

## GIS-based air pollution distribution mapping of emissions from public buses for Coimbatore Corporation, Tamil Nadu, India

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Vehicle transport on roads is a dominant source of air pollution, and hence spatial assessment of its risks is necessary for the decision makers to evaluate its impact on the public. Indian road transport, especially buses, contribute significantly to air pollution, that too in highly accessible areas like bus stands and bus stops. This paper proposes a three-step integrated method to map relative pollution levels of bus stops and bus routes of Coimbatore Corporation using spatial analysis tools of ArcGIS and suggestion of routes for eco-friendly buses and vehicles.

**[Keywords:** GIS; Air pollution; Public transport; Bus; Eco-friendly vehicles; Coimbatore Corporation]

### Introduction

A balanced public transport system is the key to sustainable development of any city, which should be free from pollution. Traffic congestion and environmental pollution due to transportation are identified as critical problems in many countries, especially in the developing countries<sup>1</sup>. Among all types of transportation; road transport is the major contributor to air pollution. The road transport sector has contributed 94.5% of total transport emission<sup>2</sup>.

Infrastructure planning of transport according to public use needs environmental impact assessment study for a better highway route<sup>3</sup>. Preventing pollution and rehabilitating already polluted air, and thus restoring the environment to its original natural state requires many activities.

In addition to having appropriate knowledge about the state of the situation, including emission of pollutants, emitters, distribution of contaminants in the atmosphere, their reactions and climatic conditions, it is necessary to develop an appropriate strategy for environment protection<sup>4</sup>.

GIS is the latest technology for managing and processing locational and related information<sup>5</sup>. Integrating GIS in transportation applications makes it easy to handle and manage spatial and non-spatial data in a wide range of problem solving and decision making activities<sup>6</sup>.

Road journeys take place at times of relatively high air pollution, during peak traffic flow<sup>7</sup>. We developed an appropriate methodology to reduce the impact of air pollution and applied it to the case of the Coimbatore Corporation (Tamil Nadu, India). Coimbatore is one among the Smart City projects of India, with a focus on reduction of pollution. This study is expected to be useful for the decision makers to plan for a sustainable environment.

### Study area

Coimbatore Corporation, a part of Coimbatore district with a population of 1,050,721 as per 2011 census, is located in the western part of Tamil Nadu, India. Figure 1 shows the boundary lying between 10.91° and 11.10° north latitude and 76.85° and 77.06° east longitude with an area of 250 km<sup>2</sup>.

Coimbatore is a hub for textile and automobile parts manufacturers and has excellent industrial growth, and lately it is also growing as a hub of software industries<sup>8,9</sup>. Though Coimbatore is connected well with various parts of the country through air, rail and road network, within city boundary, the only mode of transport available is through roads. The Tamil Nadu State Transport Corporation Limited run by the state government caters to this need by maintaining a public bus service, which was established in the year 1972 and has 1329 buses under its control with 300 routes within the Corporation.

