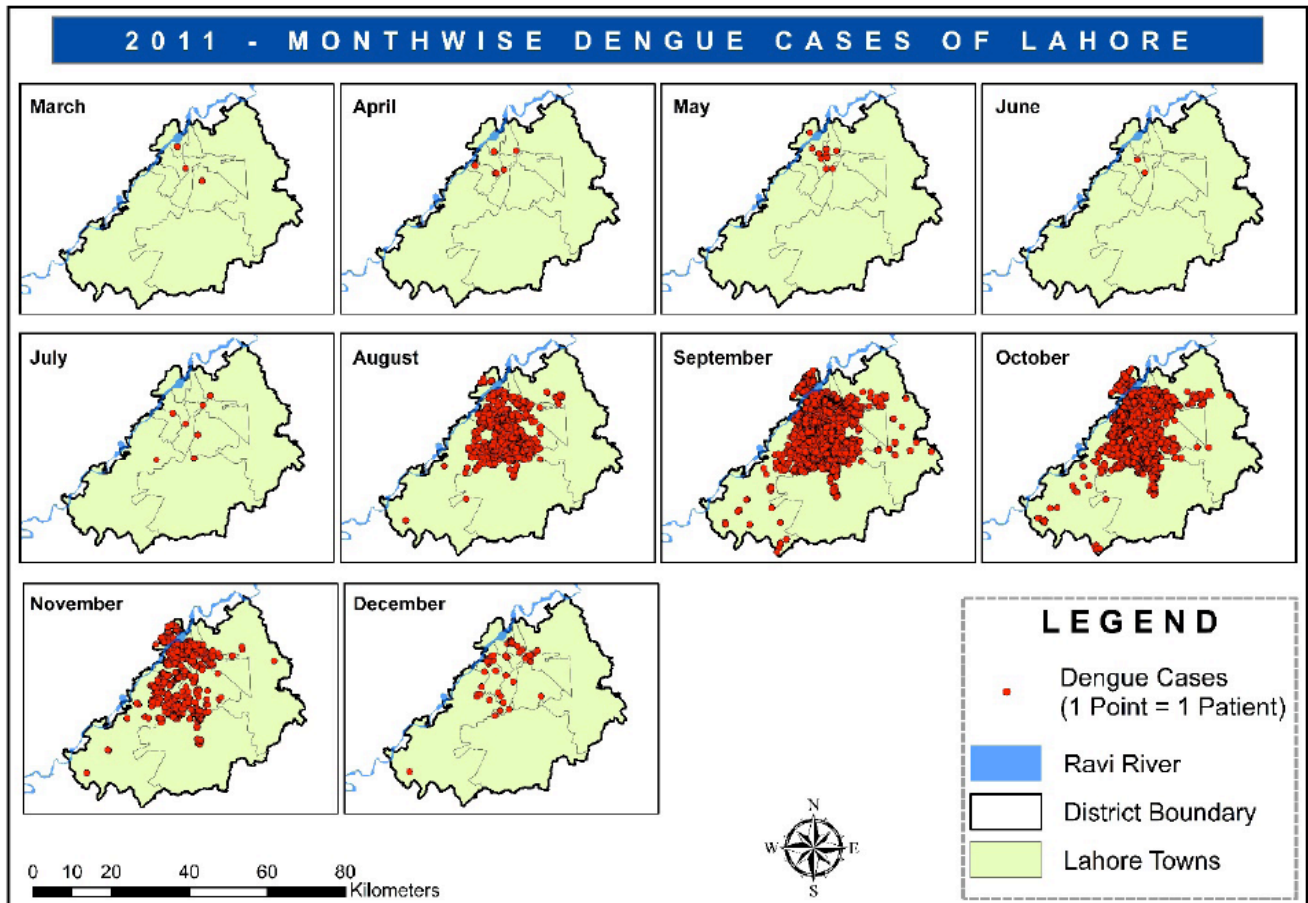


Figure 7: Dengue Disease Spatial Pattern of 2011.

