Intertemporal Spatial Analysis Of Chikungunya in Karnataka

Naga Priyanka Kuruganti

EE505

GIS

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Introduction:

Chikungunya is a vector-borne disease caused by Aedes mosquitoes often associated with fevers and extreme body pains, it is prevalent in tropical and subtropical regions, including India. Karnataka, a southern Indian state, due to its moderate temperature range (22°C–28°C), and significant rainfall makes itself a potential breeding spot for mosquitoes and thus a risk prone-zone when looking at the spread of Chikungunya.

Existing literature show that there are two highlighting features which play a role when specifically looking at Chikungunya outbreaks which are as follows:

- **Environmental Factors**: Stagnant water bodies, poor drainage systems, and climatic conditions are critical for mosquito breeding. Indian climatic condition such as that of the monsoons, humidity often contribute to the rising cases.
- **Clustering**: Higher case incidences are reported in urban centres with dense populations, poor waste management, and limited healthcare access.
- Gender doesnt seem to have any effect on the individuals who contract the virus.

It is important to note that much of the previous research has heavily depended on focussing on a single state rather than an entire region thereby delving into micro-factors and policy conditions which could reduce the risk. And, while existing research focuses on environmental factors, it specifically doesn't focus on macro-level factors such as understanding how proximity to another state border could have an impact on the increase in the number of cases. Hence, it becomes important to thereby understand how macro-level interventions can potentially reduce the risk of the virus.

Research Objectives:

1. **Analyse the Impact of Environmental Factors on Chikungunya Spread in Karnataka:**
    - Analyze environmental factors. These are usually areas expected to have a high amount of density or high temperatures. This will be a basic descriptive statistics analysis where analysis will be done on a variety of parameters which are as follows: Total Positive Cases, Rainfall(mm), Hospital Count, Population Affected and Average Temperature - High and Low.
    - To Identify Potential hotspots at the State level.

    Done for the year 2024 as the information is available at a district level.

2. **Assess the Impact of Proximity to other borders:**
    - To essentially understand whether being close to another state border could have an impact on the number of cases, the hypothesis over here is that if a place is closer to a state border, it could lead to a higher number of cases due to the mutual movements across states causing an increase as the disease spreads when a mosquito bites an infected person thereby carry the disease and then transmitting it to a healthy person via the bite.
3. **Identify High-Risk Zones:** Identification of High-risk zones within Bengaluru city- the South of Bengaluru is more congested and ideally, these areas have to have a policy change. This hypothesis will be tested. This is done for the year 2018-2019 as this is the last publicly available information.

4. Policy Analysis.

Spatial Data and Methodology:

Data	Data Source
Bangalore Data	BBMP Publications
Karnataka Data	**hfwcom.karnataka.gov.in**
Rainfall Data	https://mausam.imd.gov.in/imd_latest/contents/rainfall_statistics_3.php
Demographic Data	Indian Census
Weather Data	www.weatherspark.com www.weather.com www.wanderlog.com
Maharashtra State Data	News Articles
Hospital Data	https://karnataka.data.gov.in/resource/district-wise-private-hospitals-karnataka

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The data was converted to CSV to create a point in vector analysis. Data had to be cleaned because there was a difference in the naming across different datasets, further the latitudes and longitudes were set according to WGS 1984 to make the analysis accurate.

To derive the state district boundaries, the Karnataka district-level ArcGIS map was available which was merged to create the map. Similarly, ArcGIS map was used for Maharashtra as well.

For the analysis, a KNN-Hotspot analysis is done to understand whether there exists potential risk zones.

Results:

Objective 1:

We first conduct a descriptive statistics analysis and we see that regions which are closer to the borders (in the upward north direction) tend to have a higher amount of cases than the bottom regions when looking at total cases. However, it is important to note that the regions are which are most affected are also regions with lower amounts of rainfall indicating that rain may necessarily not be the main cause for an increase in the number of cases. Similarly (appendix) there seems to be high temperatures in regions where there are higher cases but have lower rainfall.

