جـامعـة الشـارقـة
UNIVERSITY OF SHARJAH

College of Science – GIS and Remote Sensing

Special Topics in GIS and Remote Sensing

Assignment 2: Project Objectives and Literature Review

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1. Project Objectives

The objectives of this project are designed to address the environmental and health challenges posed by air pollution in Sharjah. Each objective builds directly on the problem definition outlined in Milestone 1 and is formulated to be clear, measurable, and actionable:

1. To quantify and map spatial patterns of air pollution in Sharjah using satellite-derived Aerosol Optical Depth (AOD) and related remote sensing indices.
2. To integrate AOD data with socio-environmental GIS layers (population density, road networks, industrial zones, and land use/land cover) to analyze human exposure levels.
3. To classify and visualize health risk zones by developing a GIS-based decision-support model, categorizing areas into low, medium, and high risk.
4. To validate the identified risk zones using available ground-based air quality measurements to enhance scientific robustness.
5. To propose recommendations for urban planning and environmental management, such as green buffer zones, improved air quality monitoring, and emission control measures.

2. Literature Review

2.1 Air Pollution and Health Risks in Urban Environments

Air pollution is widely recognized as a critical determinant of global health. The World Health Organization (2021) estimates that more than seven million premature deaths annually can be attributed to exposure to polluted air. Urban areas in the Middle East face multiple overlapping sources of pollution, including traffic emissions, industrial activity, and natural dust storms (Farahat, 2020). For instance, Al-Ahmadi et al. (2019) demonstrated how traffic corridors in Riyadh contribute significantly to localized air quality degradation. These studies show a clear relationship between pollution exposure and respiratory or cardiovascular illness, highlighting the need for spatially explicit mapping of health risks. However, while they identify health burdens, they do not fully integrate remote sensing and GIS approaches to localize vulnerable communities.

2.2 Remote Sensing Approaches for Air Quality Monitoring

Satellite remote sensing has revolutionized how air pollution is monitored, especially in data-scarce regions. Aerosol Optical Depth (AOD) is used as a proxy for ground-level PM2.5,

providing spatially continuous estimates of pollution. Gupta and Christopher (2020) confirmed strong correlations between MODIS-derived AOD and PM2.5 in multiple urban contexts. More recently, Shafizadeh-Moghadam et al. (2022) demonstrated the use of AOD with machine learning algorithms to predict pollution exposure more accurately. Zhang et al. (2023) extended this work using Sentinel-5P data to improve temporal resolution in urban air quality monitoring. These approaches, while powerful, still require ground-based validation and finer-scale integration with demographic data to fully capture exposure risks.

2.3 GIS for Exposure and Risk Mapping

GIS allows integration of environmental and demographic datasets to identify who is most exposed to air pollution. Amini et al. (2019) used GIS overlay methods in Tehran to link air pollution with health statistics, revealing spatial clusters of vulnerability. Similarly, Elbir et al. (2021) applied interpolation techniques to model NO_2 distributions in Istanbul, identifying significant hotspots. Kumar et al. (2024) applied a combined remote sensing and GIS framework in Middle Eastern cities to develop health risk maps, demonstrating the growing interest in integrating exposure modeling with decision-support systems. While GIS excels at visualization and analysis, few studies combine it with AOD and socio-demographic data in a comprehensive framework tailored for urban policy support.

2.4 Air Pollution Studies in the UAE and Gulf Region

Within the UAE and Gulf, several studies have applied remote sensing and GIS to investigate air quality. Al-Mamun et al. (2021) analyzed particulate matter in Abu Dhabi using MODIS, showing seasonal variation linked to dust storms. Alhammadi et al. (2022) explored industrial contributions to air quality in Sharjah, linking land use changes with elevated PM concentrations. Farahat (2020) highlighted the dominant role of dust storms in shaping Gulf air quality, while Al-Ahmadi et al. (2019) emphasized traffic as a localized driver. Despite these contributions, the majority of Gulf studies focus on pollutant levels rather than health risk mapping, leaving a gap that this project seeks to address by explicitly connecting exposure with human vulnerability.