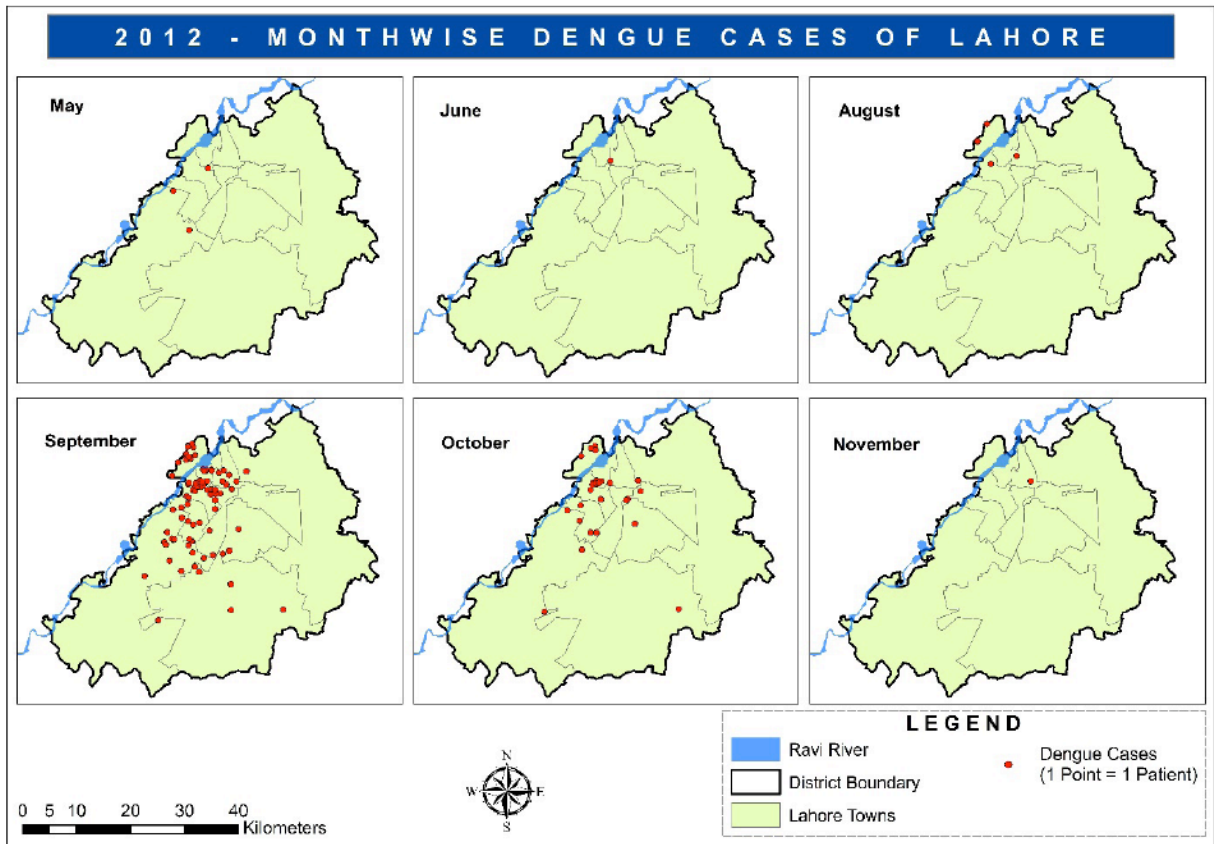


Figure 8: Dengue Disease Spatial Pattern of 2012.

