INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 13, No. 1, p. 202-211, 2018
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

Methods in Geographical Information Systems for Public Health: A dengue perspective in Lahore

Syed Ali Asad Naqvi[*1], Liaqat Ali Waseem[1], Saima Shaikh[2]

[1]*Department of Geography, Government College University Faisalabad, Faisalabad, Punjab, Pakistan*

[2]*Department of Geography, University of Karachi, Karachi, Sindh, Pakistan*

Article published on July 30, 2018

Key words: Disease Mapping, Dengue, Urban Environment, GIS, Google Earth.

Abstract

Dengue Fever is endemic in Pakistan and creating risks for the population of Lahore. Geographical solutions for diseases like dengue come from specialized disease mapping which is considered a fundamental step for solving problems in medical Geography. Current study encompasses spatial mapping and endemic foci detection of dengue disease occurred in Lahore from 2007 to 2013. For this purpose, dengue cases data of district Lahore for that specific duration had been used to map (in point format) the town wise prevalence. It was achieved through Google Earth and ArcGIS (ArcMap). One by one, all towns of Lahore were mapped for all study years to show dengue's prevalent temporal changes. Results showed that Data Ganj Bakhsh town was the most affected town with 3310 cases whereas Samanabad (2542 cases), and Gulberg (2229 cases) towns were also very much affected but the main endemic foci was Data Ganj Bakhsh town. The reasons of this disease climax in these towns were socio-economic and strategic factors such as population, built-up area densities and lack of significant action against the disease.

***Corresponding Author:** Syed Ali Asad Naqvi ✉ draliasad@gcuf.edu.pk

Introduction

Dengue Fever (DF) is endemic in Pakistan and elevating as one of the major public health problems. It is mostly prevalent in urban areas of the country and currently emerging again in Lahore. It is feared to be reemerged in Rawalpindi city and Karachi city (Khalil, 2018; PPI, 2018). Rawalpindi remained previously affected by DF during 2016 with 2, 600 positive cases. According to 2016 data, it seemed alarmingly reemerging in Lahore with 1,110 and 2,029 confirmed and suspected cases respectively (DGHSP). Previously in 2015, it affected Karachi and Rawalpindi with 2,258 and 1,900 cases respectively and its attack remained continuous, affecting other parts of the Punjab Province especially Multan city (Laghari, 2015; Staff-Reporter, 2015).

In global perspective, DF is mostly found in tropical and sub-tropical regions where more than 112 countries and their over 2.5 billion people are at risk. Its principal mosquitos i.e. *Aedes aegypti* and *Aedes albopictus* are responsible for spreading this menace to human being. It has four serotypes (DNV 1-4) and as a disease has stages from asymptomatic to DF shock syndrome (Arshad *et al.,* 2011; Li *et al.,* 2011; Naqvi *et al.,* 2015). In 1994, DF's first epidemic in Pakistan occurred in Karachi then its attack remained continuous from 2006 to 2010 specifically affected Lahore and Karachi. Unfortunately, Lahore became the worst victim of this disastrous disease during 2011. Its similar risks are unstoppable due to unavailability of licensed vaccine (Mahmood *et al.,* 2009; Khormi and Kumar, 2011; Khormi *et al.,* 2011; Naqvi *et al.,* 2015; WHO, 2017).

According to Naqvi (2015), DF is considered ecologically a special and emerging disease in Lahore which is significantly influenced by environmental factors. It has reached from Karachi to Lahore through the modes of transportation because Lahore is main economic and commercial city after Karachi where people interact from all over the country (Naqvi, 2015). Butt *et al.,* (2013) studied DF prevalence in Lahore focusing only on nightmare year of 2011. They used point based mapping to show the town wise prevalence pattern and Fig. d out that Data Ganj Bakhsh town had the most number of cases (Butt *et al.,* 2013). Naqvi *et al.,* (2015) evaluated the temporal and geographic patterns of DF prevalence in Lahore using cases data from 2007-2013. The major focus of that research article was to show the month-wise prevalence configuration. They discovered post monsoon period as the most DF supportive when from August to November the highest number of cases were reported. Amongst these months, they noticed that DF attack remined highest during September when 6,548 cases were reported. They also highlighted Data Ganj Bakhsh town as temporal endemic foci. Major difference between their research and present study is the focus on town wise spatial pattern of DF. Consequently, DF is such an alarming problem for Pakistan and World which demands our attentions in the form of prevention and research (Naqvi *et al.,* 2015).

This is a Geo-Spatial Study which provides an integrated digital environment to study dengue risk. This integration comprises of both health and geographical information system approaches. The methodology introduces the combination of google earth and ArcGIS software with dengue cases data. This methodology helped in converting non-geographical data to geographical data.

