Methodology

Section One:

Addressing environmental degradation has been an issue of utmost importance especially within these past several decades. While a multitude of governments and organizations across the world have begun the process of preservation and restoration within many areas affects by pollution and degradation, there still remains much to be done. In a more social aspect, the lack of environmental justice mapping has led to the continued perseverance of a statistical fact: that minority and poor people more often than not, experience greater heightened exposure to pollutants, limited access to adequate environmental services and ultimate a right to a clean and resourceful environment. It is thus paramount that better coverage and mapping of environmental justice are available to both the public and governmental resources in order to raise awareness over the subject, combat environmental racism and provide the necessary outreach and solutions to such issues. This project is founded upon the beliefs of tackling corruption and ensure that all people no matter the ethnicity, income level, deserve the same protections under environmental laws opportunities to experience the fundamental right to clean air, land, and water. Thus far, efforts to map environmental injustice have only been a privilege of first world countries such as the United States while other lesser developed countries often face obstacles such as the lack of data or its specificity. In order to account for such issues, Kriging techniques, which is a form of interpolation that can estimate unknown areas, can be used in areas with fewer data points. Kriging can then be used to find estimates to unknown locations meaning countries with fewer data points can have better-defined estimate values. In this case, the use of Kriging can be applied to both social and environmental indicators such as finding Ozone, SO_2, and PM2.5 concentrations in air pollution in order to better map environmental injustice in Vietnam.

The inequalities faced in Vietnam by different groups aren't very well defined by relevant research and data at its current status. Not many maps devoted to mapping income or ethnic distributions across Vietnam have come to fruition. Poverty indicators still aren't defined by small unit grid cells. The boundaries for environmental justice mapping which rely on the overlay of social and environmental indicators to find correlations between such specific variables are thus not defined as of yet due to the lack of data specificity and precision. The input of much of the data required to create such an extensive map does not exist in Vietnam at the level of intricacy yet. A census is being planned to be completed by around September 2020 which could potentially bring much up to date information needed in order to further much GIS mapping in the nation. The results for any statistical project or research can only be as good as the data.

The basis for this project fits under the descriptive inquiry as it seeks to create a profile of a set of extensive social and environmental indicators within a nation, drawing from those indicators to find correlations between different variables that exist. The essence of this project is to find potential instances of injustice where certain groups are marginalized to face deadlier health risks or conditions from pollution. Is the Tay ethnic minority more likely to live near coal plants and industrial factories? Do the emissions and output from these factories lead to higher rates of lung disease or asthma in the area? It also draws from the exploratory inquiry in this sense as it attempts to explain why certain groups are marginalized too. For example, we can explain why income or race has a strong correlation to overall health from the access to the distribution profiles created for each group. At the same time, however, the results from such a map can also provide inputs for evaluative inquiry where it can be used to evaluate the effectiveness of government policies, transparency or other macroeconomic and its link to poverty and health indicators. Essentially this project seeks to answer the Who, What, How, and even the Why of a potential issue.

Section Two: Moran's 1

While improper datasets may prevent an effective and precise version of the environmental justice map from coming to fruition in Vietnam, given the existence of proper datasets, the unequal exposure of substances can be analyzed through the use of the local and global Moran's 1 statistical methods and Pearson Correlation methods. Research on the topic was modeled and executed in Ghent, Belgium by Thomas Verbeek found in ***Unequal residential exposure to air pollution and noise: A geospatial environmental justice analysis for Ghent, Belgium.*** [1] Given a set of features and associated attributes, Moran's 1 can calculate whether the expressed value is clustered, dispersed or random as it is the correlation coefficient for the relationship between some variable and its surroundings.

The Moran's I statistic for spatial autocorrelation is given as:

$$I = \frac{n}{S_0} \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} w_{i,j} z_i z_j}{\sum_{i=1}^{n} z_i^2} \qquad (1)$$

Figure 1: Illustrates the mathematical formula behind Spatial Autocorrection. An expected and observed index value is calculated where a computed z-score and p-value is used to determine whether the difference between these two indices are significant or not.

Through the use of Spatial Autocorrelation and Pearson correlation values, the author found that neighborhoods with a lower average income, higher unemployment rates, more minority ethnic groups faced greater rates of air pollution but not noise by combining such indicators with socioeconomic values. The data for air quality was derived from theATMOSYS annual air quality map from traffic-related pollution, providing rasterized georeferenced data. The quantified noise exposure was drawn from various noise maps from the 2010 EU Environmental Noise Directive while other socioeconomic data were collected from 201 statistical sectors which averaged 1,200 responders each. The significance of the Moran's statistical coefficient values for residential exposure to air pollution was computed through the calculation of the p-value of 999 random permutations. The p-value, in this case, measures how likely the cluster value computed from Moran's 1 is to occur randomly. The possibility of pollution randomly being there is thus taken into account. Concluding a value of .78, the spatial distribution of air pollution illustrates a clustered value. Comparing Moran's 1 with the Local Indicators of Spatial Association (LISA) areas of high air pollution clusters were identified. The Moran's 1 value for four covariates: median household income, percentage of people of foreign origin, percentage of rental houses and the number of house moves per 1,000 inhabitants were also calculated and compared with the cluster distribution of air pollution. Multiple regression techniques were also employed to analyze the correlation between covariates.