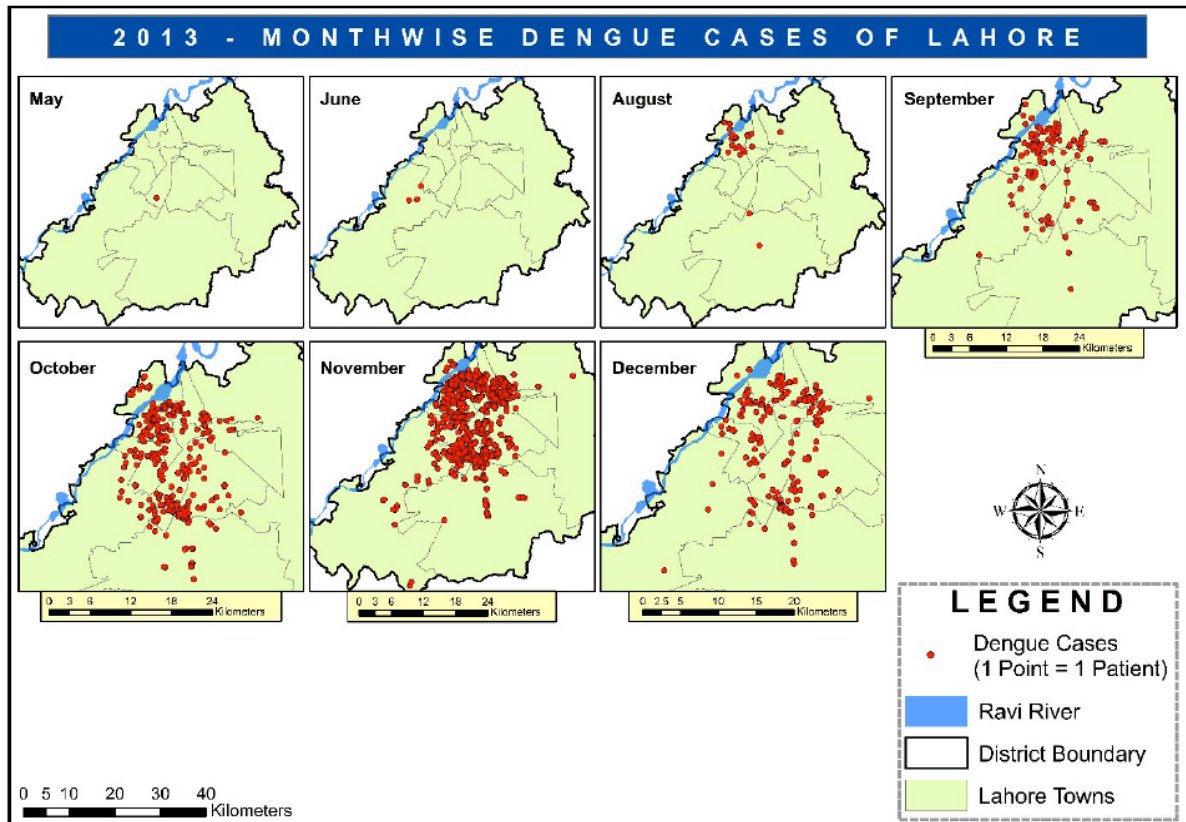


Figure 9: Dengue Disease Spatial Pattern of 2013.

In 2012 (see Figure 8), fortunately dengue was controlled after huge struggle by the Provincial Government and local Public, but still 124 cases reported. The disease affected months of 2012 were May, June, August, September, October and November. The Maximum number of cases (87 cases) were reported during the month of September and minimum number of cases were reported during June

and November when only 1 case was reported during each month. The months of January, February, March, April, July and December had no dengue case reported. The positive aspect of this year is the control of dengue vector after 2011's massive disaster.

In 2013, total number of 1512 dengue cases were reported. The affected months were May, June,

