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4 authors:

Toufiq Hossain
Sheltech Consultants (Pvt.) Ltd.

Md Juwel Rana
Rajshahi University of Engineering and Technology

Anutosh Das
Rajshahi University of Engineering and Technology

Sumita Roy
Rajshahi University of Engineering & Technology (RUET)

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Regionalization and Assessing Disease Prone Regions through Environmental Pollution in Bangladesh

M. T. Hossain[1], M. J. Rana[2], A. Das[3], S. Roy[4]

[1]Department of Urban and Regional Planning, RUET, Bangladesh (toufiq.hossain2910@gmail.com)
[2]Department of Urban and Regional Planning, RUET, Bangladesh (juwelruet@gmail.com)
[3]Department of Urban and Regional Planning, RUET, Bangladesh (anutosh@urp.ruet.ac.bd)
[4]Department of Urban and Regional Planning, RUET, Bangladesh (sumitaroy@urp.ruet.ac.bd)

Abstract

Environmental pollution is a major health hazard that affects millions of people worldwide. Bangladesh is one of the most vulnerable countries to environmental pollution due to its high population density, unplanned urbanization, and inadequate environmental management practices. This research paper focuses on the regionalization of Bangladesh based on environmental pollution to determine disease-prone regions. To conduct the analysis, data were collected from various sources such as BBS and then processed and analyzed using statistical software, such as SPSS, to assess the level of pollution in different regions of Bangladesh. Additionally, GIS (Geographic Information System) software was utilized to integrate spatial data and visualize the regional distribution of environmental pollution and disease prevalence. This enabled the identification of disease-prone regions and the determination of the areas most influenced by disease transmission. The identified disease-prone regions can serve as a basis for targeted interventions and resource allocation to mitigate the health risks associated with pollution. Moreover, the determination of influenced areas aids in implementing effective strategies to control the spread of diseases.

Keywords: *Regionalization, disease-prone regions, environmental pollution, SPSS, GIS.*

1. Introduction

Environmental pollution is an issue of great concern on a global scale, posing a serious threat to the well-being of human populations (N. Nahar et al., 2021). The acceleration of industrialization and urbanization has resulted in the release of pollutants into the environment, leading to a range of negative impacts on ecosystems and human health. In South Asia's densely populated Bangladesh, the impact of environmental pollution on public health is particularly significant (Ikram & Wahab, 2021; M. S. Islam, 2021). The purpose of this study is to employ formal and functional regionalization techniques to identify areas in Bangladesh that are affected by disease through environmental pollution. The formal regionalization approach involves the examination of seven key factors, including population, area (sq km), greeneries, chemical fertilizer (MT), vector-borne disease (Cholera), waterborne disease (Diarrhea and other infections), and airborne disease, in order to identify regions that are prone to disease. On the other hand, the functional regionalization technique incorporates industry as an additional factor to determine the areas that are influenced by disease transmission. Through these methods, we aim to delineate disease-prone regions and identify the areas that require attention.

Bangladesh is currently facing various challenges when it comes to managing and mitigating pollution, which can be attributed to the rapid growth of its industrial sector and high population density. Ineffectual waste management systems, unregulated emissions from vehicles and factories and the unselective application of pesticides and fertilizers all contribute to the deterioration of air, water, and soil quality, thus heightening the health risks for the population (Haque, 2021; Hoque et al., 2021; Rahman & Alam, 2021). The discharge of untreated sewage and industrial waste into rivers is a major contributor to pollution, particularly during the low-flow season, leading to high ammonia levels and low dissolved oxygen (Biswas et al., 2021).

An interdisciplinary method that combines environmental science, geographical information systems (GIS), SPSS can be utilized to determine the regions in Bangladesh that are susceptible to disease. Researchers can analyze environmental data, including air and water quality measurements, pollution sources, and population density, to identify areas with higher pollution levels that correspond with an increased prevalence of disease as well as the underlying cause behind this phenomenon can be identified (Mahmud et al., 2021).