There are two major aims and objectives of this study; first is to (spatial and temporal) map the town wise dengue prevalence in district Lahore which is then (secondly) used to reveal the endemic foci. Geographical techniques are vital for public health and dengue control. Geographical Information System (GIS) is used in this study which is very powerful technological application of Geography. It provides numerous methods and techniques for public health from management to safety (Cromley and McLafferty, 2011). In this study, GIS proved significant in both perspectives of mapping and analysis. Visualization of both perspectives was a key to see the dengue risk. Mapping is performed using a systematic methodology.

Point feature classes showing locations of DF cases in geodatabase environment was the way adopted in this study. This methodology can be vital for our country where geographic corridors for diseases are missing. This study can help in two ways; firstly, its devised systematic methodology for mapping can be vital which secondly can help in spatial analysis and modeling.

Material and methods

Study Area

Lahore district (Fig. 1) has been chosen as the study area for this research. According to the 2017 census, Lahore is currently the second largest city of Pakistan and the capital of Punjab Province (Shirazi and Kazmi, 2014). In 2001, Local Government Ordinance was enforced and Lahore with its local Government became the City District (Mazhar and Jamal, 2009). Its total area is 1772Km² and geo-coordinates are 31°15' and 31°43'N latitude and 74°10' and 74°39'E longitude (Shirazi and Kazmi, 2013). Administratively, Lahore has nine Towns with one Cantonment area. Iqbal Town is the largest covering 476.79 km² of area and Shalimar town with 26.88km² area is the smallest town of Lahore district. The climate of Lahore has both warm and cold states. It is in the lucky monsoon region of South Asia where it receives plenty of rainfall which is significant factor for DF growth. It has high pressure conditions in winter and low in summer. It has lengthy summer season with sporadic rainfall and cool to cold winter season (Shirazi, 2012; Naqvi, 2015; Naqvi *et al.,* 2015). This study has two but related parts; in first, mapping of DF cases is presented and in second, DF's endemic foci areas are highlighted. This study will give the health sector and researchers a geographic insight of the disease like DF to control its swift incidence especially in cities.

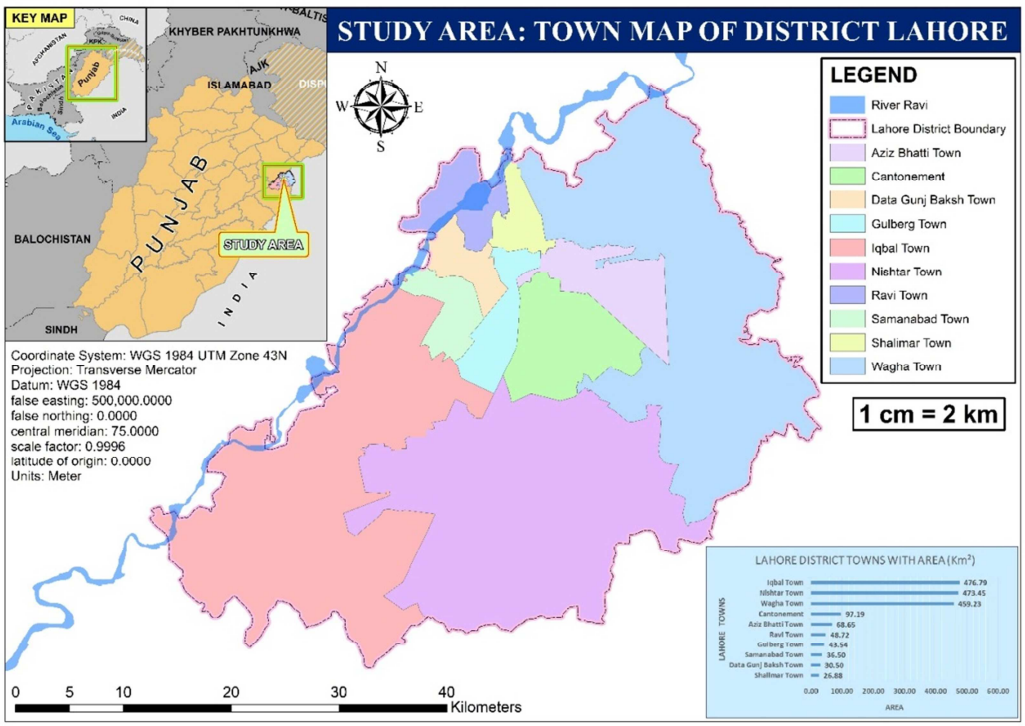

Fig. 1. Study Area Map.

Methods for (DF Cases) Point Mapping

This part is all about converting DF non-geographic data (without GPS coordinates) to geographic data (Fig. 2). For this purpose, data of DF cases from 2007 to 2013 were collected from Directorate General of Health Services, Punjab (DGHSP). The data were in MS Excel spreadsheet format (.xls) and had different fields i.e. patient's names, contact numbers, home addresses, and DF clinical results etc. The purpose of geographical conversion was to perform geo-spatial analysis.