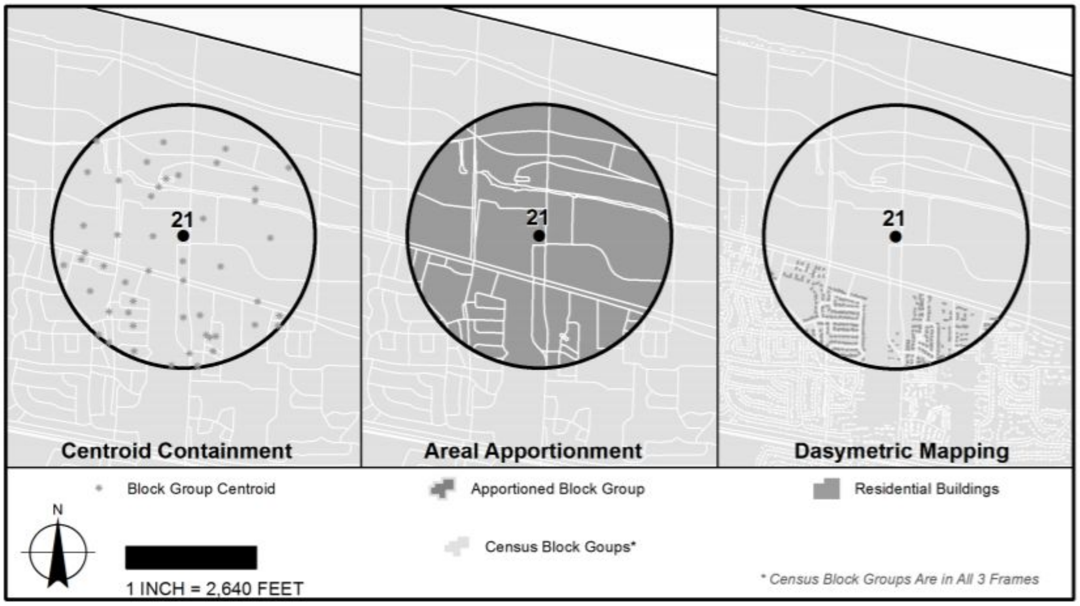
Section Three: Population Estimation Methods

A research paper by Kyle Goodman details the use and comparison of three different GIS population methods for estimating exposure of people to brownfields in Portland, Oregon. Brownfields are former industrial sites that may harbor large amounts of contamination. The author collected three different datasets for this project with demographic information being collected from the US census database in Oregon, contamination zone data being collected from Oregon's Department of Environmental Quality and city boundaries being collected from the Oregon Metro. The Oregon Metro contains GIS data from 25 surrounding cities and two counties. The first technique used to estimate the population within the contamination zones is the Centroid Containment Method which, "converts the census enumeration polygons into points within the center of the census block polygon. [2]" The second method is the Areal Apportionment Method which is one of the most common GIS techniques used for population estimation in environmental justice. This method relies on the use of proportional adjustments where the goal is to include the population that is within the exposure zone, excluding those who are not in the zone. An intersect geoprocess is run to capture the census blocks within the contamination zones near the brownfields. To calculate the population within the predicted polygon exposure site the formula in figure 2 is used.

$$Ps = Pt * Pcb$$

Figure 2: Where Pt is the population type is multiplied with the Percentage of Census Block (Pcb) to find the potential people affected by the contamination (Ps)

The third and final method used is the vector-based dasymetric mapping which serves to estimate people per building within the buffer zones surrounding the brownfields. While the other two methods rely on the use of generic shapes, this method provides use of more realistic spatial units. Dasymetric mapping reorganizes the aggregated data by taking it out of arbitrary geographic boundaries and redistributes it into a more realistic representation of the data (that can then be measured within the affected area.



The number of people per building (PPB) was found by Pt by total building volume (Bt) and multiplying this result by the volume of each individual building (Bv). This gives the formula below.

$$PPB = \left(\frac{Pt}{Bt}\right) * Bv$$

In order to calculate the percentage of minority populations at risk of contamination and ultimately the Population Inequality Quotient Index which is the "proportion of minorities in at-risk areas to their proportions in not-at-risk areas, [2]" the formula below was derived.

$$\left(\frac{At-risk\ Minorities/Total\ citywide\ at-risk = At-risk\ Ratio}{Not-at-risk\ Minorities/Total\ not-at-risk\ citywide\ population = Not-at-risk\ Ratio}\right) = Population\ Inequity\ Quotient\ Index$$

Both the Centroid Containment Method and the Arreal Apportionment Method had less than a .03% difference in estimating the population around Portland while the dasymetric mapping had 2.5%, resulting in 9,000 fewer people not being estimated. This was due to the "ancillary buildings data not having exact classification for single-family residential or multifamily residential buildings across the entire dataset. [2]" Overall, however, all three methods had less thana 1% difference when comparing the percentage of people affected by contamination. The Arreal Apportionment Method tended to overestimate values while the dasymetric mapping method tended to underestimate values.

Discussion:

The methods used in these two research papers come from different perspectives to solve the same problem. However, I believe that the use of Moran's 1 method provides a more sophisticated set of results that adheres to my vision of what an environmental justice map is about as it more focuses on the correlation aspect through the use of Spatial Autocorrelation which can provide more robust black and white data results similar to the use of the Pearson Correlation. This is only in the case where datasets are strong and fluid which isn't the case for Vietnam. The use of population estimators in the second paper, however, can provide preliminary steps for very simple environmental justice mapping of contamination zones as it serves to estimate populations based on simple overlays of buildings, and contamination zones. While Moran's 1 and the population estimates provide different outlooks to solve the same problem, I personally think the use of Moran's 1 provides stronger correlations and data. We must keep in mind that the two forms of correlation calculations are used in different scenarios. Nevertheless, results can only be as strong as the datasets are descriptive.

References:

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