IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

ANALYZING THE GEOGRAPHICAL AND TEMPORAL PATTERNS OF LEPTOSPIROSIS SPREAD IN KERALA, INDIA: A COMPREHENSIVE RISK ASSESSMENT

Dr. Neethu V.V[1*]

Teacher[1], Indus International School, Bangalore,562125

Abstract:

Leptospirosis is a widespread and potentially deadly zoonosis that is endemic in many tropical regions and causes large epidemic after heavy rainfall and flooding. People living in urban areas are at high risk of rat exposure and leptospirosis. The global burden of leptospirosis is expected to rise with demographic shifts (increase in the population) that results in the increase in the number of urban poor (people residing in slum) in tropical regions. The impact of leptospirosis on slum population may increase with storms and urban flooding due to climate change. Rat fever has been a major threat to the State of Kerala with more than 1,000 cases being reported annually. It causes the highest number of deaths among all communicable diseases in the state of Kerala. At least 100 deaths had been reported yearly in Kerala before 2010. This study is designed to understand and analyze the disease patterns across the state, using Geographic Information System (GIS), Satellite Remote Sensing (RS) along with climatic and demographic datasets. The datasets have been analyzed with statistical techniques using Geoda Software. As a result, maps, tables and graphs have been plotted to estimate the most significant parameters. These parameters have been assigned a weight value to prepare a model and Threat Index Map for the study area. This model can be used as a disease early warning system.

Key words: *Leptospirosis, flood, climate change, GIS*

1. INTRODUCTION

Leptospirosis, a zoonotic disease, has become a serious public health problem in the world. The developing countries that have tropical and subtropical climates are more vulnerable to it (11). Leptospirosis is seen in countries which have a subtropical climate and suitable environmental conditions that provide the bacteria to cause the disease. The bacterium which spreads from the urine of rats is the main reason of water and soil infections. Farmers, who are in contact with infected water or soil, are the most vulnerable people to leptospirosis (14).

In South Asia, during the monsoon different types of health problems will emerge, due to climate change. Climate change affects the extent of monsoon rainfall in the region causing flooding which increases the risks of major disease outbreaks. Flood and stagnant water after heavy rainfall increases the risk of vector-borne diseases such as dengue, malaria, plague, chikungunya, typhoid, cholera and Leptospirosis. Leptospirosis is a bacterial infection caused by the spiral-shaped bacteria (spirochete) of the genus Leptospira (11). This is mainly seen in wild and even sometimes in domesticated rodents. Rats are the primary source of leptospirosis, although farm animals and livestock, such as horses, pigs, dogs or cattle, and even wild animals can also be a reservoir for the bacteria. However, human-to-human transmission seems to occur occasionally (11).

In India, the cases of leptospirosis started reporting from 1980 onwards, after that it shows a trend in the increase of the incidence and consequences of leptospirosis. The states of Tamil Nadu, Gujarat, and Karnataka have reported an outbreak. Other states of India have reported the incidence of periodic leptospirosis cases (11, 12). Rat fever has long been a major threat to the State of Kerala with more than 1,000 cases being reported annually. It causes the highest number of deaths among all communicable diseases in the state of Kerala. At least 100 deaths were reported yearly in Kerala before 2010.

Epidemiological spread of leptospirosis bacteria is influenced by environmental and socio-demographic factors (6). The factors that are associated with the environment, includes temperature and topography are thought to affect the incidence of leptospirosis. Spatial analysis aims to find out the relationship of an event towards the aspects of space.

2. OBJECTIVES OF THE STUDY

The objective of the present study is to:

- To assess the spatial autocorrelation of leptospirosis incidence in Kerala state for the period of 2014-2018, and to identify the significant spatial clusters having a high or low incidence of leptospirosis in Kerala state by using GIS.
- To identify the hotspots of the Leptospirosis incidence in Kerala.

3. HYPOTHESIS OF THE STUDY

During the month of June, the Arabian Sea branch of the southwest monsoon first hits the Western Ghats of the coastal state of Kerala (India) thus making this area the first state in India to receive rain from the southwest monsoon. This causes the outbreaks of infectious diseases, which has become as annual phenomenon of the monsoon itself. In this area no geographical study was carried out on the spread of Leptospirosis. It is the first attempt to spatially map the incidence of leptospirosis in Kerala to demonstrate the spatio-temporal pattern, which is helpful for the risk assessment and the disease prevention in this area.

4. METHODOLOGY

The present study is done by using the secondary data of Kerala state. Year wise incidence of Leptospirosis cases in each district has been collected from IDSP.