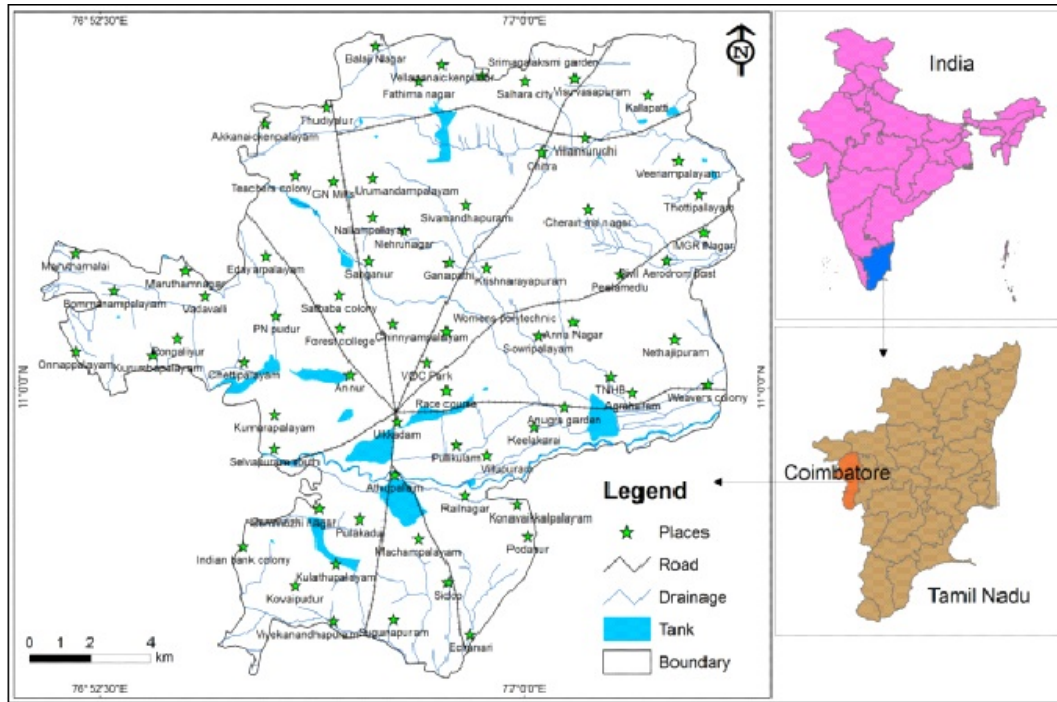


Fig. 1 — Study area

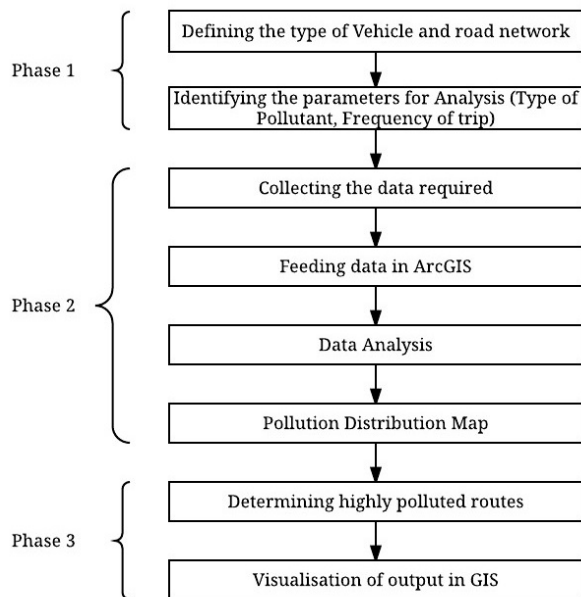


Fig. 2 — Methodology

**Materials and Methods**

The route identification for the eco-friendly city was carried out in multilevel steps (Figure 2). The data regarding the public buses run by the transport corporation alone is considered. The study area at present has 193 bus stops within its boundary. It is evident that impact of the emissions from existing petrol and diesel engine vehicles will be on the

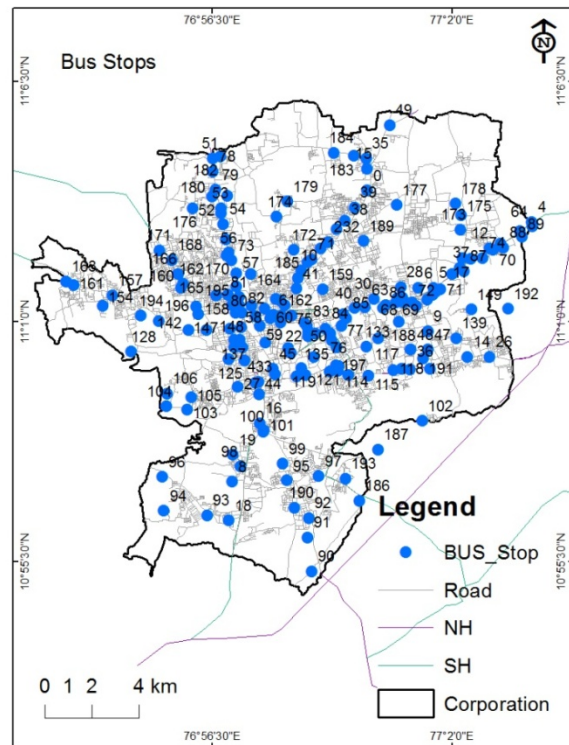


Fig. 3 — Bus stop map of Coimbatore Corporation

existing bus routes and bus stops. The data on the present bus stop location and eco-unfriendly routes was digitized using ArcGIS 10.3. Figure 3 shows the GPS data on bus stops. We have ignored the age of

the buses and assumed all the buses emit equal emissions since the bus allocation process is dynamic. The frequency of buses operated in a route is proportional to its rate at the bus stop, which was generated based on the data collected and fed into GIS platform to get the bus stop frequency map (Figure 4).