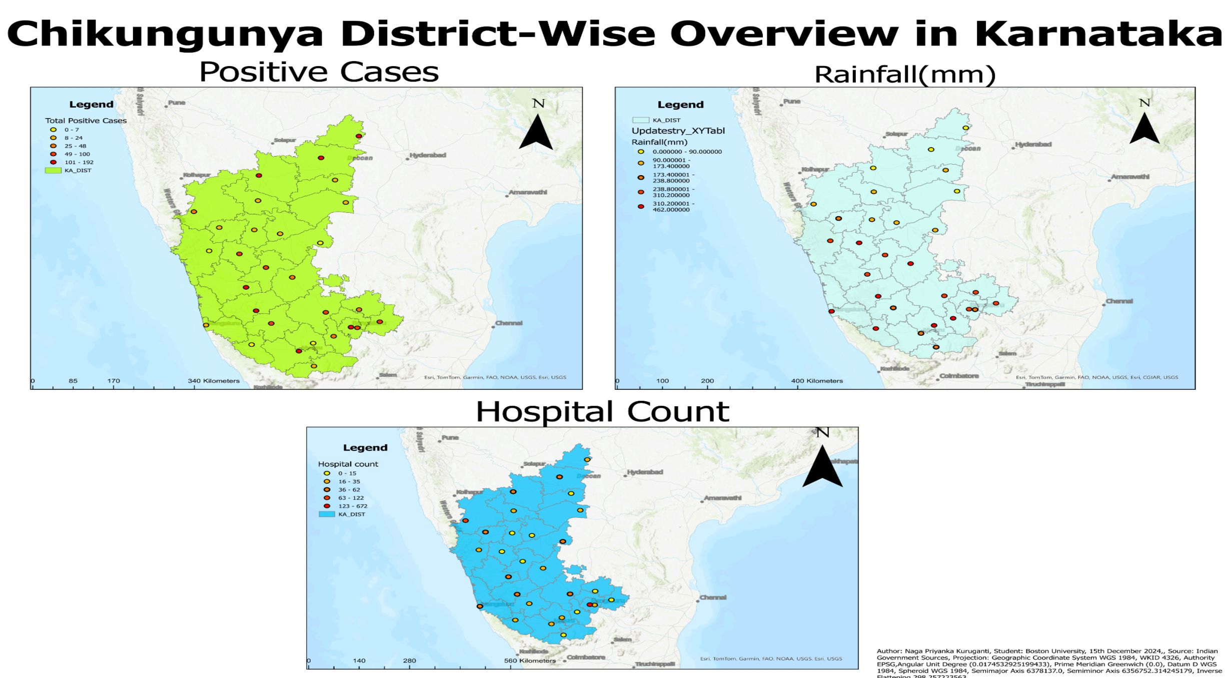

Figure: Descriptive Statistics of Certain Factors Which Cause Chikungunya

Following this we run a KNN-Regression by taking a town in the middle as the centre(Shimoga) and creating distance thresholds for all other places. This threshold is done with increments of 50km as each distance increases. We observe that the places towards the upward direction of the state are those regions which are potential hotspots indicating that these are risk zones. Further, we also observe a low-high clustering in regions which are all attributed to a high number of cases in the descriptive statistics indicating that these also not looked upon properly can lead to a higher number of cases.