Spatial analysis of the spread of Leptospirosis in the study area can be done by K-mean clustering and the spatial autocorrelation (Global Moran’s 1) method by using Geoda Software. Hot spot analysis can be done by using Geo statistical methods in Arc GIS 10.3. Getis-Ord Gi statistic was used to detect hot spots of the incidence of Leptospirosis in the study area.

5. STUDY AREA

Kerala has an area of 38,864 square kilometers, lies between 8° 18' and 12° 48' north latitude and 74° 52' and 77° 22' east longitude. It is bounded on the east by a geological escarpment running roughly northwest to southeast parallel to the coast known as the Western Ghats, on the west by the Arabian Sea, on the south by the state of Tamil Nadu, and on the north by the state of Karnataka. Located in the southwestern fringes of the Western Ghats, Kerala is characterized by an asymmetrical topography. Its landform is dominated by undulating, subdued hills and steep scarp slopes, and its altitude ranges from below mean sea level to 2,694 meters above the mean sea level. Kerala's location and altitudinal variations have endowed the state with a wide range of agroecological conditions. Figure 1 describes the study area.

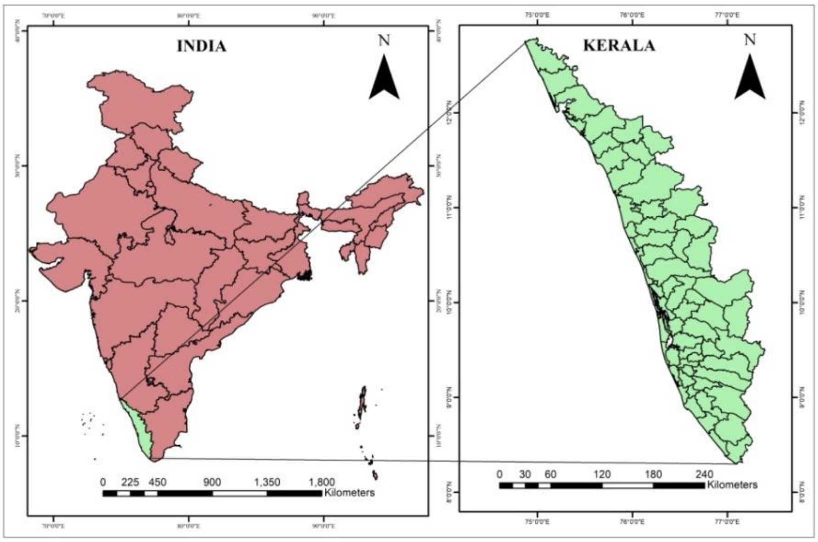


Figure 1. Study area

6. RESULTS AND DISCUSSIONS

The study of spatial distribution pattern is very useful to reduce the burden of rat fever incidence. In the current study, the incidence of Leptospirosis cases in Kerala state has been analyzed and their spatial distribution patterns are observed for a period of 5 years. Rat fever has long been a major threat to the State of Kerala. Table 1 describes the total number of Leptospirosis cases and the deaths reported in Kerala for the year 2014 to 2018. The table shows the month wise distribution of the reported cases in the state.

Figure 2 explains the reported cases of Leptospirosis in Kerala for the year 2014 to 2018. Month wise distribution is shown for the total reported cases. From 2014 onwards it shows an increase in the cases. Cases are reported in all the months, but the highest numbers of cases are seen in the months of June, July, August and September. In Kerala these months receive highest amount of rainfall. In September 2018 the highest numbers of cases have been reported in the State of Kerala.

Figure 3 depicts that in 2014, confirmed cases was 717 with 19 (2.6%) deaths. Notably, the incidence and mortality of leptospirosis in Kerala for the following years showed a declining trend as compared to the previous years. In 2015, 43 people died of rat fever and in the subsequent years the death toll was found to be

35 and 80 in 2016 and 2017, respectively. From the month of January 2018 to July 2018 (before the flood), 28 deaths were reported due to leptospirosis in Kerala.

Table 1. The incidence of Leptospirosis in Ernakulam district.