2. Literature Review

Environmental pollution is a significant worldwide health issue that has considerable implications for millions of individuals. Bangladesh, specifically, is at a heightened risk due to its high population density, accelerated urbanization, and substandard environmental management practices (N. Nahar et al., 2021). The gravity of environmental pollution in developing nations, such as Bangladesh, has been extensively researched. The primary forms of pollution, including air, water, soil, noise and plastic/microplastic pollution, have been identified as global public health concerns (Ajibade et al., 2020). This literature review endeavors to investigate the present corpus of information pertaining to environmental contamination in Bangladesh, its effects on health, and the approach of regionalization to pinpointing regions susceptible to disease.
The regionalization of Bangladesh through the analysis of pollution levels can provide valuable insight into the implementation of targeted interventions and allocation of resources aimed at reducing health risks (A. Nahar et al., 2019). Identifying regions with a high risk of disease can assist policymakers in prioritizing environmental management, healthcare services, and pollution control measures in these areas. Numerous studies have investigated the correlation between environmental pollution and health outcomes in Bangladesh (Dodd et al., 2019). conducted a comprehensive assessment of air pollution levels and associated health risks in major cities, highlighting the need for targeted interventions to mitigate the adverse effects on public health (Khomenko et al., 2021; Southerland et al., 2021). The method of regionalization provides significant knowledge in comprehending spatial discrepancies in contamination levels and their correlated health hazards (Guo et al., 2021). In this study, data from various sources, such as the Bangladesh Bureau of Statistics (BBS), were collected and processed for analysis using statistical software, specifically SPSS. The statistical analysis allowed for the assessment of pollution levels in different regions of Bangladesh (Cañaveral et al., 2021). SPSS and GIS are obligatory to assess the regional distribution of pollution and its influence on disease transmission (Bosi & Desmarchelier, 2021).
Identification of regions susceptible to disease offers an opportunity to implement interventions that are aimed at mitigating the health hazards associated with pollution. The present study presents a solid foundation for evidence-based decision-making to combat environmental health challenges in Bangladesh (Riad et al., 2020). Moreover, the identification of affected areas supports the implementation of effective measures to curb the spread of diseases (M. A. Islam et al., 2020).

3. Methodology

The methodology for this regionalization project consists of several key steps. First, the topic selection process involves identifying a research area that is relevant and significant. The next step is data collection, which involves gathering secondary data through existing datasets. After collecting data, data analysis is conducted using appropriate statistical techniques such as SPSS to answer research questions or test hypotheses, and the results are interpreted to draw a meaningful map.
The next one is a Functional project where the methodology consists of several key steps. Firstly, secondary data was collected from the Bangladesh Bureau of Statistics (BBS). The administrative boundary layout map of Bangladesh was imported into GIS, and the district was divided into upazilas based on the map. Spatial analysis was then performed using GIS tools to identify influence areas between upazilas and some districts and Reilly's Law of Retail Gravitation was applied,

$$M_{ab} = \frac{D_{ab}}{1+\sqrt{\frac{P_b}{P_a}}} \quad \text{..........................} \quad (1)$$

(Source: "The Law of Retail Gravitation" by William J. Reilly)

M_{ab} = Mass of Attraction between a and b
D_{ab} = Distance between a and b
P_a = population of place a
P_b = population of place b
Using this formula and next the data have been calculated by MS Excel using statistical methods and find out the influence point between two upazilas or districts. The results and findings were presented using visualizations, such as maps, charts, and tables, to effectively communicate the analysis outcomes.

4. Data Collection and Analysis

This research is based on secondary data (BBS) of several factors that are selected for delineating regions based on spreading diseases such as population, area, greeneries, chemical fertilizer, vector, air and water-borne disease.

All these seven factors' data of 64 districts have been collected from the Bangladesh Bureau of Statistics (BBS, 2021). Next, from the data, the composite weight of each factor is calculated by MS Excel using different statistical methods. The different statistical methods that have been used for this research are:
The value of W of each district indicates the weight of the districts concerning its selected factors. Then for getting suitable class intervals used Equal Class Interval Method, Mean Standard Deviation Method, and Arithmetic Mean Method.

Method: Composite Weighted Index Method

Step 1: Weight Calculation of Individual Factors

W_n= Mean of Log_{10} (x_n)/Standard Deviation of Log10 (x_n) [n=1,2,3,4…….]
W_1 (Population) = 23.14963234
W_2 (Area) = 14.64577968
W_3 (Greeneries) = 11.3874372
W_4 (Chemical Fertilizer) = 8.213561967
W_5 (Vector-borne disease- Cholera) = 3.782197992
W_6 (Waterborne disease- Diarrhea & Other infection) =5.808031568
W_7 (Airborne disease) = 2.102010159

Step 2: Composite weight Calculation of Each District

$$W=((\log_{10}(x_1)*w_1+\log_{10}(x_2)*w_2+\log_{10}(x_3)*w_3+\log_{10}(x_4)*w_4+\log_{10}(x_5)*w_5+\log_{10}(x_6)*w_6+\log_{10}(x_7)*w_7)/(w_1+w_2+w_3+w_4+w_5+w_6+w_7)) \quad \ldots\ldots\ldots\ldots (2)$$

Step 3: Method Selection

- Equal Class Interval Method
- Arithmetic Method
- Mean-Standard Deviation Method

Calculation of Composite Weight of Each District

From equation (2), we calculate W for all 64 districts, and using these values we prepare 3 histograms of Equal Class Interval, Mean SD and Arithmetic method to select a suitable method for making Choropleth Map.