The data had several errors such as, address duplication, false addresses, and Null fields etc. These mistakes were resolved on priority. These errors were found mostly in the data of 2007, 2008 and 2010. Various other techniques explored for this but Google Earth was chosen as a geo-source (Naqvi *et al.,* 2015). Chang *et al.,* (2009) explored DF and made the geo-based surveillance easier for resource limited organizations. They used Google Earth imagery of the town of Bluefields, Nicaragua in ArcGIS 9.3 environment and mapped the locations of larval infestation Indices, cemeteries, tire dumps, standing water areas and houses with DF cases etc. They found their surveillance program capable of giving spatial locations of risk zones which might be used to eliminate the mosquito vector (Chang *et al.,* 2009). They mapped in extracted satellite imagery from Google Earth in ArcMap, but this current research followed Google Earth directly and no imagery had been extracted. Google Earth was used to locate each patient's home location to get a spatial point for each patient. The methodology (Fig. 2) of this follows three salient steps. The first step was related to DF cases data collection and its limitations then the other step showed mapping prerequisites which were important to start mapping. In the last step, when both Google Earth and statistical data became ready to create seven KML layers, home addresses of each patient of each year (2007-2013) had been used to locate distinctly, to mark points on their rooftops. When all 18009 points of all years (2007-2013) were installed and KML layers were ready, they had been shifted to ArcMap for their conversion into Shapefiles and to call them into geodatabase. After conversion, the patients .xls (MS Excel) data had been joined with the feature classes which gave double advantage; as KML layer it was just giving the home locations of the DF victims but as feature class, it became capable of accepting the statistical data as its joined part which extended its ability of analysis. So in this case, the data and its each and every address used for point mapping in Google Earth was joined with its locational point as a feature class attribute which extended the scope (Naqvi, 2015).

After joining the attributes data, points of each town of all study years (2007-2013) were extracted to show prevalence of all towns separately and compositely.

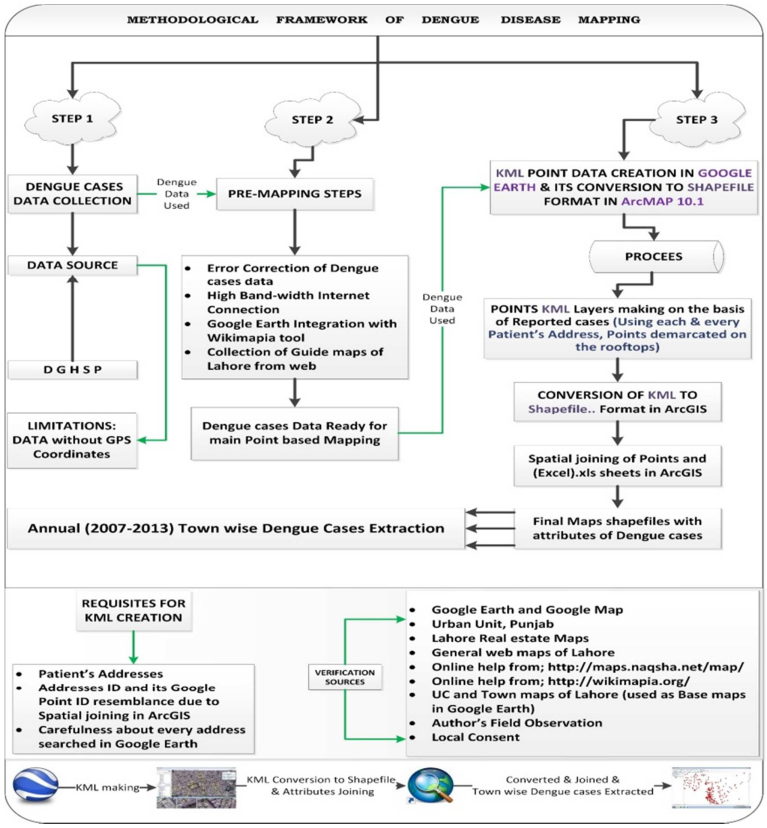

Fig. 2. The Methodology of making the non-spatial data to spatial.

DF endemic Zones Identification Analysis

This analytical part presented a benefit of our methodology in the form of a spatial analysis. The analysis is based on aggregate point tool which refers to a process of creating polygons around clusters of proximate points. The syntax of the tool is; Aggregate Points_cartography (in_features, out_ feature_class, aggregation_distance) (esri, 2017). The purpose of this analysis is to visualize disease agglomerated clusters to derive endemic foci.