Month	2014		2015		2016		2017		2018	
	Cases	Death	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths
January	28	3	53	1	95	2	100	3	53	5
February	20	3	44	3	81	3	102	3	37	2
March	47	6	41	2	91	3	81	4	29	4
April	35	1	31	1	95	5	116	5	29	-
May	79	3	45	4	116	3	143	3	80	5
June	123	4	103	4	239	6	197	9	126	10
July	101	-	194	4	250	3	134	8	169	5
August	161	7	113	8	183	3	46	6	247	16
September	135	5	58	5	195	1	78	5	856	39
October	87	5	117	2	125	2	142	14	207	2
November	164	3	130	5	105	3	156	11	137	4
December	95	3	169	4	135	1	113	9	-	-
Total	1075	43	1098	43	1710	35	1408	80	1970	92

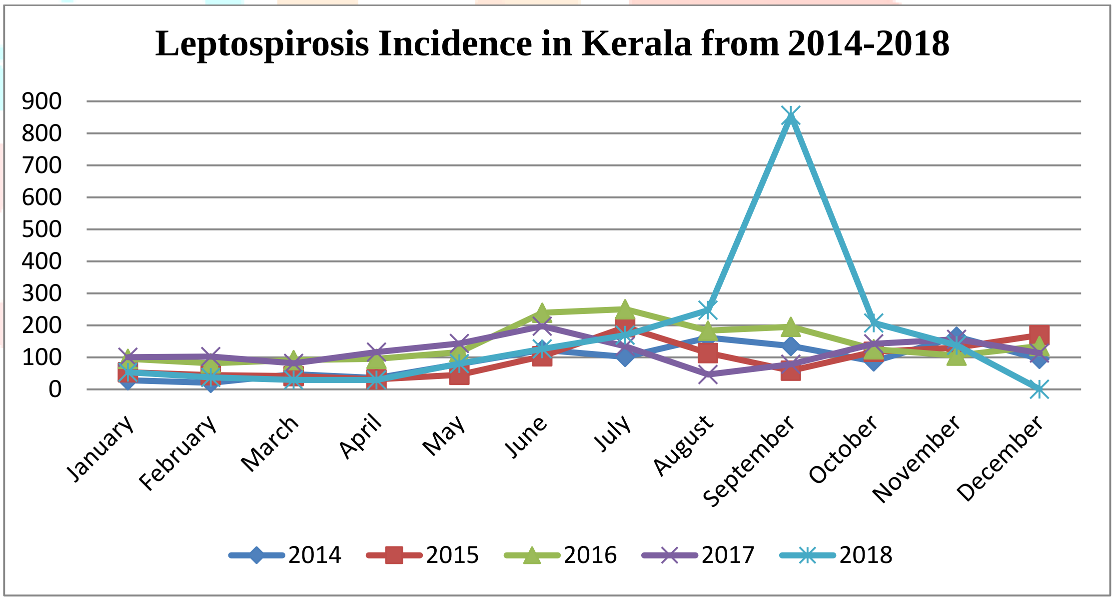


Figure 2. Leptospirosis incidences in Kerala

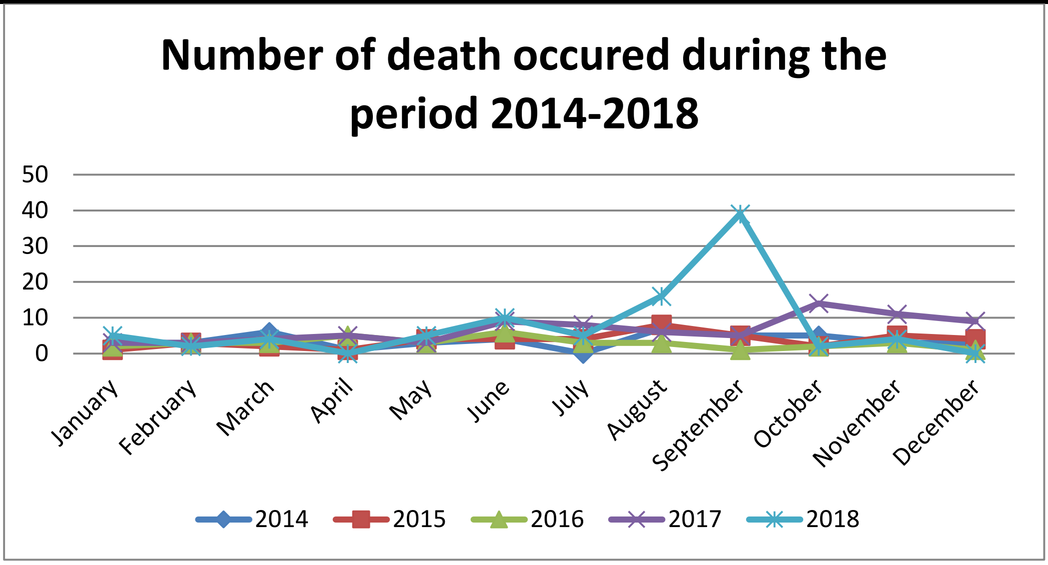
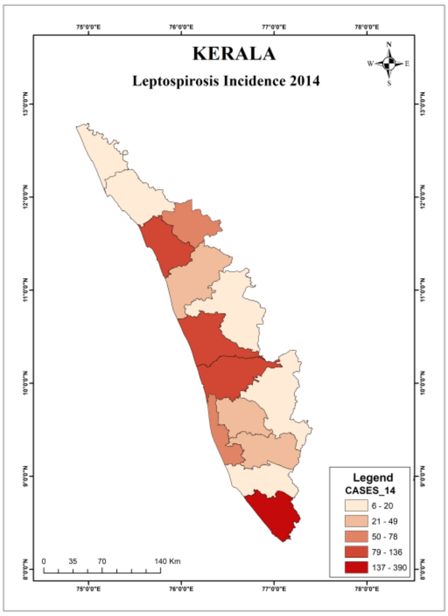