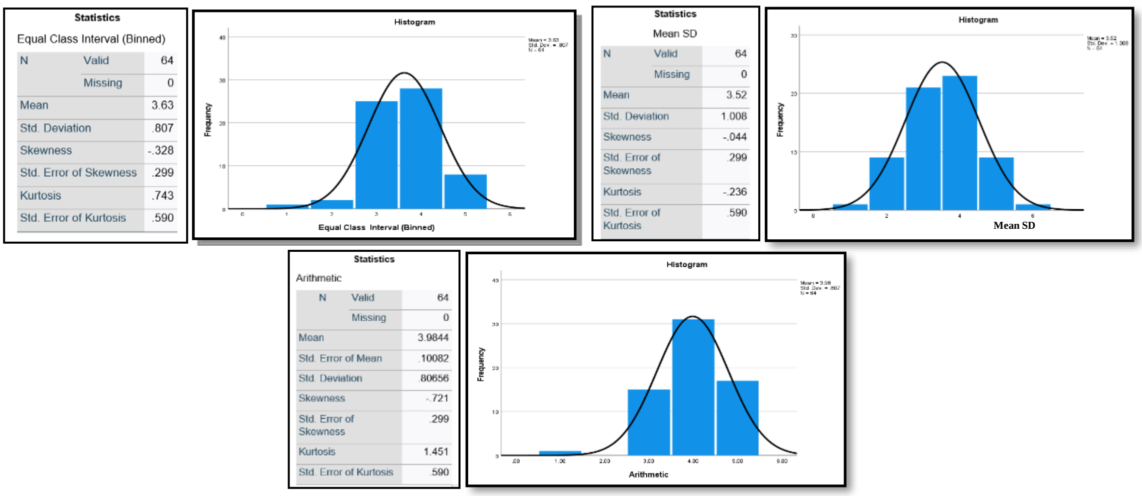


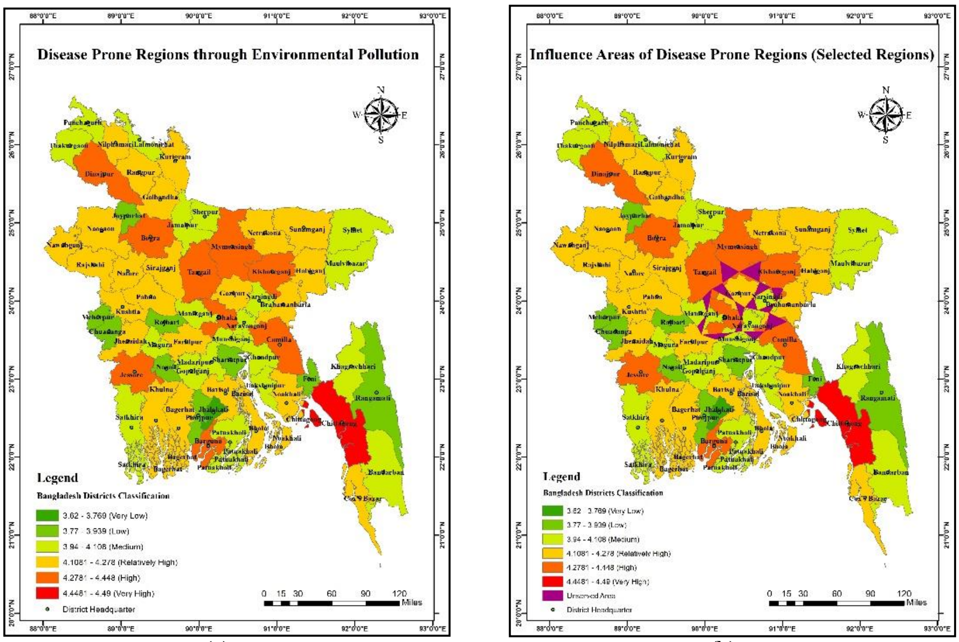
Figure 1: Histograms of Equal Class Interval, Mean SD and Arithmetic Method

The value of skewness from the method of the equal class interval is -.328 and by mean standard deviation method the skewness is -.044 and from the arithmetic method, the skewness value is -.721. The acceptance of the class interval depends on how close the value of skewness is from 0(zero). A skewness value nearer to zero means the data are most normally distributed. The value of mean standard deviation (Mean SD) method is nearer to 0(zero) than the other two methods. Therefore, the mean standard deviation method will be used for ranging the data for making Choropleth Map.