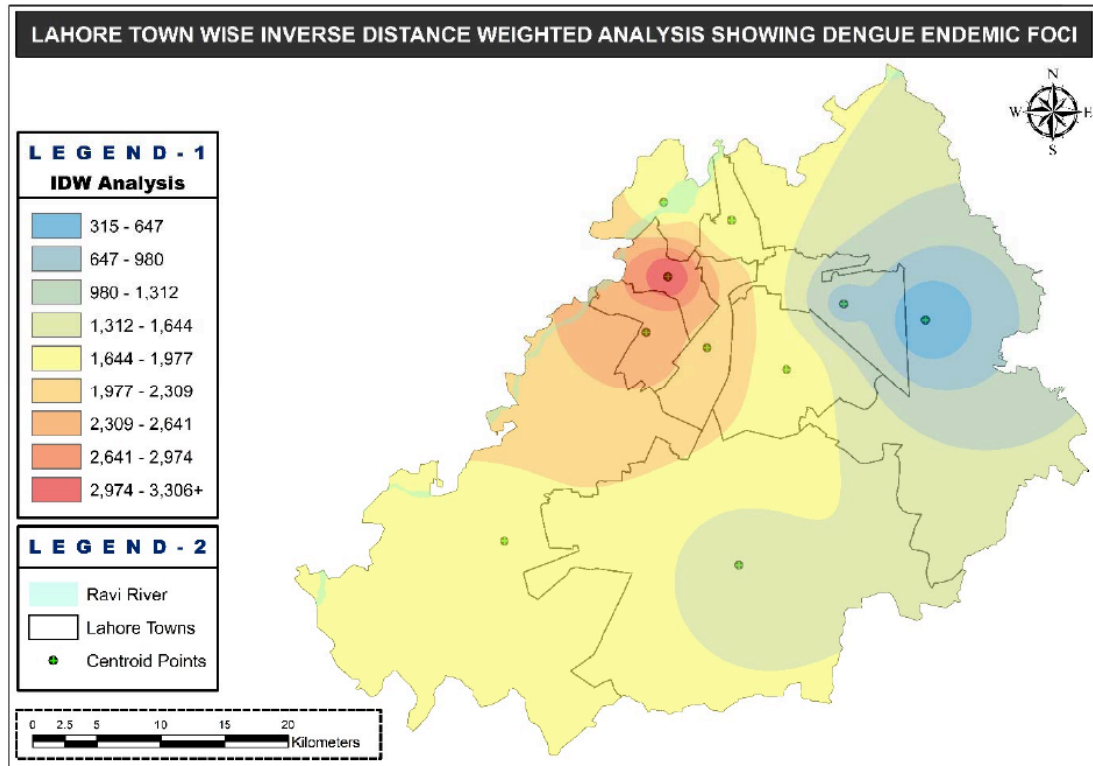


Figure 10: Dengue Disease composite (2007 to 2013) Spatial Pattern and endemic foci.

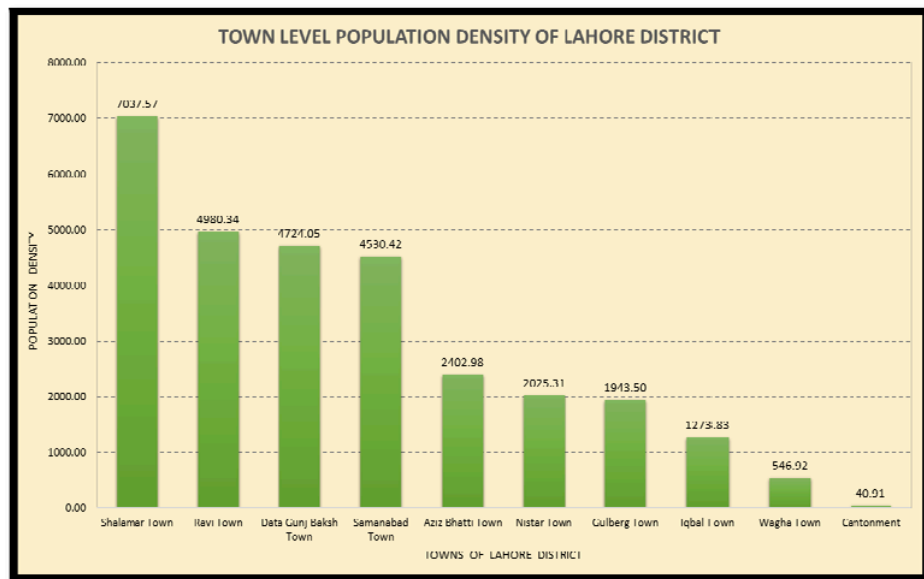


Figure 11: Population density of all towns of Lahore district.