Figure 3 Leptospirosis deaths in Kerala

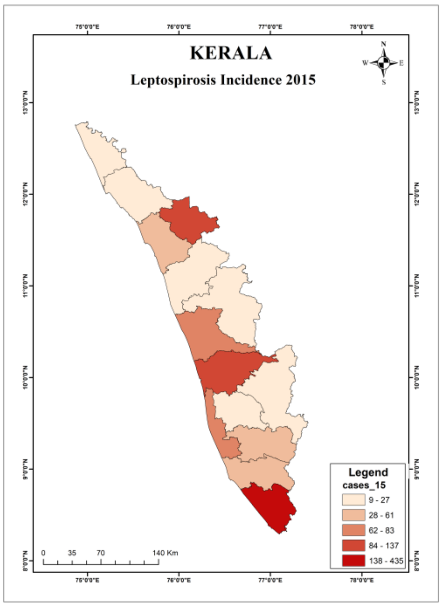
.

Following maps show the Leptospirosis incidence in different districts from the year 2014 to 2018. Incidence of Leptospirosis is in increasing trend in every district, but in the year 2014 and 2018, the incidence was decreased compared to the previous years. Thiruvananthapuram district has the high incidence of Leptospirosis and also contributing major proportion of all the cases in Kerala state from the year 2014 to 2017. Pathanamthitta district has the higher incidence of Leptospirosis cases in Kerala state in the year 2018. Districts with the lowest incidence of Leptospirosis and districts contributing a lowest proportion of leptospirosis cases were varying from year to year.

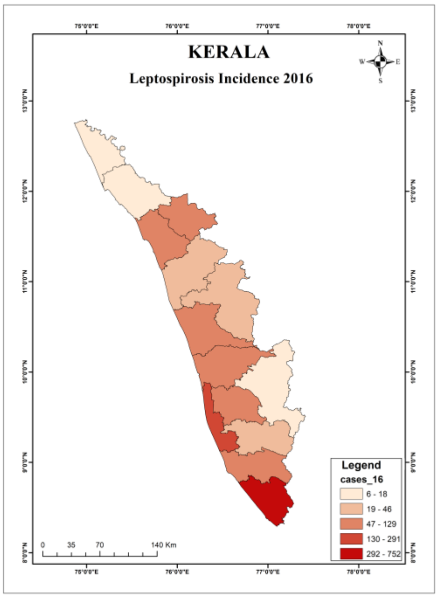
Kerala suffered unusually heavy rainfall and faced a catastrophic flood in August and September 2018, in which around 500 people died. The aftermath of the flood brings several epidemics. The Directorate of Health Services delivered an action plan for the prevention and control of communicable diseases and informed the public regarding the symptoms and appropriate treatment of such diseases with the help of volunteers. Despite that, there was a major threat of outbreak of leptospirosis in Kerala after this floods and the highest number of leptospirosis cases was reported from Kozhikode district of Kerala which was affected most by the flood.


