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Spatial Relationship between Environmental Justice and Tier II Facilities in Massachusetts

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Abstract: *This study explored the aggregation of environmental justice populations through the standardized SVI indicator (Social Vulnerability Index), and vulnerable populations have similar areas of aggregation through the aggregation analysis of the cluster map of SVI. After using spatial analysis to examine the spatial geographic location of secondary facilities and environmental justice community areas, we found significant similarities and overlaps between the two regions related to gentrification policies.*

Keywords: *Environmental justice populations; SVI indicator; cluster map; spatial analysis*

1. Introduction

This study wanted to understand the relationship between the Social Vulnerability Index (SVI) and environmental justice zones. The aggregation of environmental justice populations is explored through a standardized SVI indicator. The SVI is a comprehensive composite index that combines several critical components of selected social vulnerability indicator variables. The SVI groups include socioeconomic status: below the poverty line, unemployed, low income, and no high school diploma. And family composition and disability: 65 years or older, 17 years or younger, civilians with disabilities, and single-parent households. And minority status and language: including minority, five years old or older, and who speak English "not very well" and housing type and transportation: multi-unit structures, mobile homes, crowded, no transportation, and group homes[1].

It is obtained by performing a principal components analysis on several selected SVI variables by linearly combining several main components, which quantifies the relative level of overall social vulnerability. Geospatial correlations between environmental justice areas and secondary facilities in Massachusetts were studied. A secondary facility stores hazardous chemicals in more than a certain quantity. The population of environmental justice areas is relatively vulnerable in society and consists of low-income, minority, and English as a second language. Because of their socially invisible status, their rights may be unknowingly violated. To examine whether society tends to place sources of pollution near socially disadvantaged groups. This study wanted to determine if society tends to locate pollution sources near socially disadvantaged groups. And what environmental pollution people receive in environmental justice areas. The potential negative impacts on climate justice groups are explored by showing the spatial relationship of secondary facilities. We can use past data, studies, and field surveys to analyze the affected groups[2].

Maantay (2006) summarized the application of GIS spatial analysis in assessing environmental health and equity. In this article, the authors examine the results of maps of environmental justice issues and point out their limitations. The authors propose a series of measures to address these issues, such as improving the database and developing relevant risk indicators.

Lees et al. (2008) describe gentrification in detail as transforming poor or otherwise unattractive neighborhoods by making space for the entry of more affluent people and businesses. This form of urban planning increases the economic value by efficiently using its resources. But it can also cause social injustice, such as displacement and further segregation of various populations.

Wilson et al. (2010) examined whether areas where vulnerable populations, including people of color, congregate because of climate change expose them to higher levels of social and environmental harm. The authors use local cluster analysis to show the location of contiguous areas with similar vulnerabilities, visualizing the vulnerability index as a spatial index[3].

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Kedron (2016) identifies the spatial extent of clusters around a pre-defined site of interest from available empirical evidence using local Moran's I statistics. Combining containment buffers with traditional local Moran's I techniques, this approach identifies clusters as an alternative to commonly used containment buffers[4].

Park et al. (2022) discussed the differential contributions of the constituent components of the SVI. Using geographically weighted principal components analysis, they investigated how local indicator variables evolved over time and across the more fantastic Houston, USA, metropolitan area. It found that high social vulnerability in suburban areas was highly correlated with the percentage of mobile homes. It also finds that indicator variables of social vulnerability exhibit substantial spatial heterogeneity and dependence at the local scale[5].

2. Data and Results Analysis

2.1 Data

SVI data from the Agency of Toxic Substances and Disease Registry. It is a statistical excel table containing SVI data for each city in Massachusetts in 2018.

Climate justice population maps were obtained from MassGIS (the state's one-stop shop for interactive maps and related descriptive information). We used 2019 environmental justice population data. The map is in shp. Format.

