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Land Use Land Cover Changes and Air Quality Impacts on Environmental Sustainability in Salem District, Tamil Nadu, India

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Abstract
This study analyzes Land Use and Land Cover changes in Salem District from 1995 to 2024, using remote sensing and GIS techniques. It reveals shifts due to urbanization, agricultural expansion, deforestation, and conservation efforts. Urban areas expanded, while cropland and forests decreased. Positive trends, such as the recovery of water bodies and wastelands, are noted. The study assesses environmental impacts like air quality and pollution from industrial and vehicular activities. By linking LULC changes to pollution hotspots, it highlights the need for sustainable land management and urban planning. This work contributes valuable insights and recommendations for mitigating environmental impacts, offering policy-oriented strategies for researchers, policymakers, and planners.

Keywords: Land Use and Land Cover, Salem, Remote Sensing, Geographic Information System, Air Pollution Hotspots, Change Detection Analysis, Environmental Impacts

Introduction
Land Use Land Cover (LULC) change detection analysis is a critical tool for understanding the dynamic interactions between human activities and the natural environment. LULC represents the physical and biological features over the Earth's surface, including forests, agricultural lands, water bodies, urban areas, and barren lands. Monitoring and analyzing changes in LULC over time is essential for evaluating the environmental impacts [1].

In recent decades, rapid urbanization, agricultural expansion, deforestation, and industrial activities have significantly altered land cover patterns worldwide. These changes have profound implications for biodiversity, ecosystem services, climate regulation, and the overall health of the environment. For instance, the conversion of forests to urban or agricultural areas can lead to habitat destruction, increased greenhouse gas emissions, and reduced water quality [2]. Similarly, uncontrolled urban sprawl often results in the loss of fertile agricultural lands and exacerbates the urban heat island effect [3].

The importance of LULC change detection lies in its ability to provide insights into the spatial and temporal dynamics of land cover transitions. This knowledge is indispensable for effective land management, sustainable development planning, and environmental conservation. By identifying areas undergoing significant change, policymakers and stakeholders can prioritize actions to mitigate adverse impacts and promote sustainable land use practices [4].

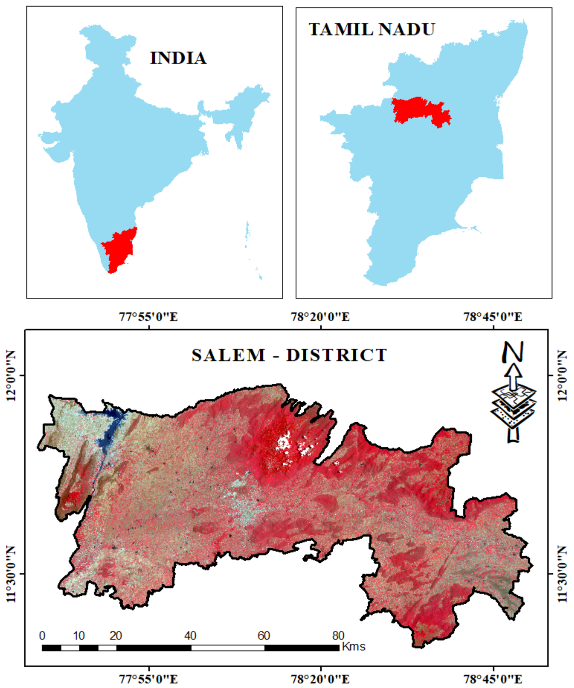
Furthermore, understanding the environmental impacts of LULC changes is crucial for addressing global challenges such as climate change, water scarcity, and food security. Accurate LULC data, coupled with advanced geospatial technologies like remote sensing and Geographic Information Systems (GIS), enables researchers to assess these impacts quantitatively and develop strategies for resilience and adaptation [5].

This study focused on the detection and analysis of LULC changes within the study area, aiming to unravel the underlying drivers and their environmental consequences. By leveraging satellite imagery and modern analytical techniques, the research seeks to contribute valuable insights for sustainable land management and environmental preservation efforts.

Study Area

The Salem District in Tamil Nadu, India's southern state, is significant both geographically and culturally. Situated between latitudes 11°14′ N and 12°53′ N and longitudes 77°44′ E and 78°50′ E, the district spans 5,245 square kilometers (Map - 1). The districts of Dharmapuri to the north, Erode to the west, Namakkal to the south, and Tiruchirappalli to the east encircle Salem. Because of its varied topography which includes plains, hills, and river basins the area is crucial for research on agriculture, industry, and the environment [6].

The Shevaroy and Kalrayan Hills, a part of the Eastern Ghats, dominate the district's landscape. These hills sustain a diverse range of plants and animals, some of which are indigenous, and are crucial in determining the area's microclimate. The main sources of water are the Cauvery River and its tributaries, including the Thirumanimutharu and Sarabanga. Nonetheless, the district is also distinguished by a large number of lakes and seasonal streams, which are crucial for irrigation and the provision of drinking water [7].