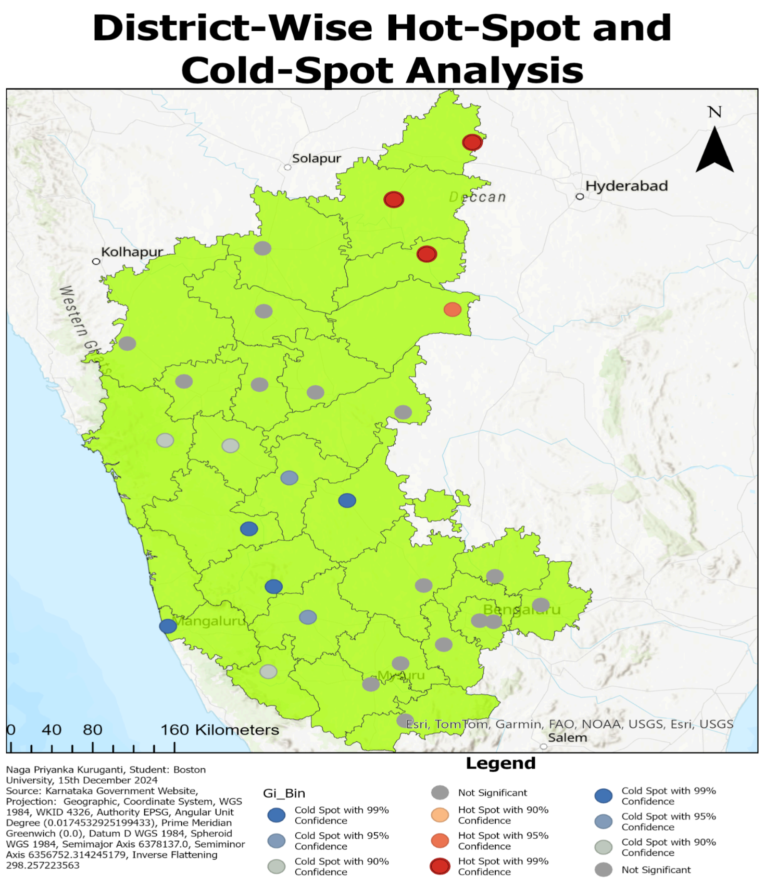

Figure: Hotspot analysis

Objective 2:

A border analysis is done by looking at the bordering region between Karnataka and Maharashtra. In order to test the analysis, the comparison was done between Sangli(Maharashtra) and Belgavi(Karnataka) as the distance between the two is approximately 120km making it feasible to cross across the two borders. Upon doing the Hot-Spot analysis it was observed that both the regions sharing a low-high clustering indicating that the regions have a potential chance of carrying the disease from one location to another by means of movement, jobs or everyday tasks.