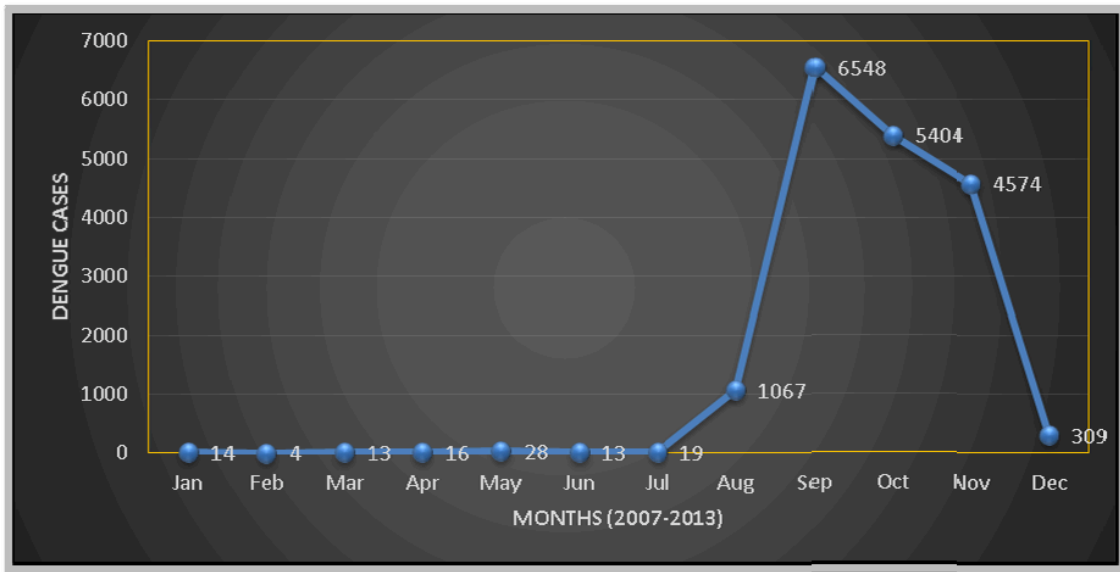


Figure 12: Dengue Disease monthly Pattern from 2007-2013.

August, September, October, November and December. Maximum number of dengue cases were reported during the month of November (875 cases) and only 1 case was reported during the month of May. No cases was reported during the months of January, February, March, April and July. Figure 9 can be viewed for better visualization.

October 2013 in the map (Figure 9) is the part where clusters are under development which agglomerated in November 2013 but like before Ravi River and densely populated zones are playing their role very tremendously here again. It looked like dengue returned again in spite of positive efforts for its control it still attacked back again this year.

4.2. Section – 2

This section discusses spatial prospective of dengue prevalence using IDW technique on the basis of towns of Lahore district. The objective was to explore most affected town during 2007 to 2013 and for this purpose cases of these years were appended and a composite Shapefile was made containing all cases for whole study period. IDW technique is very helpful when some unknown value is needed to measure from known value so here it was evaluated using cases of towns [16].

Results (Figure 10) show that Data Gunj Baksh town was the most affected town and the cases (3310 cases) of dengue were most frequently occurring there throughout the incidence period (2007 to 2013) especially in 2011 when 2069 cases were reported.

Before reasoning the highest incidence of this town it is better to know that it stands at 3rd place (Figure 11) among other densely populated towns. Author thinks that this massive incidence in this town and other neighboring towns especially Samanabad and Ravi was due to relatively higher population density as shown in Figure 11 and their Ravi River neighborhood also accelerated this a lot.

If dengue cases of this town (Data Gunj Baksh town) are compared to its total area (30.50 Km²) then it would be over 108 patients per Square Kilometer. A lot of other factors might also have been involved in it, e.g. Vegetation, Post monsoon Rainfalls, low Living standards, dense Built up land and less public awareness etc.

5. CONCLUSION

Dengue and its impacts in Lahore are disastrous; Dengue spatial pattern is very highly variable though concentrated in Towns near Ravi River. The month wise overall overview of disease for all years is also variant (see Figure 12); dengue remained insignificant in the months of January (14 cases), February (4 case), March (13 cases), April (16 cases), May (28 cases), June (13 cases) and July (19 cases) but from the Month of August (1061 cases) an increase is observed then the next month of September (6548 cases) was month with the highest number of cases, after that a slight decline is observed in the month of October (5404 cases) making it the second most affected month, November (4574 cases) was at third position and lastly further declining more towards

December (309 cases) which remained less affected month relatively.

Endemic Foci is noticed in 2011 which recognized the dengue as endemic in Lahore district and this devastating situation could have caused due to densely populated towns and influence of the Ravi River. This present study reveals many aspects of special magnificence, the most important is it has discovered the month wise dengue disease prevalence and pattern through Geo-spatial techniques which included maps and other was using of IDW for endemic foci town. In this paper, a straight forward and simplified cartographic approach with interpolation method has been implemented to discover the spatial and temporal agglomeration of the disease and its patterns. However, detailed studies are required to explore the dengue prevalence and its association with factors like Rainfall, Temperature, and Climate Change, Population trends, mobility of people, health infra-structure and Urbanization etc.

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