Map 1: Study Area Map - Salem District

Literature Review

Land Use Land Cover (LULC) change detection and its environmental impacts have been widely studied to understand the patterns, drivers, and consequences of landscape transformations. Various methodologies, datasets, and tools have been employed globally to assess these changes, leveraging advancements in remote sensing and geospatial technologies. Table -1 below summarizes key studies relevant to LULC change detection and its environmental impacts, providing insights into the themes, findings, and methods used:

Author(s)	Article Title	Theme of the Article	Key Findings
Clark, R., Mitchell, K., & Thompson, L.	The Urban Heat Island Effect and its Implications for Climate Change	Urban heat islands and climate change	LULC changes in urban areas significantly intensify the urban heat island effect, affecting local climates.
Brown, P., Wilson, J., & Adams, M.	Sustainable Land Management in the Face of Rapid Change	Sustainable land management amidst LULC changes	Proposed strategies for balancing LULC changes with sustainable land management practices.

Miller, S., & Green, D.	Advances in Remote Sensing for Environmental Monitoring	Advances in remote sensing technology	Reviewed the use of modern sensors like Sentinel-2 and Landsat for detecting environmental changes.
Anand, M., et al.	Land use dynamics in Salem District: A temporal analysis	Temporal analysis of LULC in Salem District	Documented significant LULC changes in Salem District, driven by urbanization and agricultural expansion.
Vijayakumar, N., et al.	Hydrogeological studies in Salem District, Tamil Nadu	Hydrogeology and LULC changes	Studied the impact of LULC changes on groundwater resources in Salem.
SreelakshmyMThangamani V.	Analysis of land use/land cover and change detection using remote sensing and GIS: A case study	Remote sensing and GIS for LULC change detection	Demonstrated GIS and remote sensing techniques to analyze LULC changes and their environmental impacts.
Thilagavathi, N., Subramani, T, Suresh, M.	LULC change detection analysis in Salem Chalk Hills, South India using remote sensing and GIS	LULC change analysis in Salem Chalk Hills	Identified significant LULC changes in Salem Chalk Hills due to mining and urban expansion.

Table 1: Literature Review

Objective

This study aims to analyze Land Use/Land Cover (LULC) changes over time, focusing on transitions like urbanization, agricultural expansion, and deforestation. It explores the link between LULC changes and pollution sources to assess their environmental impacts, particularly on-air quality. The finding reveals sustainable land management practices to mitigate environmental degradation.

Materials and Methodology

Using multi-source satellite data, this study examines LULC changes and pollution sources over four periods (1995, 2005, 2017, and 2024). Data from 1995 and 2005 included Landsat-5 (30 m and 72 m resampled to 56 m) and IRS 1B (23.5 m), while 2017 and 2024 used Sentinel-2 MSI (10 m) and Sentinel-5P TROPOMI (7 km) is a multispectral sensor that records reflectance of wavelengths important for measuring atmospheric concentrations of ozone, methane, formaldehyde, aerosol, carbon monoxide, nitrogen oxide, and sulfur dioxide for air pollution analysis. Preprocessing included radiometric and geometric corrections, with supervised LULC classification. Correlation analysis identified links between LULC changes and pollution hotspots. Tools like Google Earth Engine, ArcGIS, and QGIS supported analysis and visualization.

Data Sources

This study is dedicated to Land Use and Land Cover Change detection analysis for Salem District. The research was conducted using spatial datasets obtained from the various datasets which are collected from the following sources (Table -2). All spatial datasets were projected into the same coordinate system (WGS-1984), in Meters.

Period	Satellite	Sensor	Spatial Resolution
1995	Landsat - 5 and IRS 1B	Thematic Mapper (TM), Enhanced Thematic Mapper (ETM +), Linear Imaging Self-Scanning Sensor – 1 (LISS I)	30 and 72 m (resampled to 56 m) respectively
2005	Landsat - 5 and Resourcesat	ETM+, LISS III	30 and 23.5 m respectively
2017	Sentinel-2	MultiSpectral Instrument (MSI)	10 m spatial resolution.
2024	Sentinel-2	MultiSpectral Instrument (MSI)	10 m spatial resolution.
2024	Copernicus Sentinel-5P	TROPOMI (Tropospheric Monitoring Instrument)	7 km

Table 2: Satellite Remote Sensing Data used for LULC Mapping and this Study

Landuse and Landcover Classification Parameters

Land Use and Land Cover (LULC) parameters such as water bodies, forests, mining areas, built-up areas, wastelands, barren lands, and croplands are crucial for understanding environmental dynamics and human activities. Monitoring these changes aids in resource management, urban planning, and ecological conservation.