Results and discussion

DF point mapping and Agglomerated Clusters

DF cases (points) had been mapped according to their town wise distributions to derive the prevalence pattern. Results showed devastating picture of DF prevalence. In 2007, total 241 out of 267 DF cases qualified for mapping. Spatial locations of DF cases (Fig. 3) showed Data Ganj Bakhsh town as the most affected town where 76 cases reported in the whole year. At that time, the other towns such as, Shalimar, Samanabad, and Gulberg had just 58, 42, and 17 cases respectively but after Aziz Bhatti town which had only 12 cases, Allama Iqbal, Wahga, and Ravi towns comprised just 11, 11, and 8 cases respectively. Cantonment area and Nishtar Town were least affected with only 3 cases each. So, during this year, major small clusters of the points remained in Data Ganj Bakhsh, Shalimar and Samanabad towns. In 2008, 1180 out 1332 cases were considered eligible for mapping. Results showed (Fig. 3) that Samanabad and Data Ganj Bakhsh were the most affected towns with 295 and 291 cases respectively. Towns, i.e. Ravi (161 cases), Shalimar (140 cases), Allama Iqbal (109 cases) and Gulberg (87 cases) were also very affected areas. Cantonment area had 46 cases and the least affected towns were Aziz Bhatti, Nishtar with 20 cases each and Wahga with only 11 cases. Points mainly clustered in Samanabad and Data Ganj Bakhsh towns.

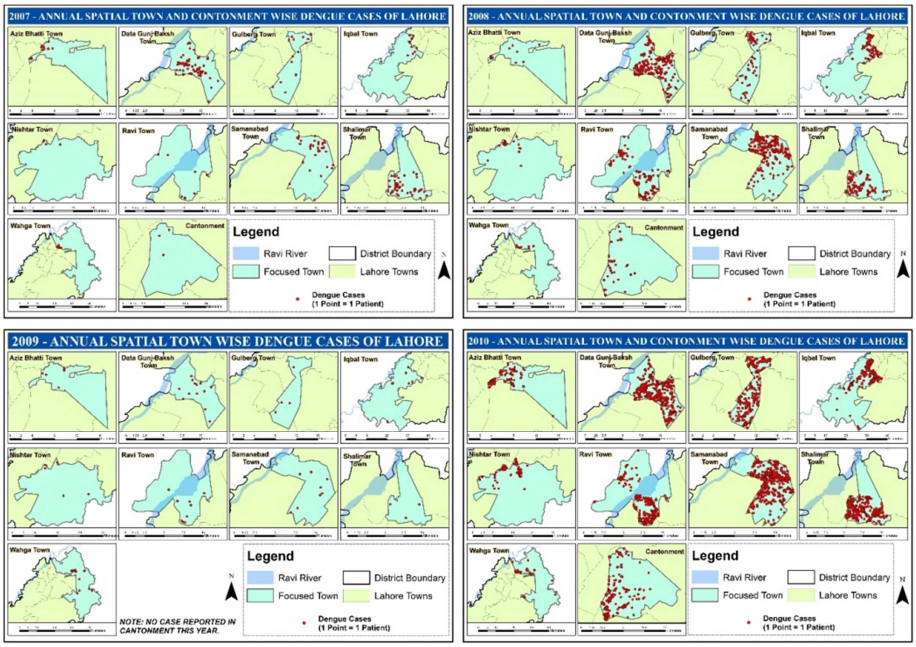

Fig. 3. Maps Showing town wise DF cases points from 2007 to 2010.

The least affected year was 2009 (Fig. 3), when Wahga town had most of the cases (23 cases) and cantonment was unaffected. Towns previously with higher prevalence's had very lower DF cases in this year especially Data Ganj Bakhsh town with only 16 cases. Other towns such as, Ravi (11 cases), Samanabad and Nishtar (9 cases), Allama Iqbal (8 cases), Aziz Bhatti (6 cases), Gulberg (4 cases) and Shalimar (3 cases) were also minor affected areas. The reason of this minor DF attack could have been due to the minor rainfall this year which remained the lowest relatively to other study years.

During 2010, DF was triggered again affecting a lot of population (Fig. 3). Total eligible 3580 cases out of 4494 cases were mapped and results showed Samanabad Town with the most cases (713 cases) and Wahga Town with the lowest 46 cases. Remaining towns such as, Data Ganj Bakhsh (591 cases), Shalimar (469 cases), Ravi (434 cases), Gulberg (413 cases), Allama Iqbal (316 cases), Aziz Bhatti (228 cases) and Nishtar (126 cases) were also very much affected.

The Cantonment area had 244 cases and emerged again as significantly affected after one year.

Unfortunately, high DF prevalence continued even more drastically during 2011. This disastrous attack of DF victimized the whole Lahore district intensely. During this year (Fig. 4), Data Ganj Bakhsh town had 2069 cases and it was documented as the most affected town of Lahore and minimum number of cases (176 cases) came from Wahga Town.