4.1 Analysis

Bangladesh has little vegetation, which makes the consequences of environmental pollution worse. Since we were unable to get integrated data on greeneries, we compiled the greeneries statistics by combining the gross cropland and forestland of each district. As a result, there are more instances of health issues, such as mental health problems and illnesses brought on by the heat. In Bangladesh, excessive chemical fertilizer use has caused soil degradation, which has an impact on crop quality and productivity. Overuse of chemical fertilizers has also contaminated soil and water supplies, which has facilitated the spread of illnesses like arsenic poisoning. In Bangladesh, air pollution is a serious issue that has been related to a variety of respiratory illnesses. Another problem that Bangladesh has experienced is water pollution, which has been connected to numerous water-borne illnesses like cholera and typhoid fever.

4.1.1 Choropleth map and influence area boundary of disease-prone regions through environmental pollution



(a) (b)

Figure 2: Choropleth Map(a) And Influence Area Boundary(b) of Disease-Prone Region

Figure 2 (a) shows 6 different classes which indicate the difference between each district according to diseases where the red zone indicates high disease prone region and the green zone indicates low disease prone region. This figure (b) also shows the influence area boundary of districts to describe a region's influence on spreading diseases to its surrounding districts. And to describe precisely we picked 3 districts which are Dhaka, Gazipur, and Narayanganj as they all are in different range and it helps to determine which category of district influence more to spread disease.

4.1.2 Functional gap analysis

Table 1: Functional Gap Calculation

District	Geographical Area	Influence Area	Influence area excluding Geographical area	% of Influence area outside the Geographical area
Dhaka	1463.6	2187.08	723.48	49.43%
Gazipur	1806.35	1381.08	-425.27	-23.54%
Narayanganj	684.34	984.38	300.04	43.84%

Dhaka district has a greater influence area than Gazipur and Narayanganj Sadar due to its higher population density, less greenery, and unplanned construction. This area has a 49.43% higher influence on disease transmission and air and water pollution. Gazipur's influence area is 23.54% less corresponding to its geographical area, due to the growing influence of Dhaka on surrounding neighborhoods. Narayanganj's influence area is similar to Dhaka, with the "Purbachal New Town" project being a major cause of spreading disease as the project involves removing a lot of greeneries, building more companies, and expanding the road system. Due to higher population density, rapid urbanization, and industrialization compared to other regions, Dhaka district may be more vulnerable than other disease-prone areas. According to (BBS, 2021), if we compare Dhaka and Gazipur with the factors influencing to spread diseases, despite having a smaller geographical area, the Dhaka district (2604) contains more industries than Gazipur (1773) though less in geographical area, which releases a lot of toxins, which might lead to a variety of illnesses. There are more chemical fertilizers used in the Dhaka district (9258.7 metric tons) than in the Gazipur district (6011.85 metric tons). According to (N. Nawar et al., 2022), Dhaka district area lost 56% of greenspace between 1989 and 2020 and it only has 8% of green space where at least 20% is required. Because of this, the Dhaka district has a greater influence on disease dissemination than the Gazipur district.