- **Water Bodies**
  Including rivers, lakes, and wetlands. Monitoring helps assess water availability, detect droughts or floods, and manage aquatic ecosystems [8].
- **Forests**
  Essential for carbon sequestration and biodiversity. Monitoring forest cover changes supports deforestation

management and landscape transformation insights [9].

- **Mining Areas**
  Alter land surfaces, leading to environmental degradation. Remote sensing monitors these changes for land reclamation planning [10,11].
- **Built-up Areas**
  Urban developments. Monitoring urban expansion aids in infrastructure planning and urban sprawl management [11].
- **Wastelands and Barren Lands**
  Unproductive areas. Monitoring supports land reclamation and desertification prevention [8].

Croplands

Vital for food production. Monitoring agricultural changes aids in planning, food security, and climate impact assessments [12]. Incorporating these LULC parameters into change detection analyses enhances decision-making for sustainable development and environmental conservation.

Results and Discussion

The analysis of Land Use Land Cover (LULC) changes from 1995 to 2023 (Table - 3) provides valuable insights into the dynamic transformations in land utilization driven by both natural processes and anthropogenic activities [13]. This section presents a detailed examination of the spatial and temporal changes observed in various land cover classes, including water bodies, forests, croplands, built-up areas, barrenlands, wastelands, and mining areas [14]. The findings are critically analyzed to understand the underlying factors influencing these changes, such as urbanization, agricultural expansion, deforestation, conservation efforts, and land reclamation programs [15]. Furthermore, the environmental implications of these changes are discussed to highlight the balance between development and sustainability [16]. This analysis serves as a foundation for proposing effective land management strategies to mitigate adverse impacts and promote sustainable land use practices [17].

LULC 1995

In 1995, the landscape was predominantly covered by cropland, which occupied 2815.268 square kilometers, reflecting the region's agricultural dominance. Forests were the second-largest land cover, spanning 1599.884 square kilometers, showcasing a thriving ecosystem. Water bodies were abundant, covering 145.74 square kilometers, ensuring significant water availability. Mining activities were modest, with only 6.829 square kilometers of land allocated for this purpose. Buildup areas were minimal, occupying 93.963 square kilometers, indicating limited urban development. Barren land accounted for 8.015 square kilometers, while wasteland occupied 575.301 square kilometers, suggesting opportunities for land improvement and reclamation (Map. 2).

LULC 2005

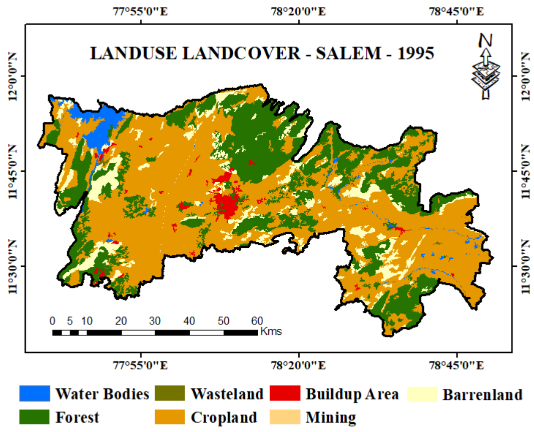
In 2005, noticeable changes occurred in the land use pattern. Water bodies slightly decreased to 139.465 square kilometers, reflecting potential water loss. Forest cover showed a small recovery, increasing to 1617.951 square kilometers, indicating some level of conservation efforts. Cropland experienced a decline, dropping to 2672.482 square kilometers, possibly due to land conversion for other purposes. Mining activities slightly expanded to 2.263 square kilometers, reflecting growing resource extraction. Urbanization began to take shape, with buildup areas increasing to 114.301 square kilometers. Barrenland reduced to 4.664 square kilometers, suggesting improvements in land use. However, the wasteland grew to 693.874 square kilometers, hinting at inefficiencies in land management (Map. 3).

LULC 2017

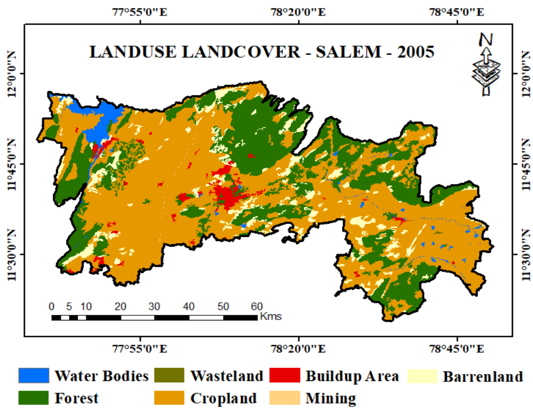
In 2017, Water bodies drastically reduced to 53.586 square kilometers, signaling significant water resource depletion. Forest cover declined sharply to 1132.256 square kilometers, marking a concerning loss of vegetation. Cropland also reduced further to 2455.834 square kilometers, indicating continued pressure on agricultural land. Mining activities nearly halted, covering only 0.22 square kilometers. Urbanization accelerated, with buildup areas expanding significantly to 815.392 square kilometers. Barrenland increased slightly to 5.194 square kilometers, while wasteland reached a peak of 782.518 square kilometers, highlighting increased land degradation (Map. 4).