The cantonment area also had 1426 cases. The towns such as, Gulberg (1501 cases), Allama Iqbal (1343 cases), Samanabad (1338 cases), Nishtar (1107 cases), Ravi (984 cases), Shalimar (823 cases) and Aziz Bhatti (516 cases) remained significantly affected. The salient reason of high DF occurrences during 2010 and 2011 could be attributed to heavy precipitation during the period. DF had been substantially controlled in 2012 because of extensive efforts of the Government and peoples. Fig. 4 shows tranquil picture where Ravi and Wahga towns with 35 and 2 cases were most affected and least affected areas respectively. Allama Iqbal town and Data Ganj Bakhsh town had 25 and 24 cases respectively and Shalimar town had just 10 cases.

Other least affected towns included Samanabad (8 cases), Gulberg (7 cases), Nishtar (6 cases) and Aziz Bhatti (3 cases). The cantonment area too had lower number of cases which were just 4 cases.

DF's compact attack came again during 2013 (Fig. 4) and Data Ganj Bakhsh town was the most affected with 243 cases whereas Wahga towns had only 46 cases remained least affected.

Cantonment area had 171 cases repeatedly here again after one year so cantonment seemed more affected with the gap of one year in between (i.e. 2008, 2011 and 2013).

Other towns such as, Gulberg (200 cases), Nishtar (199 cases), Shalimar (175 cases), Samanabad (137 cases), Ravi (136 cases), Aziz Bhatti (105 cases) and Allama Iqbal (100 cases) had also significant number of cases.

In composite perspective (2007-2013), Fig. 4 and Fig. 5 presented very severely affected situation of Lahore. The core areas of Lahore district which mainly affected were areas where there is relatively higher population density. Most affected town was Data Ganj Bakhsh town which had 3310 cases.

The other affected areas included Samanabad town (2542 cases), Gulberg town (2229 cases), Allama Iqbal town (1912 cases), Cantonment area (1894 cases), Ravi town (1769 cases), Shalimar town (1678), Nishtar town (1470), Aziz Bhatti town (890 cases) to Wahga town (315 cases) which had least number of cases.

DF endemic foci

The results of point aggregation analysis (Fig. 6) reveal four different clusters of higher prevalence. First most significant cluster is found in Samanabad and Data Ganj Bakhsh towns mostly. These towns are smaller in sizes and denser in population. So, the disease proximity in these towns remained high and viewable main hospitals were few which could have forced the public to move into the private hospitals. Second major cluster shows second level risk of this disease in which mostly Shalimar and Ravi towns are affected, however the cluster is not so denser as like the previous one but still disease proximity is higher. Third cluster is seemed agglomerated near the borders of Gulberg, Nishtar towns and Cantonment area and fourth cluster is agglomerated mostly in Cantonment area but it is also entering Gulberg town. Subsequently, Disease major endemic foci remained in densely populated areas where there was more built-up land besides more people.