KERALA
Leptospirosis Incidence 2014
Legend
CASES_14
6 - 20
21 - 49
50 - 78
79 - 136
137 - 390
0 35 70 140 Km

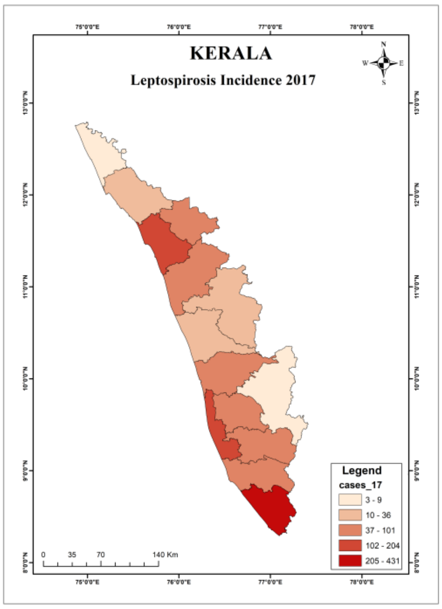
a


KERALA
Leptospirosis Incidence 2015
Legend
cases_15
9 - 27
28 - 61
62 - 83
84 - 137
138 - 435
0 35 70 140 Km

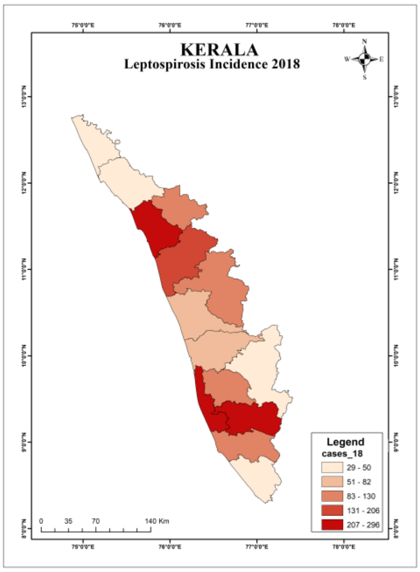
b


KERALA
Leptospirosis Incidence 2016
Legend
cases_16
6 - 18
19 - 46
47 - 129
130 - 291
292 - 752
0 35 70 140 Km

c


KERALA
Leptospirosis Incidence 2017
Legend
cases_17
3 - 9
10 - 36
37 - 101
102 - 204
205 - 431
0 35 70 140 Km

d


KERALA
Leptospirosis Incidence 2018
Legend
cases_18
29 - 50
51 - 82
83 - 130
131 - 206
207 - 296
0 35 70 140 Km

e

It was reported that leptospirosis, and dengue fever has killed more than 70 people in shorter time span. As of September 11, 2018, the Integrated Disease Surveillance Project (IDSP) data revealed that there were 2598 suspected leptospirosis cases with 95 suspected deaths, whereas the confirmed cases stood at 1318 with a confirmed death rate of 53 (4.0%). On the other hand, statistics from the Kerala State Health Department reported 570 confirmed cases and 18 (3.2%) confirmed deaths; however, the suspected cases were 1107 with 33 suspected deaths since 1 September 2018.

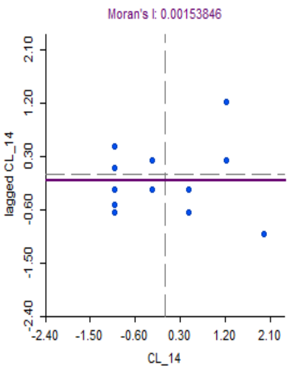
6.1 Global Spatial Autocorrelation

Among the different indicators used to assess geographic distribution of target observations, Moran's I is universally adopted (1). It directly indicates the clustering of similar incidence in different districts of Kerala state. It will act as a powerful tool to explore the spatial autocorrelations between districts. The global Moran I range between −1 and + 1. It shows the overall relationship of all the districts in the whole of Kerala state. Global Moran's I = 1 means a positive spatial autocorrelation whereas Global Moran's I = −1 means no spatial autocorrelation. Spatial correlation is more significant when the value approaches −1 and 1, whereas Global Moran's I = 0 means a random geographic distribution of all the districts

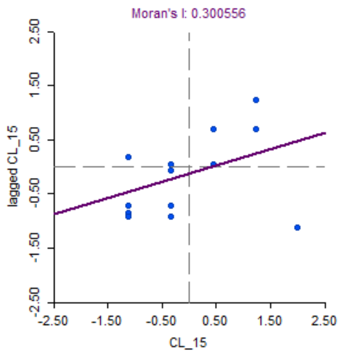
Table 2. Global Moran's 1value of Leptospirosis Incidence for 2014-2018