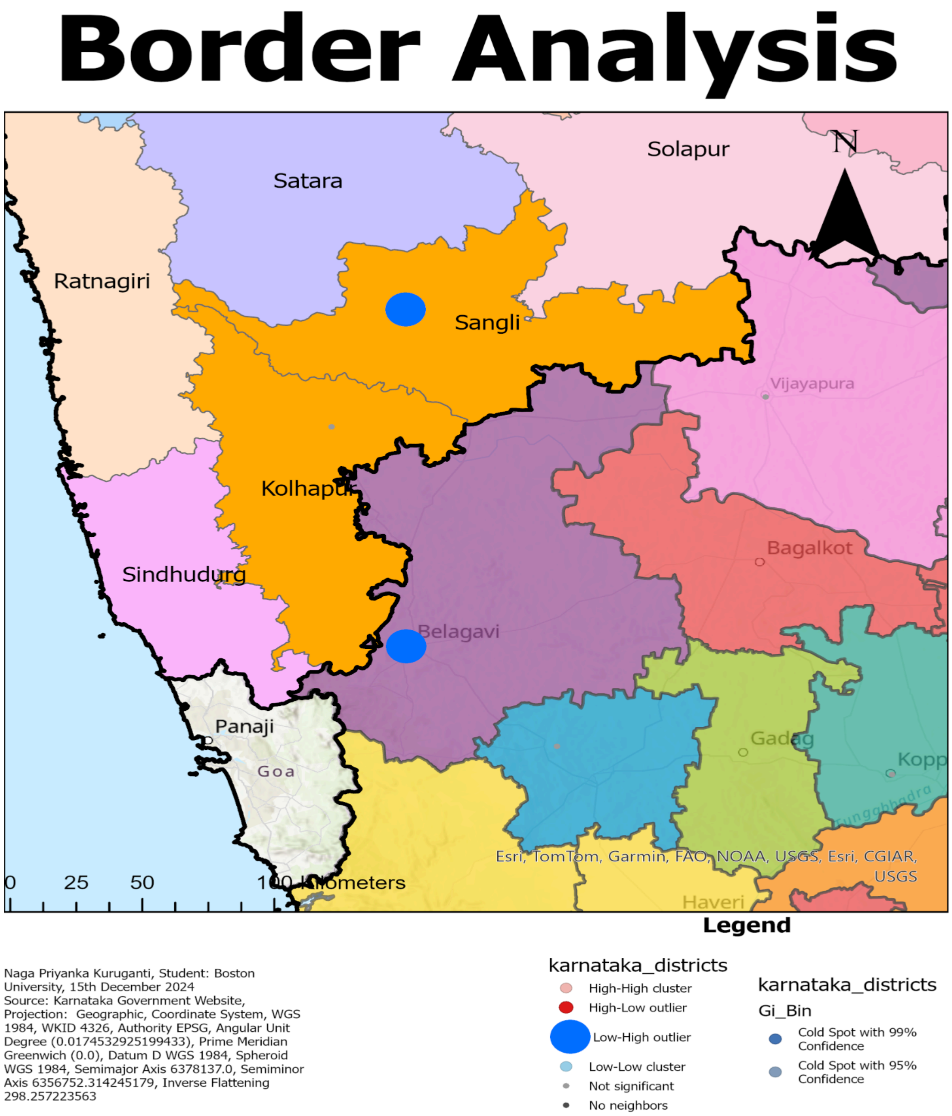

Figure: Border Analysis

Objective 3:

When conducting the KNN we observe that the cities which were historically planned: Bommanahalli, West and South Bangalore are the regions which are hotspots. These areas are characterized by high population density and older urban planning, with inadequate drainage and sanitation infrastructure. In contrast, recently developed neighbourhoods exhibited fewer cases.

The clustering patterns indicate that historically planned regions are at more risk with higher cases than recently planned towns.

