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Spatiotemporal Changes of Urban Growth and Particulate Matter 2.5 Concentrations in Sylhet Sadar Upazila : A regional study using GIS RS techniques.

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Abstract

Despite being one of the fastest-growing developing countries, Bangladesh is consistently ranked among the most air-polluted in the world. The adverse effects of air pollution on the economy and public health are significant, yet efforts to combat it have been minimal. Unplanned urbanization and industrialization are key contributors to air pollution, particularly particulate matter. This study employed the Support Vector Machine (SVM) to identify different land use types and utilized ANOVA tests to examine the variations in land cover categories over time. The findings reveal a substantial increase of approximately 28.42% in built-up areas, alongside a decrease of 39.53% in mixed forest cover between 2001 and 2019 in Sylhet. Concurrently, PM2.5 concentrations have risen from 49.00 µg/m³ to 57.10 µg/m³. The study concludes that the expansion of built-up and barren lands contributes to the escalation of PM2.5 levels, whereas forested areas and water bodies are associated with reductions in PM2.5 concentrations.

Statement of Purpose

Bangladesh, the world's seventh most populous country, is home to approximately 160 million people (1). Dhaka, its capital, is ranked as the fifth most polluted city globally (1). The country's major urban areas are undergoing rapid urbanization, motorization, and industrialization, contributing significantly to ambient air pollution (2). Additionally, extreme climate events, including heatwaves, high temperatures, and tropical cyclones, exacerbate air pollution levels. Particulate matter, consisting of solid particles and liquid droplets, is pervasive in the air, with PM2.5—particles 2.5 micrometers or smaller—capable of penetrating deep into the respiratory tract and lungs (2). Exposure to PM2.5 is linked to a range of health issues, from lung irritation to serious conditions like lung cancer and cardiovascular diseases, leading to increased hospital admissions and mortality (3). The severe air pollution in Dhaka has garnered international concern for its profound implications on public health and the urban environment (3). This study aims to meticulously analyze the spatiotemporal dynamics of urban growth and PM2.5 concentrations in Sylhet Sadar Upazila and determine the correlation between PM2.5 levels and various land use types.

Data and Methodology

- Utilizes data from NASA's Socioeconomic Data and Applications Center (SEDAC) and the Local Government Engineering Department (LGED).
- Employs satellite imagery from Landsat 7, Landsat 8, and Sentinel-2, with spatial resolutions of 10 to 30 meters.
- -Applies a down-sampling method to standardize datasets with varying resolutions.
- Identifies Land Use Land Cover (LULC) categories such as barren land, mixed forest, built-up areas, and water bodies using the SVM technique in GIS platforms like ArcGIS Pro.
- Sources PM2.5 concentration data from 2001 to 2019 from SEDAC.
- Establishes a correlation between different land use types and PM2.5 concentrations through linear regression analysis.