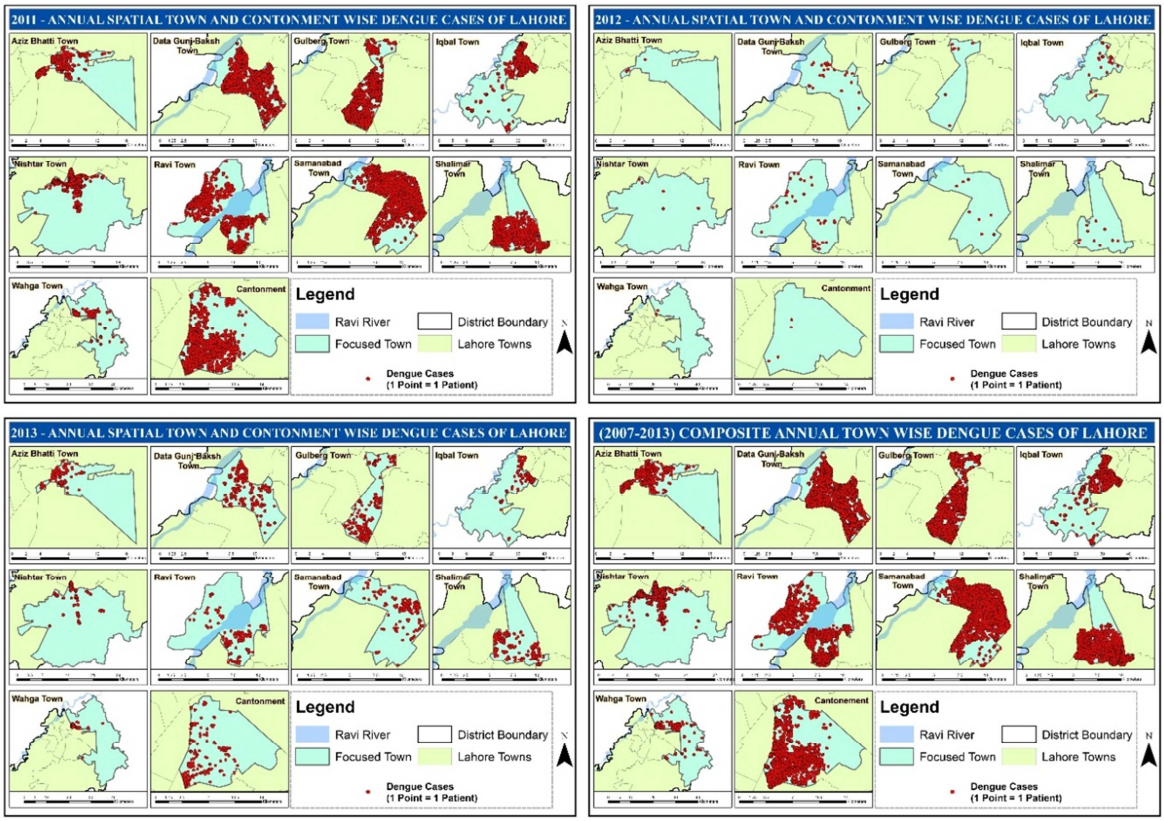

Fig. 4. Maps Showing town wise DF cases points from 2011 to 2013 and overall occurrences from 2007 to 2013.

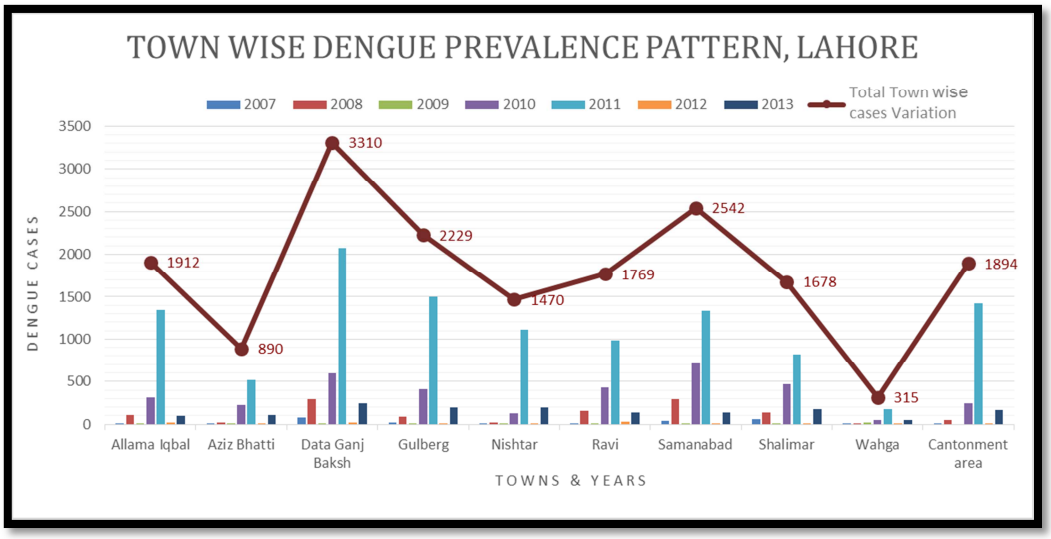

Fig. 5. DF Town wise cases and prevalence pattern of Lahore (2007-2013).

The results demonstrate DF survival in different temporal and spatial states. DF kept coming back and becoming endemic especially in cities like Lahore. It seemed originating in Lahore during 2007 and intensified in 2008 but despite lower prevalence during 2009 it struck back hard in 2010 and 2011. Another period of low prevalence came during 2012 which was also replaced by 2013's higher incidence (Liu *et al.,* 2014; Naqvi, 2015; Naqvi *et al.,* 2015; MCKAY, 2016). These spatiotemporal conditions indicated that DF could be risen again owing to the post monsoon period that remained supportive for DF and could trigger another epidemic. Some other factors also contributed towards higher DF prevalence's especially, socio-economic factors (e.g. population density, livelihood, income, occupation,

behavior, knowledge, and education), institutional factors (e.g. access to hospitals, their quality of health care and control and prevention plans) and some biological factors (such as age, acquired immunity and health status). These factors are considered key disease driving forces which contribute in making a population vulnerable or prone to the disease (Delmelle *et al.,* 2016; Garchitorena *et al.,* 2017; Farinelli *et al.,* 2018; Lippi *et al.,* 2018; Mayfield *et al.,* 2018).

Analysis in current study also revealed these factors. We found DF clusters mainly in areas where mostly low-income class to middle income class existed with more population densities and haphazard built up land. Poor to low heath system regarding infectious diseases and bad sanitation both in domestic and town level also contributed to this higher prevalence. These socio-economic factors always triggered DF menace in this city district (Liu *et al.,* 2014).