YEAR	Global Moran's 1Value
2014	0.001
2015	0.30
2016	-0.21
2017	-0.12
2018	-0.09

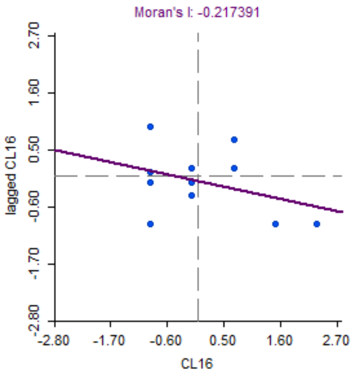
MORAN'S1 SCATTER PLOTS



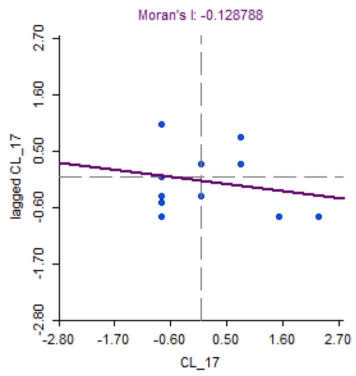
2014



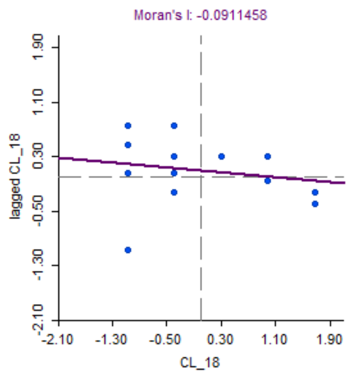
2015



2016



2017



2018

Moran scatter plots were used to depict the spatial distribution patterns of the districts. It will reveal a relationship between the incidence of each district and the weighted mean value of the bordering districts. The horizontal axis is for the incidence of leptospirosis in each district, whereas the vertical axis stands for the weighted mean value of bordering units of each plot. Each of the 14 districts is represented by one plot in the diagrams. The slope of the fitting line is represented by global Moran's I. Moran scatter plots prepared for each year from 2014 to 2018, each plot has four quadrants split by the horizontal and vertical axes represent different spatial autocorrelation relationships. Quadrants I has high ± high and quadrant III had low ± low, pattern. It indicates a positive spatial autocorrelation. Quadrant II has high ± low and quadrant IV has low ± high pattern. They will reveal a negative spatial autocorrelation (1).

From the figure Scatterplots it indicates that the distribution of leptospirosis cases is not in a uniform pattern. Global Moran's I value shows positive value in 2 years, namely 2014, and 2015 and in the remaining years, it is nearer to zero. Scatter plots revealed that some districts were present in the first quadrant in the year 2015 showing High to High pattern.

LISA maps are used to identify the spatial clusters of infectious diseases in many studies. In the current study, LISA maps depicted the districts having a significant local autocorrelation. Districts having significant spatial distribution pattern were highlighted in the map (2). Districts which had significant high-high spatial distribution pattern were highlighted in dark red color. Kollam is the only district significantly reporting High to high spatial distribution pattern and highlighted in dark red color. Although Thiruvananthapuram reported high incidence every year. In the year 2015 the district of Kozhikode, Thrissur, Alappuzha, Pathanamthitta, and Kollam and in 2017 the Kollam district has significantly high to high pattern.

Thiruvananthapuram reported high incidence every year, in the 2014 district significantly reported high-low distribution pattern and highlighted in pale red color Remaining districts are not showing any significant pattern in any year. It indicated that the spatial distribution pattern is not uniform every year.

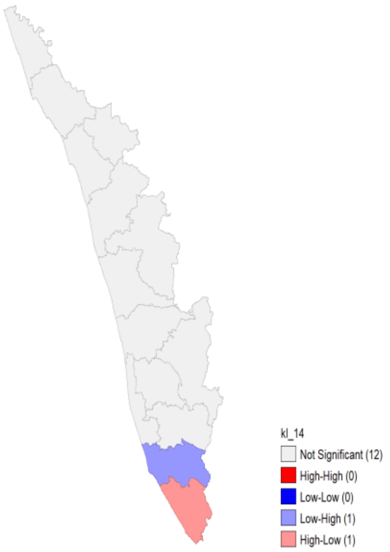
6.2 Hotspot Analysis

Hotspot analysis is performed by using Getis-ordi analysis in Arc GIS to find out the most vulnerable area for the incidence of leptospirosis. From figure 6 it is clearly shown that the hotspots of the Leptospirosis are Kollam and Thiruvananthapuram district which is the southernmost district of the state. The cold spot areas are the northernmost district of the state Kannur and Kasaragod. Reasons for non-uniform spatial distribution pattern of Leptospirosis incidence might be, variation in the rainfall, availability of health-care services, migration of population, number of construction sites, etc.