The Massachusetts Executive Office of Energy and Environmental Affairs provided information on the Tier II facility characteristics. The Massachusetts 2020 Tier II Facility Characterization Map contains the locations where individual facilities are, and the files are in shapefiles for download.

2.2 Results Analysis

(1) SVI

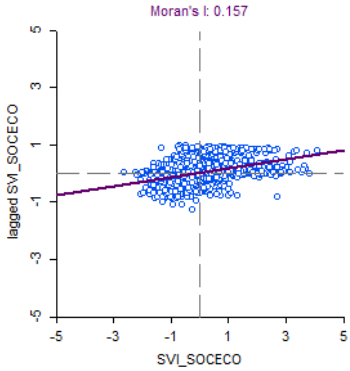

Figure 1: Moran Scattle Plot of Socioeconomic Status

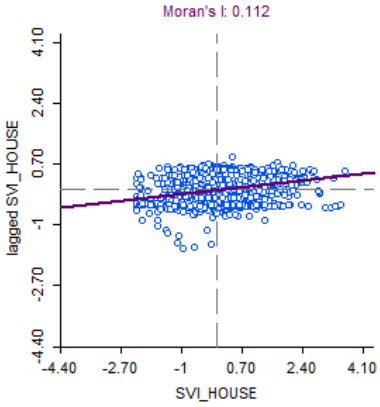

Figure 2: Moran Scattle Plot of Household Composition & Disability

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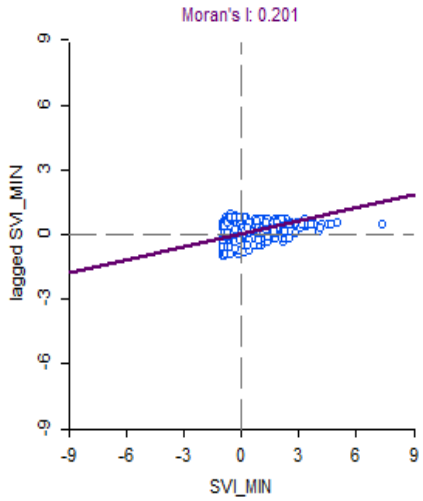

Figure 3: Moran Scattle Plot of Minority Status & Language

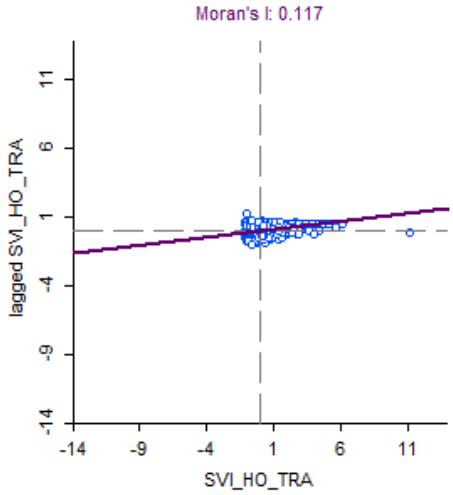

Figure 4: Moran Scattle Plot of Housing Type & Transportation

We made four scatter plots (Figure 1-4) and four cluster maps (Figure 5-8) based on the four indicators, respectively. Moran's I is statistically significant because it is positively correlated when Moran's I is greater than zero, indicating that objects with similar attributes are clustered together. From the cluster maps, those with Minority Status & Language (Figure 7) as indicators show the most apparent clustering trend. Areas close to larger cities (Boston, Springfield) show high clustering (dark red), while large areas of low clustering exist away from cities. This may be due to ethnic clustering, where the same ethnicity prefers to form a community. Local communities would be more likely to attract the same ethnic population in such an environment[6]. They may be less likely to use the official language (English) and adopt the native language for daily communication. It seems that the socially susceptible population is more dispersed from the Household composition & Disability indicator (Figure 6) because these variables (age >65, age <17, disability, and single-parent households) are more generalized, and political or economic factors do not easily influence it. The remaining two indicators (Socioeconomic Status, Figure 5, and Housing Type & Transportation, Figure 8) are based on the economy. Because of the need for money, the group may gravitate to cities with more job opportunities.