4.1.2(a) Influenced boundary map of Dhaka, Gazipur and Narayanganj

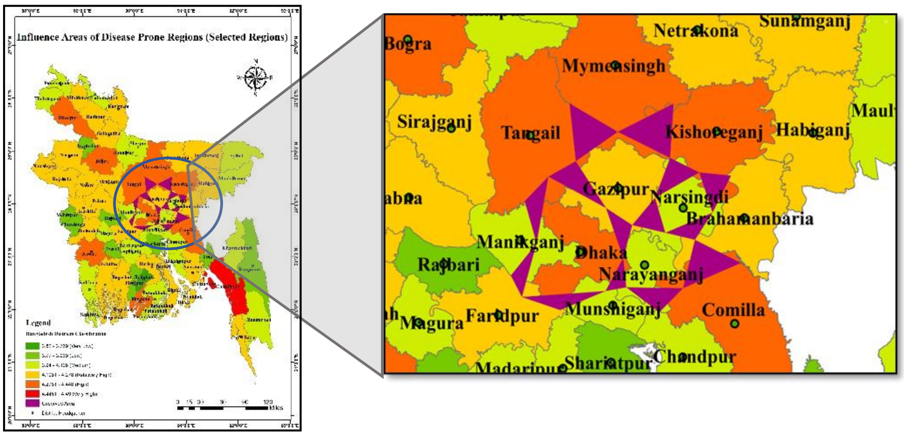


Figure 3:Influenced Boundary Map of Dhaka, Gazipur and Narayanganj

From Figure 3, we can see that, the Dhaka district's impact extends to the areas nearby. Thus, diseases that occur in the neighboring districts of Dhaka, such as Manikganj, Gazipur, Munsiganj, Tangail, etc., such as waterborne diseases, vector-borne diseases, etc., are partially spread as a result of the Dhaka region. We might infer from this data that, relative to its physical boundaries, Gazipur has less effect on the spread of diseases.

4.1.2(b) Functional Regionalization of Upazilas

To understand more precisely, we will now analyze the influence areas of all upazilas within our study area. By using ArcGIS software, we prepared multiple maps where the geographical boundary and influence area boundary are shown to interpret the influenced area of different upazilas.

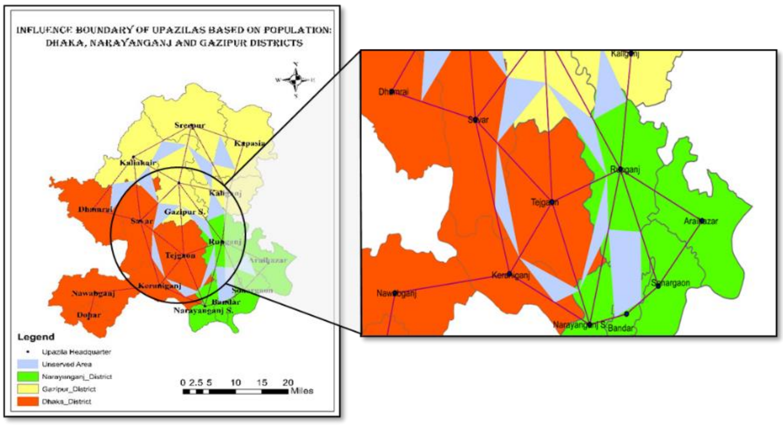


Figure 4: Influenced Boundary Map of Upazilas

From this figure, we can see that Tejgaon upazila in Dhaka, Bangladesh, has the highest influence on disease transmission due to its dense population, commercial and industrial hub, and well-connected transportation networks. The city's high population density creates conditions conducive to rapid disease spread, with close proximity among individuals increasing the chances of direct person-to-person transmission. Additionally, Tejgaon's proximity to businesses, factories, and offices attracts daily influxes of people from various regions, increasing the likelihood of introducing infectious diseases and facilitating their transmission back to their respective regions upon returning home. Furthermore, Tejgaon's well-connected transportation networks act as potential pathways for disease dissemination, as people traveling to and from Tejgaon may unknowingly carry infectious agents, contributing to the wider spread of diseases to other regions.

5. Findings and Conclusion

The study revealed significant variations in the levels of environmental pollution across different regions. Factors such as air quality, water contamination, soil pollution, and industrial activities contributed to these regional differences. The analysis helped to identify and classify regions in Bangladesh that are more susceptible to pollution-related diseases using SPSS and GIS software. The analysis demonstrated a clear association between environmental pollution and disease prevalence where regions with higher pollution levels exhibited an increased incidence of respiratory diseases, cardiovascular disorders, skin ailments, and other health issues linked to environmental toxins. Determination of influenced areas aids in implementing effective strategies such as sustainable development, industrial regulation, pollution control measures, etc., to control the spread of diseases and to minimize the impact on public health.

In conclusion, this research paper highlights the importance of addressing environmental pollution as a major health hazard in Bangladesh due to its high population density, unplanned urbanization, inadequate environmental management practices, etc. The regionalization approach used in the study provides valuable insights into disease-prone regions by analyzing pollution levels and integrating spatial data. This research contributes to the development of comprehensive and evidence-based approaches to protect public health and improve environmental management practices in Bangladesh.

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