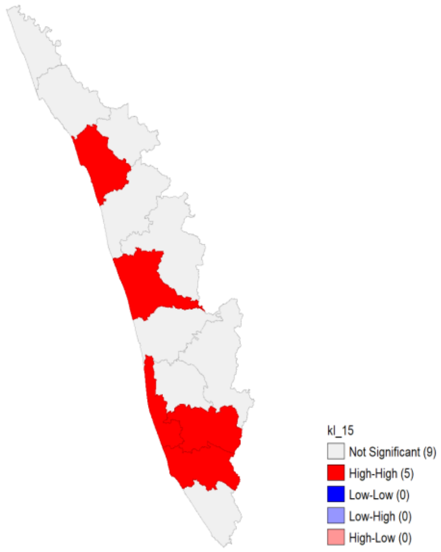
Moran's1

LISA

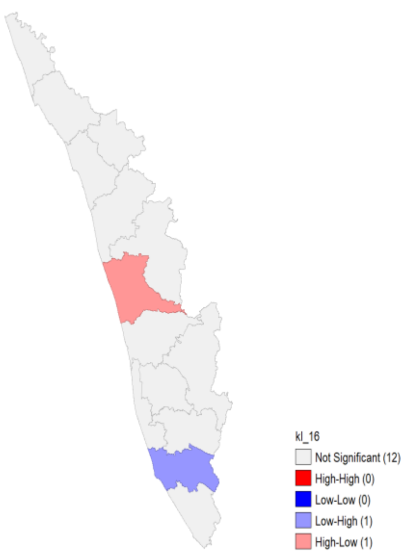
MAPS



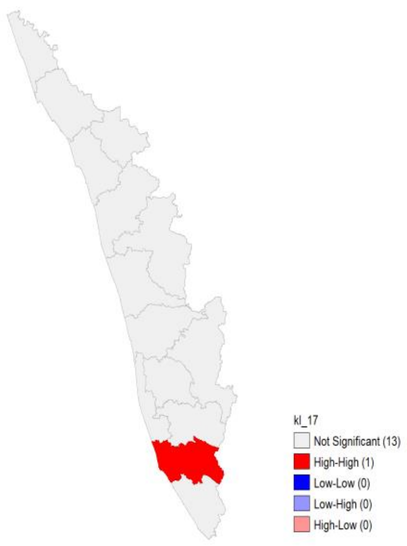
2014



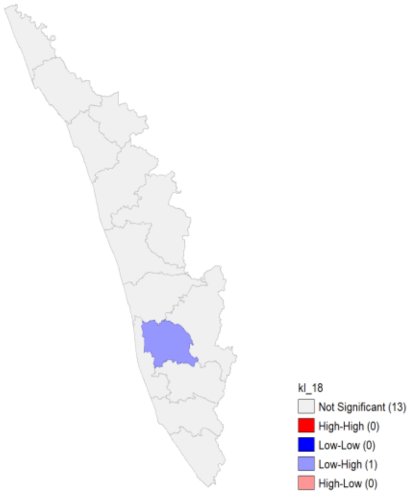
2015



2016



2017



2018

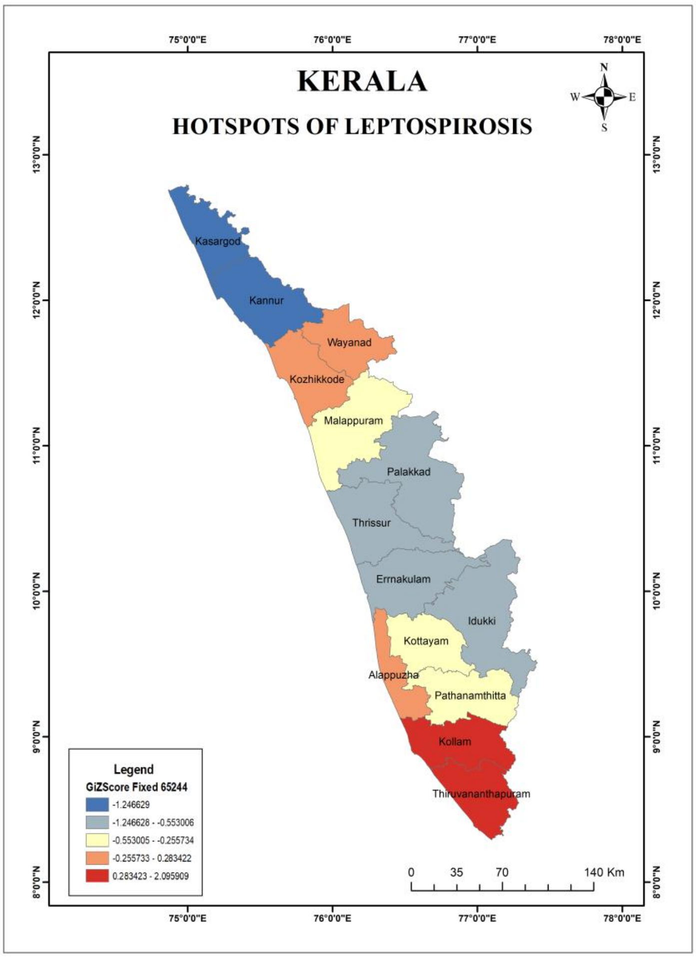


Figure 6 Hotspots of Leptospirosis

CONCLUSION

Leptospirosis incidence spatial distribution pattern is not uniform every year. Kollam and Thiruvananthapuram district significantly reporting the high incidence Global warming and deforestation, heavy rainfall and flooding is common in the State of Kerala. It is therefore important to promote the public health awareness for primary prevention with proper sanitation, hand washing, wearing protective clothing, drinking boiled water, and avoid contact with contaminated water or soil, which are the common sources of exposure. Moreover, precautions should be taken to prevent the bacterial invasion by using protective clothes and foot wears among occupational workers at high-risk of exposure to the contaminated water. Identification of clusters would help health-care administrators optimize the resources during in the near future epidemic control measures thereby reducing the burden of cases.

REFERENCES

1. Anselin L. Spatial Econometrics: Methods and Models. Boston: Kluwer Academic Publishers; 1988.
2. Anselin L. Local indicators of spatial association-LISA. Geogr Anal 1995;27:93-115
3. CDC. Leptospirosis. [online] 2018 [cited 2018 Dec 1]. Available from: https://www.cdc.gov/leptospirosis/index.html
4. Costa F, Hagan JE, Calcagno J, Kane M, Torgerson P, Martinez-Silveira MS, Stein C, Abela-Ridder B, Ko AI. Global Morbidity and Mortality of Leptospirosis: A 747 Systematic Review. PLoS Negl Trop Dis. 2015 Sep 17;9(9):e0003898. https://doi.org/10.1371/journal.pntd.0003898
5. DHS. Epidemiological Situation of Communicable Diseases in Kerala (2006-2010). Integrated disease surveillance project. [online] 2018 [cited 2018 Dec 1]. Available from: http://dhs.kerala.gov.in/docs/part1.pdf