The cluster diagram is shown in Figure 5-8.

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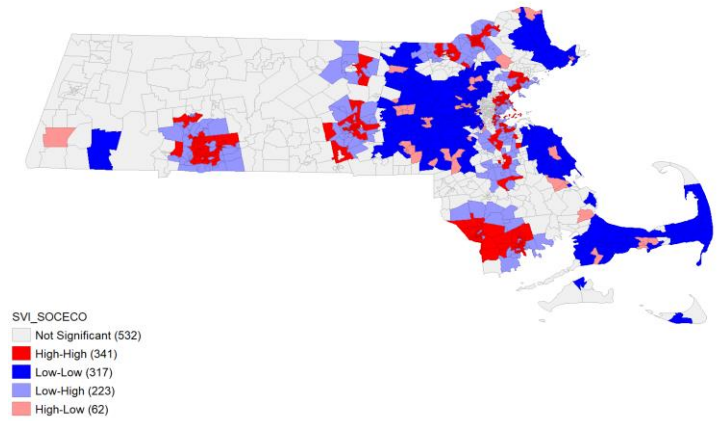

Figure 5: Cluster Map of Socioeconomic Status

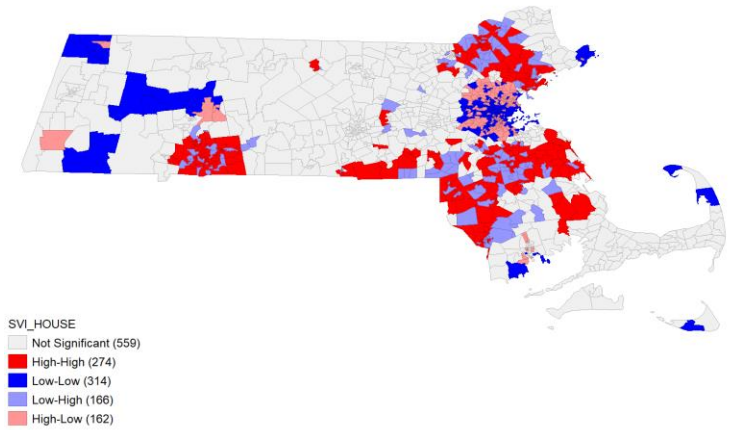

Figure 6: Cluster Map of Household Composition & Disability

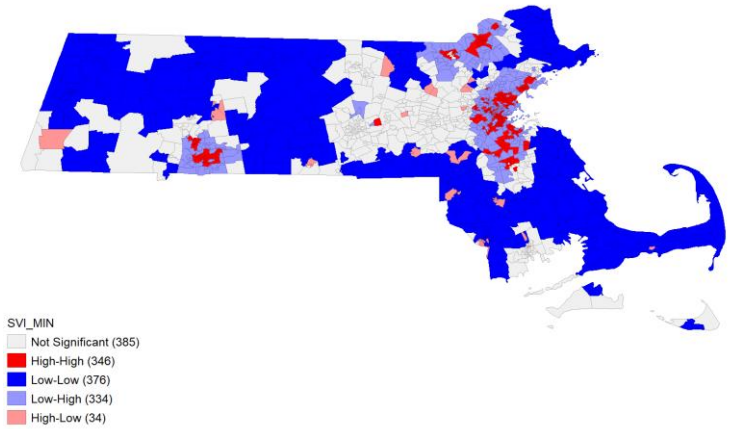

Figure 7: Cluster Map of Minority Status & Language

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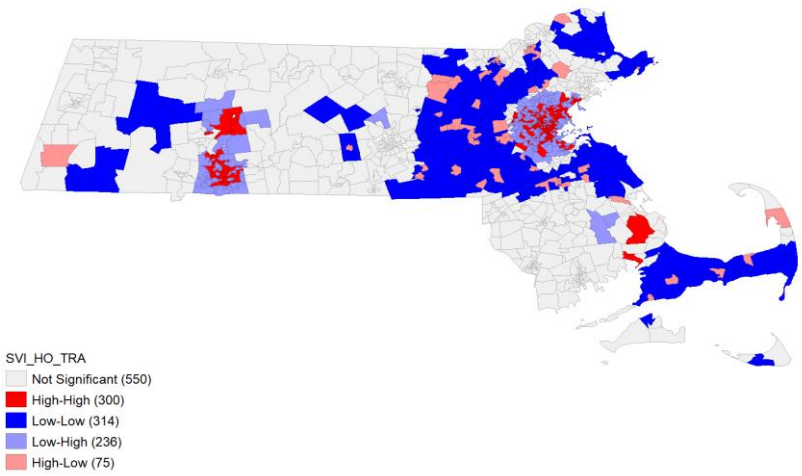

Figure 8: Cluster Map of Housing Type & Transportation

(2) Tier II Facilities

The kernel density map (refer to Figure 9) gives the most intuitive density distribution of Tier II facilities. The concentration of facilities in major cities in Massachusetts, including Boston, Springfield, Worcester, Lowell, Barnstable, etc, can be seen based on the color depth centers. Since