LULC 2024

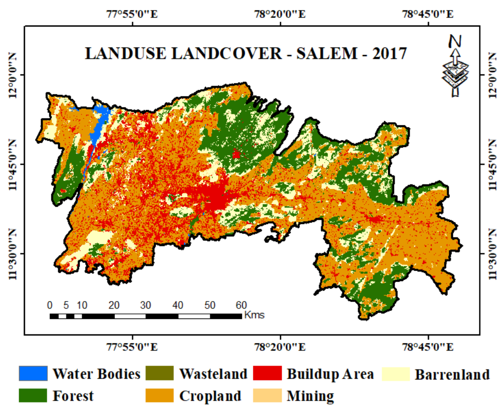
In 2024, there were signs of recovery in several land cover categories. Water bodies rebounded to 132.522 square kilometers, likely due to improved water resource management. Forest cover also showed significant recovery, increasing to 1475.607 square kilometers, reflecting successful reforestation or conservation efforts. However, cropland continued its decline, covering 2241.001 square kilometers, indicating ongoing conversion of agricultural land for other purposes. Mining activities slightly expanded to 0.632 square kilometers, suggesting controlled and sustainable operations. Urban areas continued to grow rapidly, with buildup areas now covering 1094.665 square kilometers, reflecting increased development. Barren land was reduced to 2.042 square kilometers, while wasteland decreased significantly to 298.531 square kilometers, indicating successful land reclamation initiatives (Map. 5).



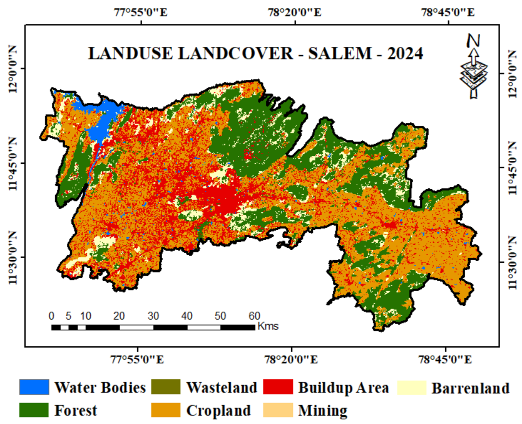
Map 2: Land use Landcover of Salem – 1995



Map 3: Land use Landcover of Salem – 2005



Map 4: Land use Landcover of Salem – 2017



Map 5: Land use Landcover of Salem – 2024

Classes	1995	2005	2017	2024
Water Bodies	145.74	139.465	53.586	132.522
Forest	1599.884	1617.951	1132.256	1475.607
Mining Area	6.829	2.263	0.22	0.632
Cropland	2815.268	2672.482	2455.834	2241.001
Buildup Area	93.963	114.301	815.392	1094.665
Barren land	8.015	4.664	5.194	2.042
Wasteland	575.301	693.874	782.518	298.531
TOTAL	5245	5245	5245	5245

Table 3: Land use and Landcover Area in Sq Km over the Period from 1995 to 2024

Accuracy Assessment - 2024

The accuracy of the Land Use Land Cover (LULC) classification for Salem District in 2024 was assessed using ground verification and reference data in Google Earth Engine Pro. A confusion matrix was created to compare the classified LULC map with reference data for seven classes: C_1, C_2, C_3, C_4, C_5, C_6, and C_7 with 50 samples in total (Table - 4). All classes achieved 100% producer's and user's accuracy. The overall accuracy was 100%, and the kappa coefficient was 1, indicating perfect agreement between the classification and reference data. This ensures the classification results are reliable for environmental planning and resource management.

Class	Reference Samples	Correctly Classified Samples	Producer's Accuracy	User's Accuracy
C_1	3	3	100 %	100 %
C_2	13	13	100 %	100 %
C_3	2	2	100 %	100 %
C_4	2	2	100 %	100 %
C_5	8	8	100 %	100 %
C_6	15	15	100 %	100 %
C_7	7	7	100 %	100 %

Table 4: Classification Accuracy Results

The Land Use Land Cover (LULC) classification for the Salem District was evaluated for accuracy using ground verification and reference data within Google Earth Engine Pro. This cloud-based platform facilitated precise assessment by leveraging high-resolution satellite imagery. The accuracy assessment ensures that the classification results are reliable for environmental planning and resource management in the region.