6. Gracie, R. et al., 2014. Geographical Scale Effects on the Analysis of Leptospirosis Determinants. International Journal of Environmental Research and Public Health, 11(10): 10366– 10383.
7. IDSP. Leptospirosis. [online] 2018 [cited 2018 Dec 1]. Available from: https://idsp.nic.in/index.php
8. James S, Sathian B, van Teijlingen E. Asim M. Outbreak of Leptospirosis in Kerala. Nepal J Epidemiol. 2018;8(4); 745-747. DOI: 10.3126/nje.v8i4.23876
9. Li Q, Song J, Wang E, Hu H, Zhang J, Wang Y. Economic growth and pollutant emissions in China: A spatial econometric analysis. Stoch Environ Res Risk Assess 2014;28: 429-42.
10. Mohan CM. Clinical Profile of Patients With Leptospirosis In A Tertiary Care Centre In North Kerala. Nepal J Epidemiol. 2014;4(2)
11. Moraga P, Montes F. Detection of spatial disease clusters with LISA functions. Stat Med 2011;30:1057-71.
12. Nayak MSDP, Narayan KA. Spatial distribution of dengue fever incidence in Kerala state – A retrospective study. Int J Med Sci Public Health 2019;8(6):430-439.Sukumaran A, Pradeepkumar AS. One Health approach: A platform for intervention in emerging public health challenges of Kerala state Int J One Health 2015;1:14-25. https://doi.org/10.14202/IJOH.2015.14-25
13. Washington State Department of Health. Leptospirosis. [online] 2018 [cited 2018 Dec 1]. Available from: https://www.doh.wa.gov/Portals/1/Documents/5100/420-059Guideline-Leptospirosis.pdf
14. World Health Organization. Report of the Brainstorming Meeting on Leptospirosis Prevention and Control. Mumbai, 16 - 17 February 2006, WHO India and Regional Medical Research Centre, WHO Collaborating Centre for Diagnosis, Research, Reference and Training in Leptospirosis.
15. WHO. Leptospirosis. Zoonoses. [online] 2018 [cited 2018 Dec 1] Available from: https://www.who.int/zoonoses/ diseases/leptospirosis/en/.