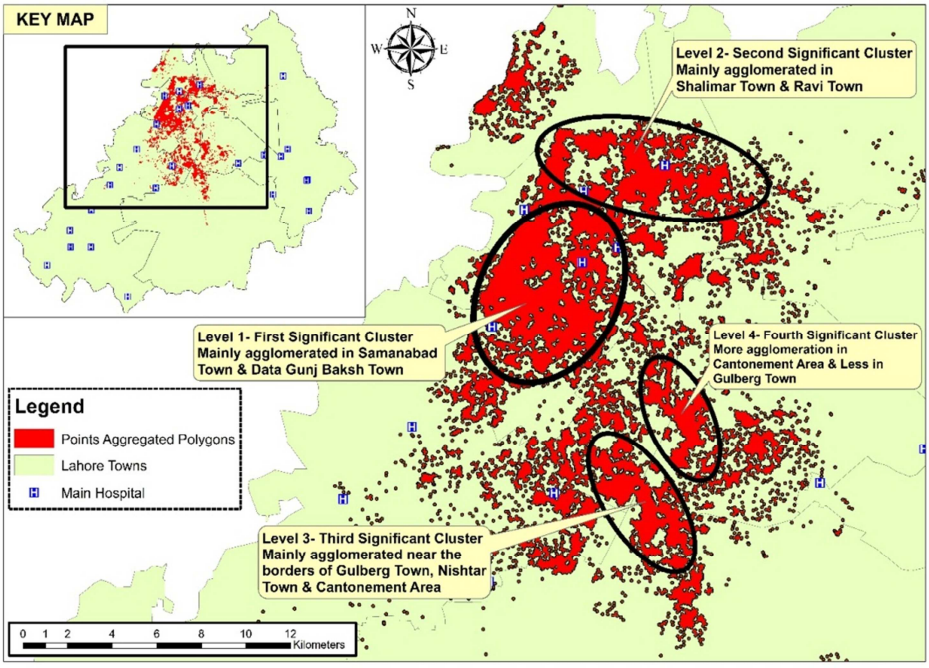

Fig. 6. DF point aggregation analysis showing agglomeration of different significant spatial clusters of endemic foci (2007-2013).

The use of Google Earth in combination with open source GIS software had been considered an effective way for decision making in health sector (Lozano-Fuentes *et al.*, 2008) but in this study, ArcGIS software made it technically more effective than the free software sources. Consequently, geo-spatial technologies have powerful capabilities regarding disease prevention and control especially in the light of optimized analysis and modeling.

Authors recommend health authorities to use these technologies as their main aiding feature.

Conclusion

This study mainly focused on dengue Geo-spatial mapping by using Google Earth and ArcGIS for Desktop.

The purpose was to show town wise annual (2007-2013) dengue prevalence patterns through point-based mapping. The results showed that dengue remained significant in Data Ganj Bakhsh town which was also considered as endemic foci. The reasons behind it might be built up land, absence of preventive measures and population density. In this study, a method of making the non-geographic data into geographic data had been introduced for diseases mapping which could be effective for other epidemiological or disease studies.

Acknowledgments

We are thankful to the "Directorate General of Health Services, Punjab" (DGHSP) for providing us the very useful dengue cases data.

References

Arshad I, Malik FA, Hussain A, Shah SA. 2011. Dengue Fever; Clinco-Pathologic Coreation And Their Associations With Poor Outcomes. Professional Medical Journal **18,** 57-63.

Butt I, Ghaffar A, Zafar T, Riaz O. 2013. Spatial pattern of dengue outbreak in Lahore, 2011. Pakistan Geographical Review **68,** 34-42.

Chang AY, Parrales ME, Jimenez J, Sobieszczyk ME, Hammer SM, Copenhaver DJ, Kulkarni RP. 2009. Combining Google Earth and GIS mapping technologies in a dengue surveillance system for developing countries. International journal of health geographics **8.**

Delmelle E, Hagenlocher M, Kienberger S, Casas I. 2016. A spatial model of socioeconomic and environmental determinants of dengue fever in Cali, Colombia. Acta Tropica **164,** 169-176 https://doi.org/10.1016/j.actatropica.2016.08.028.

Farinelli EC, Baquero OS, Stephan C, Chiaravalloti-Neto F. 2018. Low socioeconomic condition and the risk of dengue fever: A direct relationship. Acta Tropica.

Garchitorena A, Sokolow S, Roche B, Ngonghala C, Jocque M, Lund A, Barry M, Mordecai E, Daily G, Jones J. 2017. Disease ecology, health and the environment: a framework to account for ecological and socio-economic drivers in the control of neglected tropical diseases. Phil Trans R Soc B 372:20160128 DOI: 10.1098/rstb.2016.0128.