LULC Change Detection Analysis

Land Use Land Cover (LULC) patterns over the years from 1995 to 2024 exhibit significant changes due to urbanization, agricultural expansion, deforestation, and conservation efforts. This detailed change detection analysis highlights the transformation of key land cover classes (Table - 5; Chart - 1).

Water Bodies

Water bodies showed a significant decline from 145.74 square kilometers in 1995 to a low of 53.586 square kilometers in 2017, reflecting substantial water resource depletion. This may have resulted from increasing water demands, urban encroachment, and climatic factors. However, by 2024, water bodies recovered to 132.522 square kilometers, likely due to improved water management practices, restoration projects, and awareness of the critical importance of preserving water resources. This resurgence emphasizes the impact of conservation measures.

Forest Cover

Forest cover exhibited a concerning trend of decline, reducing from 1599.884 square kilometers in 1995 to 1132.256 square kilometers in 2017. This 467.628 square kilometers loss can be attributed to deforestation, agricultural land expansion, and urban growth. Encouragingly, forest cover recovered to 1475.607 square kilometers by 2024, possibly due to reforestation initiatives, stricter forest conservation laws, and environmental awareness campaigns. However, the cumulative loss of 124.277 square kilometers since 1995 highlights the long-term effects of human activity.

Cropland

Cropland, which dominated the landscape in 1995 with 2815.268 square kilometers, has been steadily declining over the years. By 2005, it decreased to 2672.482 square kilometers, and further to 2241.001 square kilometers in 2024, marking a total loss of 574.267 square kilometers. This decline reflects the conversion of agricultural land to urban and industrial uses, as well as possible land degradation. The reduced area of cropland highlights the pressing need for sustainable agriculture and efficient land-use policies.

Buildup Areas

Urbanization has been the most dynamic factor in land-use change. Buildup areas increased dramatically from just 93.963 square kilometers in 1995 to 1094.665 square kilometers in 2024. This nearly 11-fold increase reflects rapid urban and infrastructural development to accommodate growing populations and industrialization. Urban sprawl has encroached upon agricultural land, forests, and even water bodies, necessitating the adoption of sustainable urban planning to minimize environmental impacts.

Mining Areas

Mining areas fluctuated modestly over the years. In 1995, 6.829 square kilometers were devoted to mining activities, which decreased to 0.22 square kilometers by 2017, indicating a reduction of mining operations. By 2024, this area slightly increased to 0.632 square kilometers, reflecting controlled and possibly sustainable mining practices. The overall decrease from 1995 suggests a shift toward environmental protection or a reduction in local resource extraction activities.

Barren Land

Barren land exhibited an overall reduction, declining from 8.015 square kilometers in 1995 to 2.042 square kilometers in 2024. The decrease highlights efforts to rehabilitate degraded land and convert it into productive use. The fluctuations over the years, including a slight increase in 2017, indicate localized environmental stress but also show improvement in land management.

Wasteland

Wasteland fluctuated significantly, rising from 575.301 square kilometers in 1995 to 782.518 square kilometers in 2017, before dramatically decreasing to 298.531 square kilometers by 2024. This increase and subsequent decline reflect the cycles of land degradation and reclamation efforts. The substantial reduction in wasteland in recent years suggests the successful implementation of policies to restore degraded land for productive use purposes.

Classes	**1995**	**%**	**2024**	**%**	**− Area**	**%**
Water Bodies	145.74	2.7	132.522	2.5	13.218	0.2
Forest	1599.884	30.7	1475.607	28.1	124.277	2.6
Mining Area	6.829	0.1	0.632	0.01	6.197	0.09
Cropland	2815.268	53.6	2241.001	42.9	574.267	10.7
Buildup Area	93.963	1.9	1094.665	20.8	1000.702	18.9
Barren land	8.015	0.1	2.042	0.03	5.973	0.07
Wasteland	575.301	10.9	298.531	5.6	276.77	5.3
TOTAL	5245	100	5245	100	0	0

Table 5: Area of Change Detection Analysis

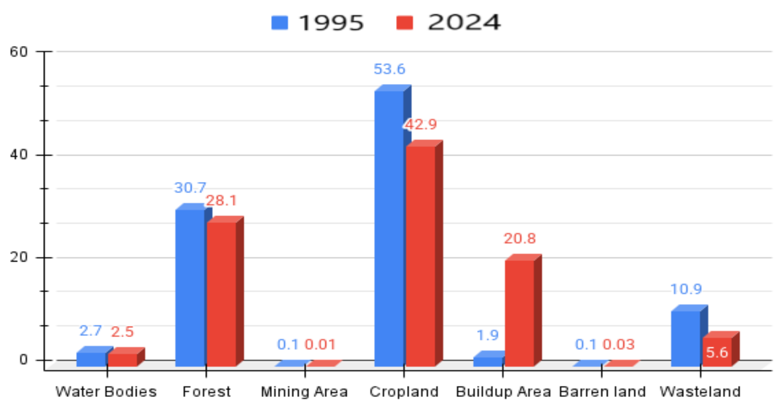


Chart 1: Changes from the Year 1995 to 2024

Air Pollution Status of Salem District

Air pollution in Salem District, Tamil Nadu, can be influenced by various factors such as industrial activities, vehicular emissions, and urbanization. Salem is known for its steel and textile industries, which significantly contribute to particulate matter (PM2.5 and PM10) or (AAI) and other pollutants like sulfur dioxide (SO_2), nitrogen oxides (NO_x), and carbon monoxide (CO).