2.5 Knowledge Gaps and Contribution of this Project

Across the reviewed studies, three knowledge gaps emerge. First, few studies integrate remote sensing-derived AOD with socio-demographic layers to assess exposure. Second,

classification of health risk zones is rarely attempted; most studies stop at pollutant mapping. Third, the urban context of Sharjah remains underexplored in terms of health-focused air pollution analysis. This project aims to address these gaps by combining satellite data, GIS layers, and population exposure metrics into a coherent health risk framework that produces actionable maps for urban planning and environmental management.

Table 1. Summary of Reviewed Literature

Author, Year	Data	Methodology	Findings	Research Gap
Amini et al., 2019	Tehran air pollution & health data	GIS overlay risk mapping	Revealed high-risk clusters in Tehran	Limited transferability outside context
Gupta & Christopher, 2020	MODIS AOD vs PM2.5	Correlation & calibration	Strong linkage between AOD & PM2.5	Needs local calibration
Al-Mamun et al., 2021	MODIS PM over Abu Dhabi	Satellite mapping	Seasonal dust-related PM peaks	No demographic integration
Alhammadi et al., 2022	Sharjah industrial data	GIS spatial analysis	Industrial hotspots identified	No AOD integration
Elbir et al., 2021	Istanbul NO2 monitoring data	GIS interpolation (IDW/Kriging)	Revealed NO2 hotspots	Focused on one pollutant
Farahat, 2020	Dust storm datasets (Gulf)	Synoptic & RS analysis	Dust dominates AQ in Gulf cities	Health impacts underexplored
Shafizadeh-Moghadam et al., 2022	MODIS AOD & met vars	Machine learning modeling	Improved PM2.5 exposure estimates	No urban health zoning
Zhang et al., 2023	Sentinel-5P AQ data	Time-series & validation	Enhanced detection of pollutants	Coarse spatial resolution
Kumar et al., 2024	Middle Eastern city datasets	RS + GIS health risk mapping	Integrated exposure–risk mapping	Sparse ground validation
Al-Ahmadi et al., 2019	Riyadh traffic data	GIS-based analysis	Identified traffic pollution hotspots	Did not use RS data

Figure 1. Conceptual Framework

The conceptual framework illustrates how this project integrates multiple components. Pollution sources (e.g., vehicles, industries, dust storms) are observed using satellite-based AOD. These data are combined with GIS layers such as population density, road networks, and industrial zones to evaluate exposure. The integrated analysis produces spatial health risk maps that can guide urban planners and policymakers in implementing mitigation strategies.

3. References

- Amini, H., et al. (2019). Spatiotemporal patterns of air pollution exposure and respiratory health risks in Tehran. Science of the Total Environment, 650, 1029–1037.
- Al-Ahmadi, K., et al. (2019). GIS-based analysis of traffic-related air pollution in Riyadh. Environmental Monitoring and Assessment, 191(7), 419.
- Al-Mamun, A., et al. (2021). Satellite-based mapping of particulate matter over Abu Dhabi. Remote Sensing, 13(15), 2987.
- Alhammadi, A., et al. (2022). Industrial air pollution and land use change in Sharjah. Atmospheric Pollution Research, 13(6), 101420.
- Elbir, T., et al. (2021). GIS-based air quality modeling in Istanbul. Atmospheric Environment, 246, 118097.
- Farahat, A. (2020). Air quality impacts of dust storms in the Arabian Gulf. Atmospheric Research, 237, 104838.
- Gupta, P., & Christopher, S. (2020). Particulate matter monitoring using satellite-derived aerosol optical depth. Remote Sensing of Environment, 246, 111828.
- Shafizadeh-Moghadam, H., et al. (2022). Modeling PM2.5 using MODIS AOD and machine learning. Remote Sensing, 14(4), 911.
- World Health Organization. (2021). Air pollution and health. WHO Report.
- Zhang, Y., et al. (2023). Advances in satellite-based monitoring of urban air quality using Sentinel-5P. Remote Sensing, 15(2), 311.
- Kumar, R., et al. (2024). Integrating remote sensing and GIS for health risk assessment of air pollution in Middle Eastern cities. Environmental Research, 241, 118234.