Khalil R. 2018. 350 Dengue Fever Suspects Visit Allied Hospitals. In: www.pakistanpoint. com/en/health/news/350-dengue-fever-suspects-visit-allied-hospit-346503.html.

Khormi HM, Kumar L. 2011. Modeling dengue fever risk based on socioeconomic parameters, nationality and age groups: GIS and remote sensing based case study. Science of the Total Environment **409,** 4713-4719.

Khormi HM, Kumar L, Elzahrany RA. 2011. Modeling spatio-temporal risk changes in the incidence of dengue fever in Saudi Arabia: a geographical information system case study. Geospatial health **6,** 77-84.

Laghari Z. 2015. Dengue affects 1900; kills six in Pindi. In: Health, Pakistan: http://www.samaa.tv/pakistan/ 2015/10/dengue-affects-1900-kills-six-in-pindi/.

Li S, Fang M, Zhou B, Ni H, Shen Q, Zhang H, Han Y, Yin J, Chang W, Xu G, Cao G. 2011. Simultaneous detection and differentiation of dengue virus serotypes 1-4, Japanese encephalitis virus, and West Nile virus by a combined reverse-transcription loop-mediated isothermal amplification assay. Virology journal **8.**

Lippi CA, Stewart-Ibarra AM, Muñoz ÁG, Borbor-Cordova MJ, Mejía R, Rivero K, Castillo K, Cárdenas WB, Ryan SJ. 2018. The social and spatial ecology of dengue presence and burden during an outbreak in Guayaquil, Ecuador, 2012. International journal of environmental research and public health **15.**

Liu C, Liu Q, Lin H, Xin B, Nie J. 2014. Spatial analysis of dengue fever in Guangdong Province, China, 2001-2006. Asia Pacific Journal of Public Health **26,** 58-66.

Lozano-Fuentes S, Elizondo-Quiroga D, Farfan-Ale JA, Loroño-Pino MA, Garcia-Rejon J, Gomez-Carro S, Lira-Zumbardo V, Najera-Vazquez R, Fernandez-Salas I, Calderon-Martinez J, Dominguez-Galera M, Mis-Avila P, Morris N, Coleman M, Eisen L. 2008. Use of Google EarthTM to strengthen public health capacity and facilitate management of vector-borne diseases in resource-poor environments. Bulletin of the World Health Organization **86,** 718-725.

Mahmood K, Jameel T, Aslam HF, Tahir M. 2009. Incidence of dengue haemorrhagic fever in local population of Lahore, Pakistan. Biomedica **25,** 93-96.

Mayfield HJ, Lowry JH, Watson CH, Kama M, Nilles EJ, Lau CL. 2018. Use of geographically weighted logistic regression to quantify spatial variation in the environmental and sociodemographic drivers of leptospirosis in Fiji: a modelling study. The lancet Planetary health **2,** e223-e232.

Mazhar F, Jamal T. 2009. Temporal population growth of Lahore. Journal of Scientific Research **39.**

MCKAY B. 2016. Mosquitoes are deadly, so why not kill them all. Wall Street Journal **2.**

Naqvi SAA. 2015. Measuring the Risk of Dengue Prevalence in Lahore Through Geo-Spatial Techniques. Karachi, Sindh, Pakistan: University of Karachi.

Naqvi SAA, Kazmi SJH, Shaikh S, Akram M. 2015. Evaluation of Prevalence Patterns of Dengue Fever in Lahore District through Geo-Spatial Techniques. Journal of Basic and Applied Sciences **11,** 20-30.

PPI. 2018. Dengue virus: First death of 2018 in Karachi reported. In: https://tribune.com.pk/story/1677554/1-dengue-virus-first-death-2018-karachi-

Shirazi SA. 2012. Spatial Analysis of NDVI and Density of Population: A Case Study of Lahore Pakistan. Science International **24,** 323-328.

Shirazi SA, Kazmi SJH. 2013. Appraisal of the Change in spatio-Temporal Patterns of Lulc and its Impacts on the Vegetation of Lahore, Pakistan. Pakistan Vision **14.**

Shirazi SA, Kazmi SJH. 2014. Analysis of Population Growth and Urban Development in Lahore-Pakistan using Geospatial Techniques: Suggesting some future Options. South Asian Studies **29,** 1 29:269-280.

Staff-Reporter. 2015. Six Die Of Dengue in Karachi. In. Karachi, Sindh, Pakistan: Pakistan Observer http://pakobserver.net/detailnews.asp?id=276055.

WHO. 2017. GACVS Statement on Dengvaxia ® (CYD-TDV). In: Global Vaccine Safety: World Health Organization: http://www.who.int/vaccine_safety/committee/GACVS-StatementonDengvaxia-CYD-