Absorbing Aerosol Index (AAI)

In 2024, Salem City exhibited significantly elevated Absorbing Aerosols Index (AAI) levels, primarily from vehicular emissions, industrial activities, and urban sources, making the city center a pollution hotspot. In contrast, rural areas like Yercaud and the reserved forests maintain low AAI levels due to minimal human activity and abundant greenery. This disparity highlights the uneven distribution of pollution across the district. These activities contribute to an abundance of dust particles and other aerosols in the atmosphere, significantly impacting air quality. In contrast, the boundary regions of Salem District, including Yercaud, Jarugumalai Reserved Forest, Kalvarayan Hills, Kanjamalai Reserved Forest, Palamalai Hills, and Pakkanadu Reserved Forest, exhibit very low AAI levels. These areas are characterized by minimal vehicular activity and abundant greenery, which helps in maintaining lower pollution levels. The stark contrast between the urban core and the rural boundaries highlights the uneven distribution of pollution within the district (Map - 6). High AAI levels in Salem City pose health risks, including respiratory and cardiovascular issues, particularly among vulnerable groups. Fine particulate matter (PM2.5) from aerosols contributes to reduced lung function and increased hospital admissions for respiratory ailments. Environmentally, aerosols contribute to urban heat islands, reduced visibility, altered rainfall patterns, and diminished agricultural productivity.

Land Use Land Cover (LULC) changes strongly correlate with these pollution trends. Rapid urbanization and industrial growth have intensified emissions and reduced green cover, increasing aerosol levels. While rural practices minimally impact AAI, shifts like mechanization or residue burning could exacerbate pollution.

Nitrogen Dioxide (NO_2)

Nitrogen Dioxide (NO_2) levels in Salem District are mostly low, with 90% of the area experiencing minimal pollution. However, urbanized regions like Salem City show low to moderate levels due to vehicular emissions, industrial activities, and urbanization. The Mettur area, particularly around the Mettur Reservoir, is a significant hotspot with high NO_2 concentrations attributed to emissions from the Mettur Thermal Power Plant. This area, with its dense NO_2 levels, can be metaphorically referred to as the "Owl Eye of NO_2" due to its distinctive pattern on pollution maps (Map - 7).

Primary NO_2 sources include thermal power plants, vehicles, industries, domestic heating, and waste burning. NO_2 pollution causes acid rain, ground-level ozone, and ecosystem disruption, harming soil, crops, air quality, and health, particularly in vulnerable groups. Health impacts are also severe, as prolonged exposure to NO_2 irritates the respiratory tract, reduces lung function, and increases susceptibility to respiratory infections like bronchitis and pneumonia. Urban expansion and deforestation exacerbate pollution by reducing vegetation that absorbs NO_2. Effective LULC management, including afforestation, green belt development, cleaner energy, and public awareness, is crucial to mitigate NO_2 pollution and its impacts. While most of the Salem District has low pollution levels, hotspots like Mettur require urgent attention to ensure sustainable development and improved quality of life.

Sulfur Dioxide (SO_2)