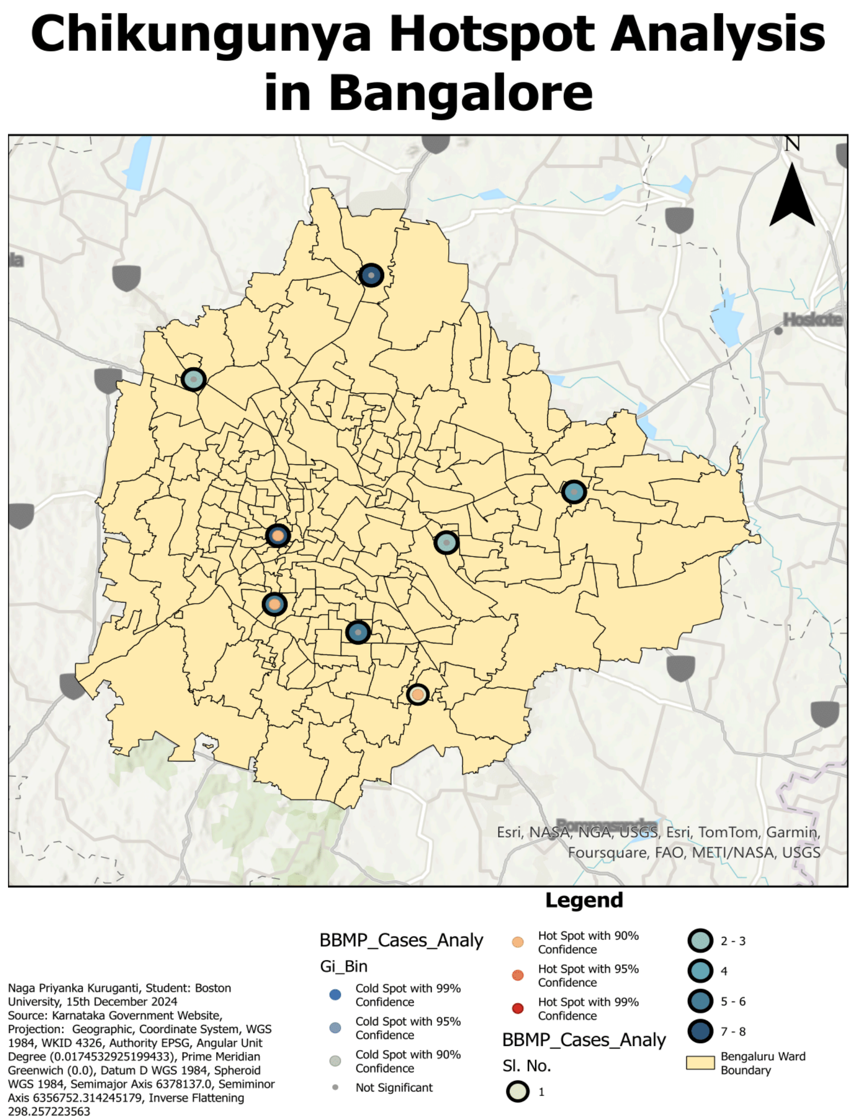

Figure: Chikungunya Hotspot Analysis in Bangalore

Discussion:

The broader ideas of this paper in some sense add to the idea that environment and clustering effects can cause an increase in the number of cases. However, this paper also adds to the idea that this increase could rather be due to movements than solely based on an increase due to climatic conditions.

There exists a need for an appropriate policy intervention so as to ensure that there exists a decline in the number of cases:

1. At the border level there is a need to have a stricter joint collaboration effort between state governments to mitigate the increase in mosquitoes.
2. At a city level there exists a higher need to come up with regular checks to improvise the drainage systems, as well as need to regularly spray mosquito disinfectants so as to ensure that there exists a decrease.
3. There is a need to have better healthcare systems interms in areas with a low-high cluster analysis indicating that this increase in cases is due to inadequate healthcare systems.

Some of the issues with this paper is that these are limited to the district level and hence, there is more data needed at the ward level to have a more accurate analysis.

Conclusion:

This study does a spatial analysis of chikungunya spread in Karnataka, using KNN-Hotspot Analysis, descriptive statistics, and proximity analysis.

Key findings include:

1. High-risk districts in northern Karnataka, driven by proximity to state borders

2. Urban clustering causes an increase in the cases at the city level.

Future work could focus on ward data to have stronger temporal trends so as to ensure better policy analysis.