Results

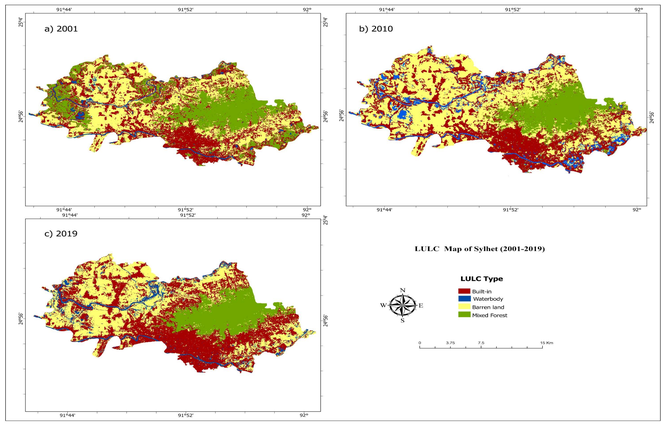

Figure 1: LULC maps of Sylhet from 2001 to 2019

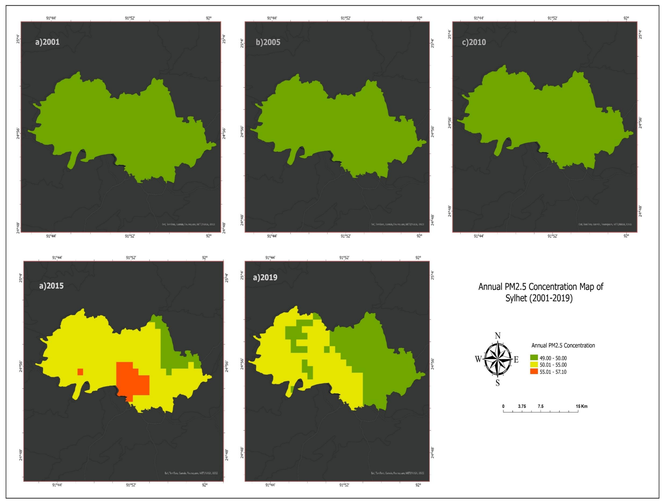

Figure 2: Annual PM2.5 Concentration from 2001 to 2019

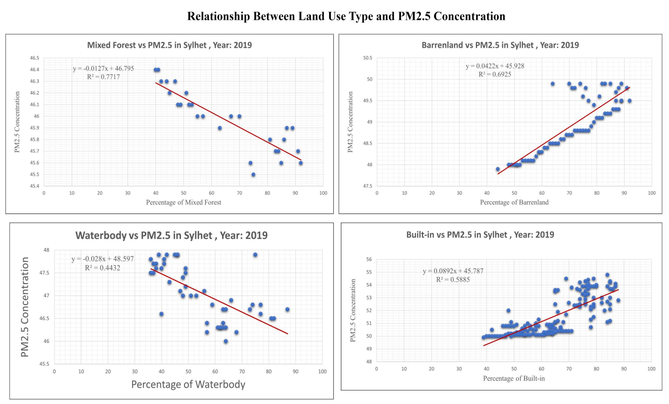

Figure 3: Correlation between Land Use Type and PM2.5 Concentration

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Results (Cont..)

Study Area	Class Name	Area 2001	Area 2010	Area 2019	Change (2001-2010) (%)	Change (2010-2019) (%)	Change (2001-2019) (%)
Sylhet	Built-in	9875.68	9976.07	12682.6	1.016	27.13	28.42
	Waterbody	1117.21	2094.08	1893.97	87.43	-9.55	69.52
	Barren land	11479.4	14111.9	11455.5	22.93	-18.82	-0.20
	Mixed Forest	8999.31	5289.98	5441.3	-41.21	2.86	-39.53

Table 1: Areal distribution of different LULC classes

Descriptive Statistics

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum	Between-Component Variance
						Lower Bound	Upper Bound			
Barren land		65	48.94	.657	.081	48.78	49.10	47.90	49.90	
Built-in		147	50.92	.944	.078	50.77	51.07	49.90	54.10	
Mixed Forest		27	45.97	.263	.051	45.87	46.07	45.50	46.40	
Waterbody		47	47.24	.425	.062	47.12	47.37	46.50	47.90	
Total		286	49.40	1.926	.114	49.18	49.62	45.50	54.10	
Model	Fixed Effects			.771	.046	49.31	49.49			
	Random Effects				1.299	45.27	53.53			4.7892

Table 2: Descriptive Statistics (Year: 2019, Study Area: Sylhet)

ANOVA

			Sum of Squares	df	Mean Square	F	Sig.
Between Groups	(Combined)		889.695	3	296.565	498.414	<.001
	Linear Term	Unweighted	269.743	1	269.743	453.337	<.001
		Weighted	261.775	1	261.775	439.946	<.001
		Deviation	627.920	2	313.960	527.648	<.001
Within Groups			167.795	282	.595		
Total			1057.490	285			

Table 3: ANOVA test result (Year: 2019, Study Area: Sylhet)

Conclusion

The study reveals a significant link between land use changes and PM2.5 levels in Sylhet from 2001 to 2019. Urban development is associated with increased PM2.5, while mixed forests and water bodies seem to reduce it. The correlation between land use and air pollution is growing stronger over time, highlighting the need for strategic planning to tackle air quality issues. These insights are vital for developing targeted environmental strategies and guiding sustainable urban growth.

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