Boston is the capital city, large companies usually choose to build their plants here, so the density of Tier II facilities is the highest.

In the cluster map (refer to Figure 10), Boston shows a similar trend to the density map, with very high HH aggregation. Other cities, except Springfield, which has some areas with HH aggregation, offer no significance.

From the Hot Spot map (refer to Figure 11), 99% confidence regions account for most hotspots, with statistically significant hotspots concentrated in the Boston region, followed by Springfield and Worcester. Finally, a small number of 90% confidence hotspots exist in Barnstable.

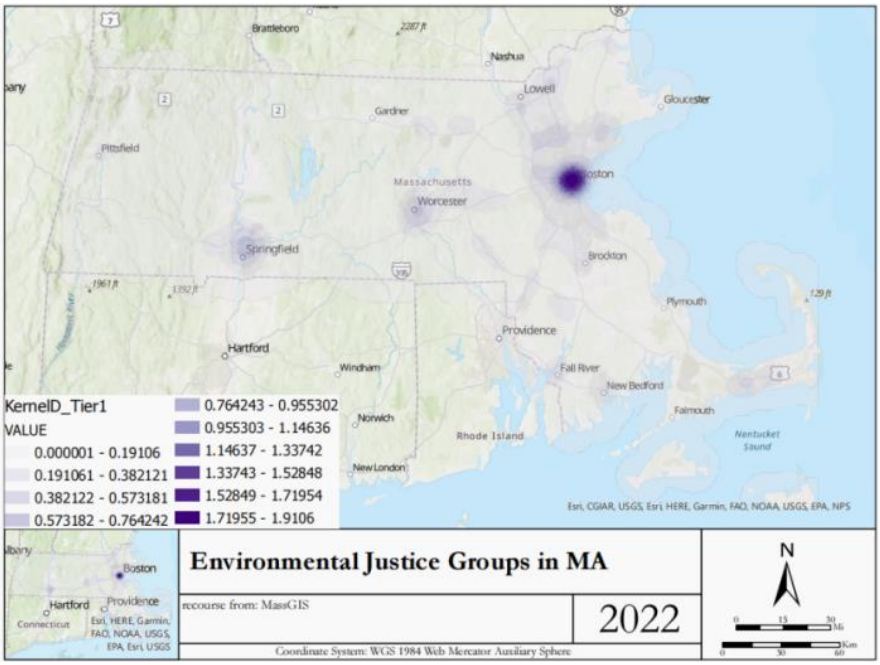

Figure 9: Map1_Kernel Density of Tier II facilities in MA

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Figure 10: Map2_Cluster map of Tier II facilities in MA