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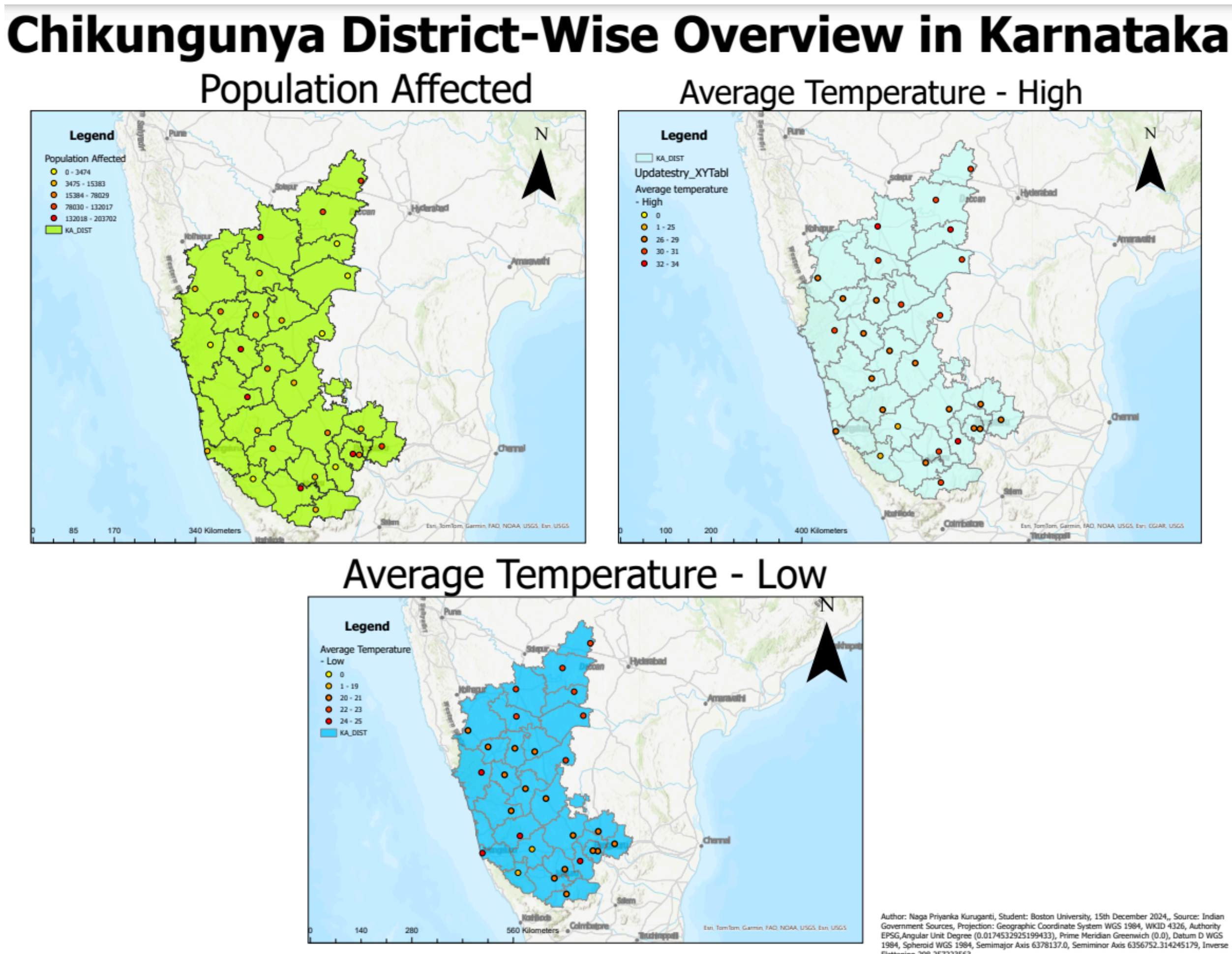
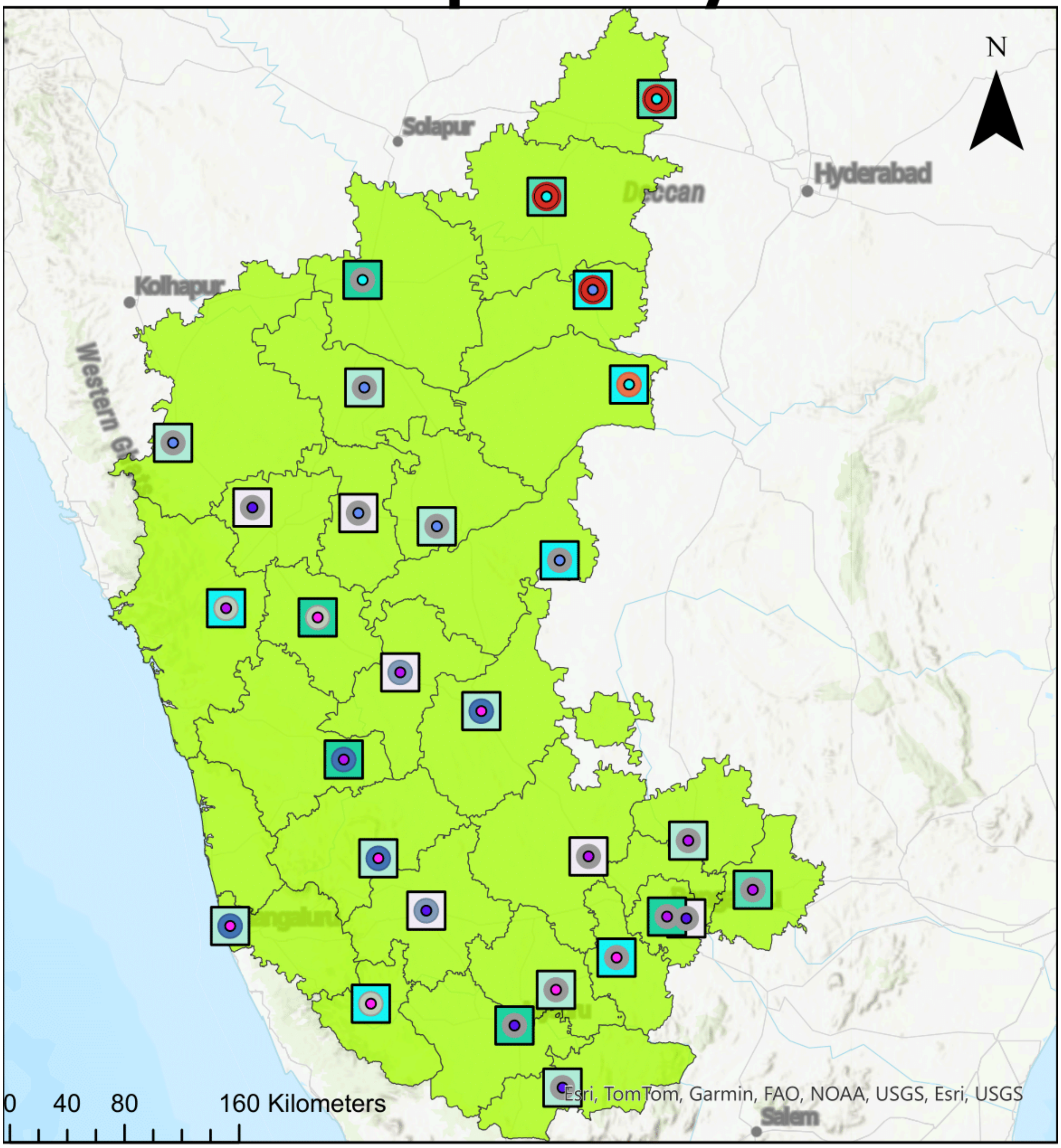