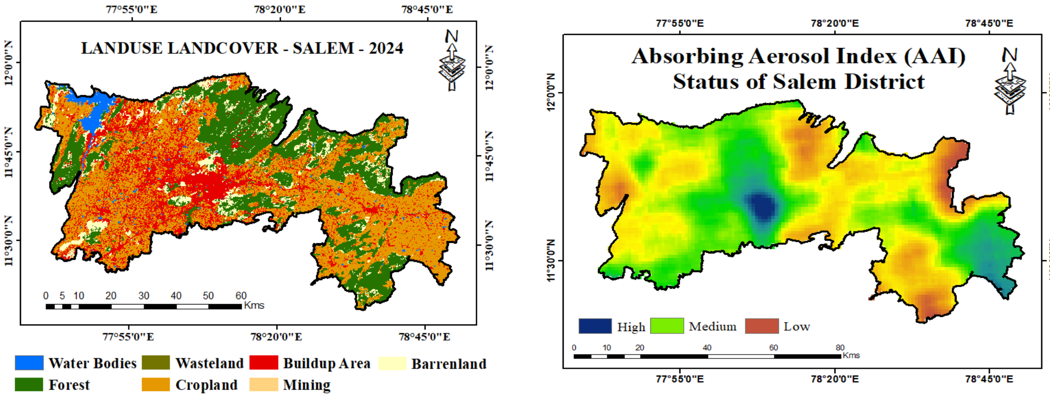
Sulfur Dioxide (SO_2) pollution in Salem District is increasing due to industrial activities, especially from factories, power plants, and transportation. Central and industrial areas, particularly around manufacturing zones, show higher SO_2 emissions, directly linked to industrial production and vehicle exhausts. Short-term exposure to high concentrations of sulfur dioxide can cause respiratory problems such as coughing, shortness of breath, and irritation of the throat and eyes. Long-term exposure has more severe implications, including chronic respiratory diseases, aggravation of asthma, and potential cardiovascular issues. Vulnerable populations, including children, the elderly, and those with pre-existing health conditions, are particularly at risk. SO_2 also contributes to acid rain, harming human health, crops, water bodies, and soil. Industrialization, urbanization, and land conversion have worsened the pollution, while areas with natural vegetation, like Yercaud hills, have lower SO_2 levels. Sustainable land management and regulation of industrial emissions are key to mitigating SO_2's impact on health and the environment. Understanding the link between land use changes and SO_2 pollution is essential for balanced policy development. However, the central and industrial areas of Salem, particularly around manufacturing zones, show higher concentrations of SO_2 emissions. These industrial hotspots have been identified as the primary sources of sulfur dioxide pollution, with emissions directly correlated to the scale of industrial production and vehicle exhausts (Map - 8).

Carbon Monoxide (CO)

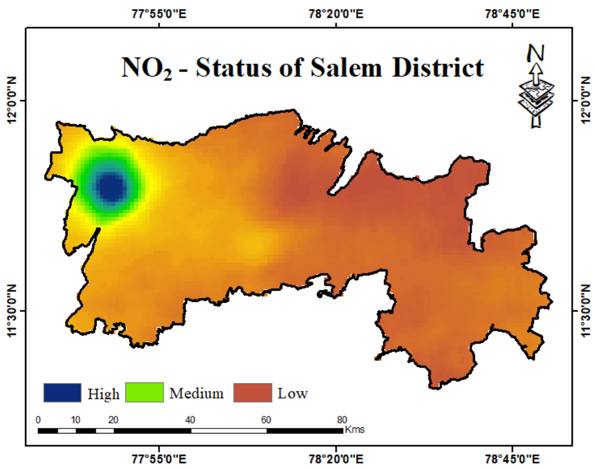
Carbon Monoxide (CO) pollution in Salem District is notably high in areas with heavy vehicle traffic, with significant concentrations observed in urban and transport corridors. As illustrated in the air quality data, CO levels tend to rise considerably in areas with dense transportation networks. The Bengaluru Main Road, a major thoroughfare, is one of the most polluted regions in terms of CO emissions. Other high-traffic areas of Salem District also show elevated CO concentrations, with emissions ranging from high to medium. This is primarily due to the heavy usage of vehicles, which contribute significantly to the increase in CO levels. In contrast, the hilly areas of Yercaud, Kalvarayan Hills, and Jarugumalai, where transportation infrastructure is limited, exhibit very low levels of CO pollution (Map - 9). The health impacts of high CO concentrations are concerning. CO is a colorless, odorless gas that, when inhaled, binds to hemoglobin in the blood, reducing the oxygen-carrying capacity. This can lead to symptoms such as dizziness, headaches, and shortness of breath. Prolonged exposure to elevated CO levels can cause more severe health issues, including heart disease and neurological problems. Vulnerable groups, such as children, the elderly, and those with pre-existing respiratory or cardiovascular conditions, are particularly at risk. The pollution also contributes to the degradation of air quality, which can exacerbate respiratory issues and lead to long-term health problems for the general population. This highlights the impact of LULC changes on CO pollution in the district. Sustainable urban planning, including the reduction of vehicle emissions, the development of eco-friendly transportation systems. By understanding the connection between LULC changes and CO emissions, policies can be formulated to reduce pollution and improve air quality, thus safeguarding public health and the environment in Salem District.