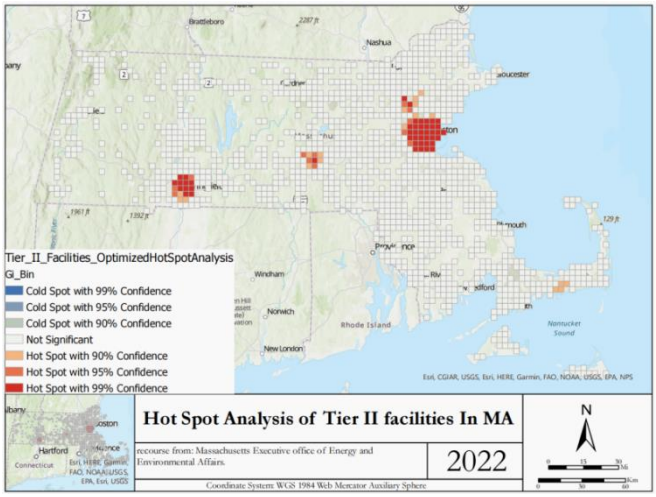

Figure 11: Map3_Hot Spot Analysis of Tier II facilities In MA

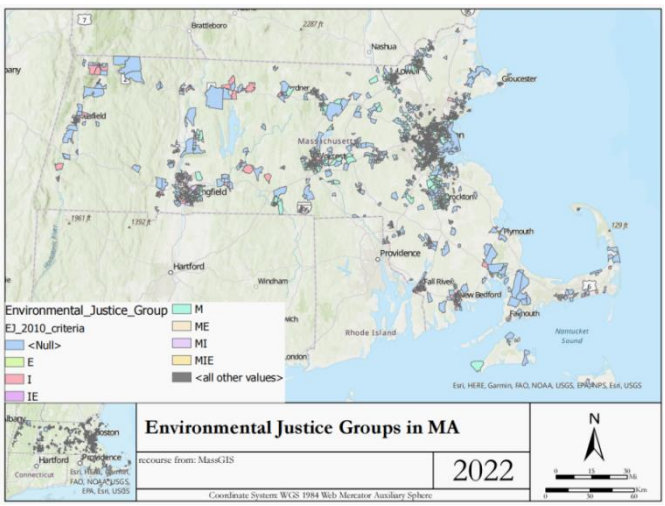

Figure 12: Map4_Environmental Justice Groups in MA

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3. Discussion

It can only be considered a preliminary model for the calculation of SVI because we have selected only some of the variables and divided them roughly into several broad categories to facilitate the analysis. If the individual variables are analyzed spatially, it may be possible to obtain a clearer cluster trend and see the pattern of change more quickly.

As the map shows, both density and aggregation are concentrated in large cities, overlapping with the Environmental Justice Group map (refer to Figure 12). A significant limitation of this analysis is that it does not consider population suburbanization. In large US cities, including Boston, the wealthy have gradually begun to migrate to the urban periphery rather than choosing to congregate in downtowns. This trend appears to be a conscious effort to squeeze out environmentally vulnerable populations to live in a way that forces them to relocate. Therefore, the time comparison will be an essential reference factor, and future studies can be developed in this direction

4. Conclusion

From the SVI cluster map, the socioeconomic, minority, and housing type & transportation indicators show high regional clustering centered on Boston and Springfield, which is similar to the complexity of climate-sensitive populations in these two urban areas as expressed in the Environmental Justice Group Map (refer to Figure 3) provided by MassGIS.

From the different spatial analysis patterns (kernel density, outliers, hotspots), universal conclusions can be drawn, again in the Boston and Springfield neighborhoods, where high values of either density or matter statistical significance exist, indicating that Tier II Facilities are heavily clustered in these areas. In addition, high confidence hotspots are also present in the Worcester neighborhood. The clustering is more in line with the environmental justice cluster map, where pollution sources are more likely to cluster in areas where climate-sensitive populations live. This trend may involve political or economic factors.

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