From the bus schedule information that was collected and using kernel density estimator, the relative pollution impact map of the study area was prepared and possible eco-friendly routes suggested and visualized. As for cost-effective factors, it is necessary to check whether road plans are reasonable concerning the economic benefits of investments<sup>10</sup>. So it is clear that not all routes can be made eco-friendly at one stretch by replacing the existing system of diesel vehicles since considerable capital investment is required. Therefore, the authority needs to prioritize routes so that gradually the routes can be converted in the forthcoming decade. For this, spatial information of relative pollution distribution will be useful for impact assessment, which was carried out using point data analysis. Using kernel density estimation to investigate the spatial clustering is not new; previous work suggests it to be a successful spatial clustering method<sup>11</sup>. The kernel density estimator tool of ArcGIS software is used to generate relative pollution distribution map based on the bus transportation data.

Kernel density estimation involves placing a proportional surface over each point and then

evaluating the distance from the point to a source location based on an analytical function and then adding the value for all surfaces for that source location<sup>12</sup>. The method is repeated for succeeding points, which thus allows placing a kernel over each observation, and adding these individual kernels gives a smooth and continuous surface (Figure 5). From the relative pollution distribution map, highly polluted routes were extracted (Figure 6). The analysis reveals that the severity due to pollution was found to be

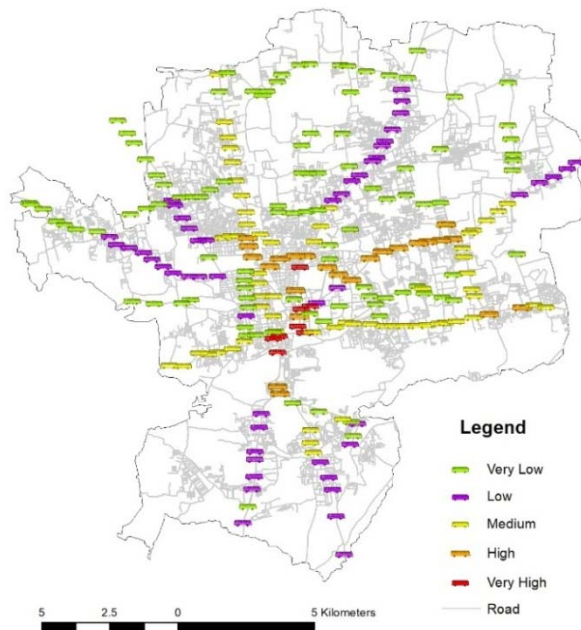


Fig. 4 — Bus stop frequency map of study area



Fig. 5 — Relative pollution distribution map

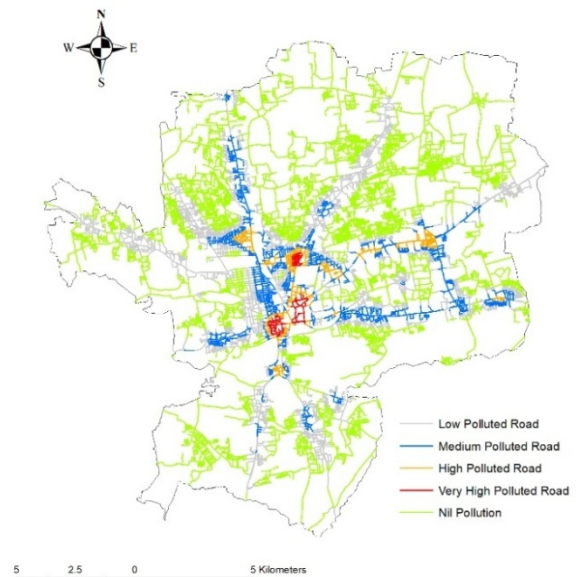


Fig. 6 — Highly polluted route map



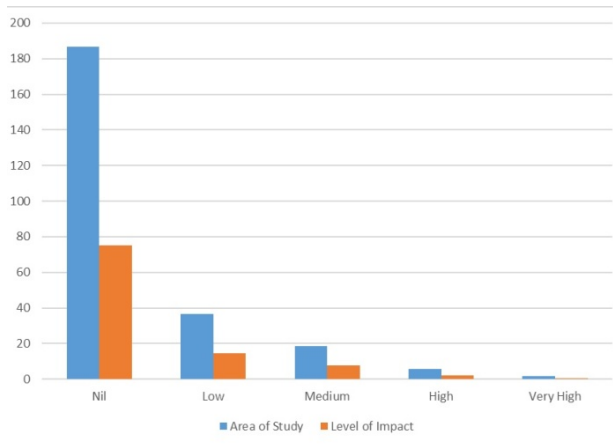


Fig. 7 — Impact on total study area

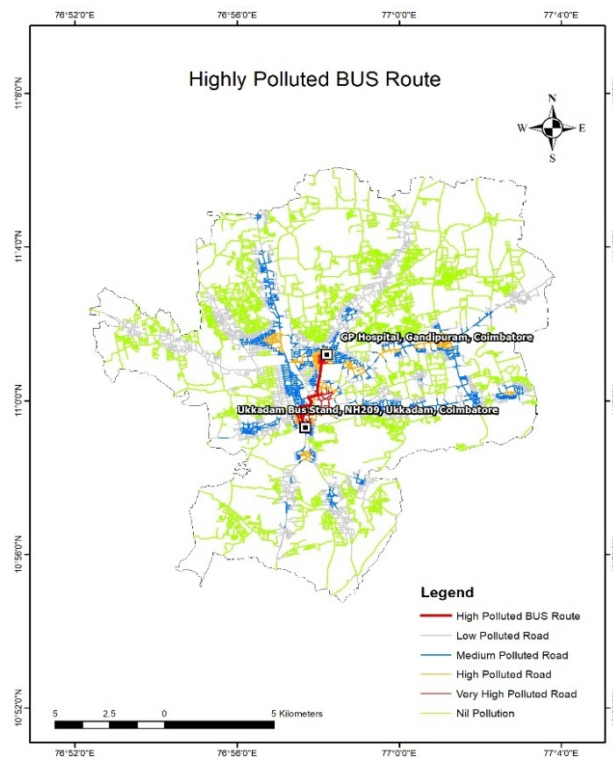


Fig. 8 — Suggested eco-friendly Route 1

negligible on the total study area with less than 1% area affected severely (Figure 7). However, it is also noteworthy that all together the bus transport affects 24% of the total study area.

**Conclusion and Suggestions**

The bus stops were identified from the final analysis and categorized from low to very high-polluted zones. A very high label in the output indicates bus stops that are most vulnerable to pollution. Those bus stops are connected to get the highly polluted route. In the present analysis, we get

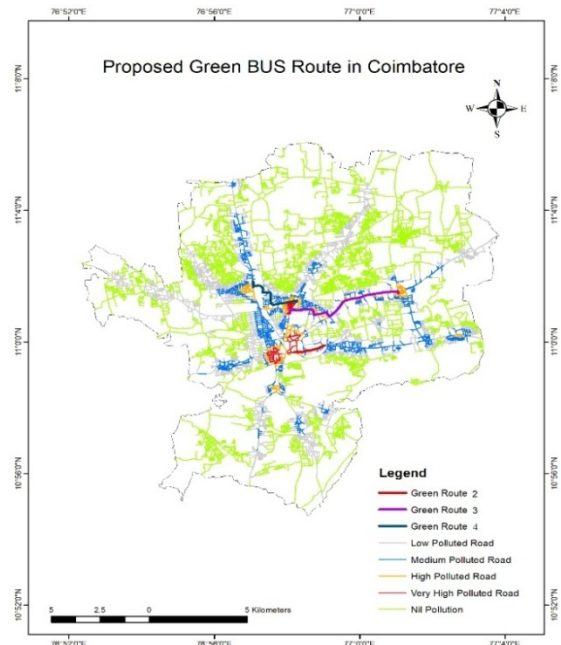


Fig. 9 — Suggested eco-friendly Routes 2, 3 and 4

the route connecting Ukkadam bus stand and Gandhipuram bus stand extended till GP hospital signal bus stop as shown in Figure 8 (which includes 13 bus stops) as the most vulnerable route that should be accorded prime importance for sustainability.

The next category is the high impact zone shown in Figure 9, which contains three routes: Saibaba kovil bus stop to GP Signal bus stop, Gandhipuram bus stand to Hopes bus stop, and Sungam bus stop to Railway station bus stop. So to avoid the air pollution impact in future, it is recommended to plan for eco-friendly vehicles in the above-said routes immediately. The remaining routes though being eco-unfriendly can be replaced with eco-friendly vehicles in future.

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