Ozone (O_3)

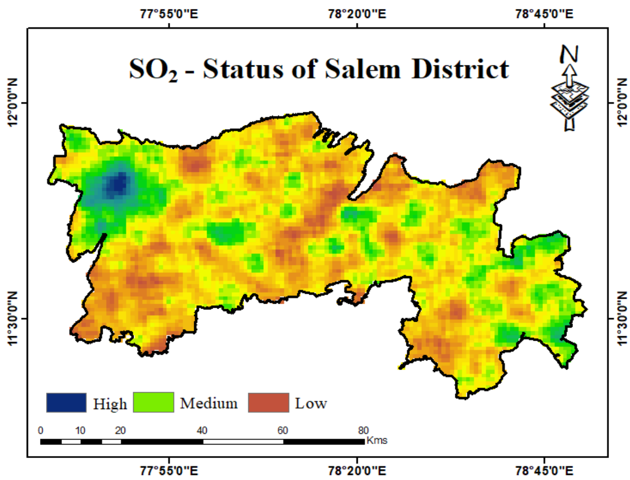
Ozone (O_3) is a secondary pollutant formed when sunlight reacts with nitrogen oxides (NO_x) and volatile organic compounds (VOCs) from vehicles, industries, and power plants. In Salem District, ozone levels are rising, especially in urban and industrial areas, due to vehicle emissions, industrial activities, and high temperatures. Ozone concentrations peak during warmer months. Areas near industrial zones and heavy traffic show high ozone levels, while rural regions like Yercaud and Kalvarayan Hills have lower levels due to minimal human activity and traffic (Map - 10). Ground-level ozone can cause respiratory issues, worsen chronic diseases, and damage crops and ecosystems. Urbanization and industrialization in Salem are linked to rising ozone pollution, with more land converted for development, and increasing emissions of ozone precursors. Conversely, areas with natural landscapes like Yercaud act as buffers, reducing ozone pollution.



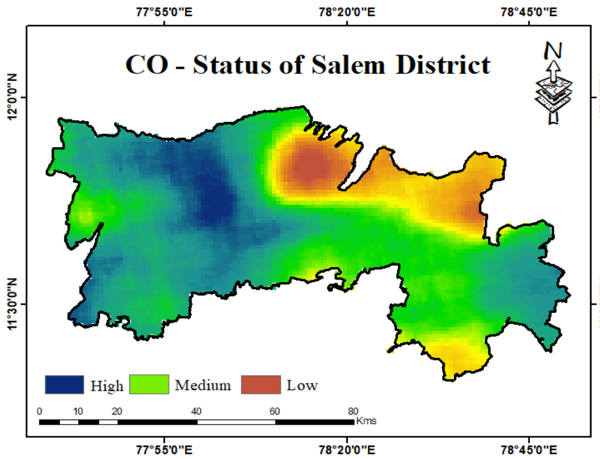
Map 6: AAI Status of Salem District



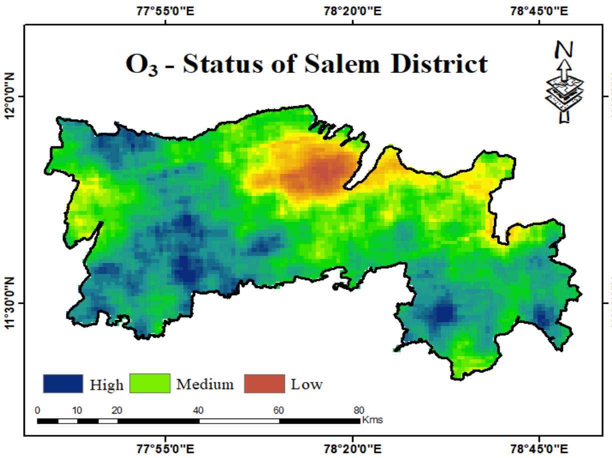
Map 7: NO_2 Status of Salem District



Map 8: SO_2 Status of Salem District



Map 9: CO Status of Salem District



Map 10: O_3 Status of Salem District

Conclusion

The comprehensive analysis of Land Use and Land Cover (LULC) changes in Salem District from 1995 to 2024 reveals significant transformations driven by urbanization, agricultural activities, and conservation efforts. The findings highlight a drastic increase in urban areas, accompanied by a decline in forest cover and cropland. However, the observed recovery in water bodies and forests in recent years underscores the potential of targeted conservation strategies and sustainable resource management.

The study also establishes a clear link between LULC changes and air pollution, emphasizing the role of urban and industrial expansion in exacerbating air quality issues. The spatial analysis of pollution hotspots demonstrates the urgent need for integrated land use planning to mitigate the adverse environmental impacts of rapid development. To ensure long-term environmental sustainability in Salem District, it is imperative to adopt a balanced approach that promotes urban and economic growth while safeguarding natural resources. This includes implementing strict pollution control measures, enhancing green cover, and fostering community participation in land management practices. The insights this research provides can guide policymakers, urban planners, and environmentalists in formulating strategies to achieve sustainable development goals in the region.

Author’s Contributions

Mohammed Junaid. S: Conceptualization, methodology, data analysis, writing original draft preparation, and visualization. Ilaiyarasan. M: critical review, and editing of the manuscript. Both authors have read and approved the final manuscript and agree to be accountable for all aspects of the work to ensure that questions related to the accuracy or integrity of any part of the research are appropriately investigated and resolved.

Conflict of Interest

There is no conflict of interest for the authors

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