Chikungunya District-Wise Overview in Karnataka
Population Affected
Legend
Population Affected
0 - 3474
3475 - 15383
15384 - 78029
78030 - 132017
132018 - 203702
KA_DIST
0 85 170 340 Kilometers
Average Temperature - High
Legend
KA_DIST
Updatestry_XYTabl
Average temperature - High
0
1 - 25
26 - 29
30 - 31
32 - 34
0 100 200 400 Kilometers
Average Temperature - Low
Legend
Average Temperature - Low
0
1 - 19
20 - 21
22 - 23
24 - 25
KA_DIST
0 140 280 560 Kilometers
N
Author: Naga Priyanka Kuruganti, Student: Boston University, 15th December 2024,, Source: Indian Government Sources, Projection: Geographic Coordinate System WGS 1984, WKID 4326, Authority EPSG,Angular Unit Degree (0.0174532925199433), Prime Meridian Greenwich (0.0), Datum D WGS 1984, Spheroid WGS 1984, Semimajor Axis 6378137.0, Semiminor Axis 6356752.314245179, Inverse Flattening 298.257223563

District-Wise Hot-Spot and Cold-Spot Analysis



Naga Priyanka Kuruganti, Student: Boston University, 15th December 2024
Source: Karnataka Government Website,
Projection: Geographic, Coordinate System, WGS 1984, WKID 4326, Authority EPSG, Angular Unit Degree (0.0174532925199433), Prime Meridian Greenwich (0.0), Datum D WGS 1984, Spheroid WGS 1984, Semimajor Axis 6378137.0, Semiminor Axis 6356752.314245179, Inverse Flattening 298.257223563

Legend

Population Affected
- 0 - 3474
- 3475 - 15383
- 15384 - 78029
- 78030 - 132017
- 132018 - 203702

Gi_Bin
- Cold Spot with 99% Confidence
- Cold Spot with 95% Confidence
- Cold Spot with 90% Confidence