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Urban Roads of Bhopal City

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***Abstract*—**Quality evaluation of urban environment is an integral part of efficient urban environment planning and management. The development of fuzzy set theory (FST) and the introduction of FST to the urban study field attempts to incorporate the gradual variation and avoid loss of information. Urban environmental quality assessment pertain to interpretation and forecast of the urban environmental quality according to the national regulation about the permitted content of contamination for the sake of protecting human health and subsistence environment . A strategic motor vehicle control strategy has to be proposed to mitigate the air pollution in the city. There is no well defined guideline for the assessment of urban air pollution and no systematic study has been reported so far for Indian cities. The methodology adopted may be useful in similar cities of India. Remote sensing & GIS can play significant role in mapping air pollution.

***Keywords*—**GIS, Pollution, Remote Sensing, Urban.

I. Introduction

ACCORDING to the Indian Air Amendment Act of 1987, air pollution is a term used to describe any unwanted chemicals or other materials that contaminate the air that we breathe resulting in the degradation of air quality. Air pollutants occur both outdoors and indoors, and can be natural or man-made. Outdoor air pollution is sometimes called as ambient air pollution, occurs in both urban and rural areas. air pollutants from man-made activities include nitrogen oxides, carbon monoxide, sulphur dioxide, hydrocarbons and particulate matter. All these pollutants are called primary pollutants because they are emitted directly into the atmosphere. Common sources of these primary pollutants include power station and industrial plants (sulphur dioxide), and road transport (carbon monoxide, particulate matter and nitrogen oxides). Since motor vehicles are the fastest growing source of Carbon dioxide and contribute a significant portion of the emissions of Carbon monoxide (CO), Hydro Carbons (HC), Nitrogen oxides (NOx) and particulate in urban areas, emissions from automotive engines are considered as a major source of urban air pollution. To gather information about extent of air and noise pollution, the Central Pollution Control Board has initiated NAMP at national level. SO2, NO2, SPM samples are collected for 24 hrs with 4hrs averaging of gaseous parameters and 8 hrs averaging of SPM for twice a week. The annual target frequency is prescribed as 104 days in a year. Many samples have been collected by Delhi based company named LEA Associates South Asia Pvt. Ltd. and French based company Egis BCEOM Pvt. Ltd. in Bhopal. The first uncertainty that exists in the environmental evaluation is the complex character of environment system in nature. The complex spatial environment system is characterized by subjectivity, incompleteness and imprecision [2]. A lot of environmental information includes fuzzy uncertainty. There is need of a fuzzy method to recognize the inherent fuzzy nature of environmental problems [2].

Further as described previously, environmental quality is a multidimensional concept. Both qualitative and quantitative information associated with several criteria needs to be considered in the process of environmental evaluation. The main objective of the work was to map air pollution along major traffic corridors in Bhopal. Much environmental information has the obvious spatial character that can be addressed by GIS. For example, the air quality may vary for different land-use classes. Population density as a socio-economic factor involved in EQE also changes in the different spatial unit. Other environmental factors such as noise, green coverage also have spatial character. So, while evaluating the UEQ, GIS provide a powerful tool for the representing of environmental information in support of environmental evaluation [6].

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II. Study Area

A. Geography

Bhopal, the capital city of Madhya Pradesh has started being counted among the fastest growing cities in the country [1]. The city which is known as “the city of lakes” is continuously losing its grace and beauty under the growing pressure of up-gradation and densification of activities resulting in increase of service related problems. The crisis, chaos and risk of commuting as prevalent in other major urban centers of India, do exist in Bhopal. Geographical Co-ordinates of study Area (41 wards) are Longitude: 77 22 04.71 E – 77 26 25.73 E Latitude: 23 11 46.59 N – 23 17 38.72 N.

Bhopal is connected to other cities in the state and country by railways as well as roads. The City is connected by broad gauge railway lines to almost all the major cities like Delhi, Mumbai, Chennai and Nagpur. The city is distinctly divided into two parts, the old city housing most of the trading and commercial activities and the newly developed area with mainly administrative, institutional and residential activities. The road network in the old city area, with very limited scope of road widening, mainly suffers from very high volume of traffic, heterogeneous traffic mix, and high degree of pedestrian movement and on – street parking. The average traffic volume around bus stand is 80,000 pcu to 85,000 pcu along Hamidia road and Aishbagh road. The presence of Bhopal railway station in the area adds more problems. Four major traffic corridors (as per MP Road Development Corporation, Fig. 1) are taken into consideration to do detailed

study. Annual mean concentration of air pollution (SO2, NO2, CO, SPM) and noise pollution is collected. Total 47 sample stations are selected along the four major traffic corridors.

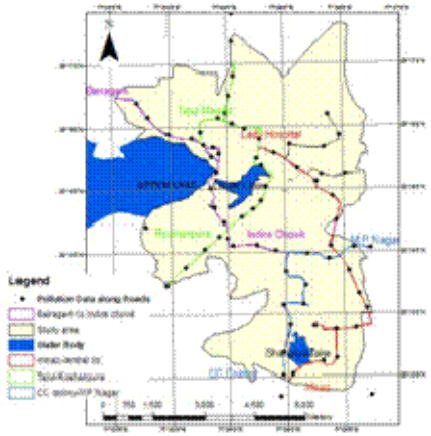

Fig. 1 Major Traffic Corridors for emitting Air & Noise pollution

B. Data and Data Sources

High resolution images (2.5 m) provide much details about features spatially however multi spectral images provides more land cover information than panchromatic data enhance understanding of both spatial & spectral resolution of feature then enhancing the accuracy and visual interpretation [3]. Annual mean concentration of air and noise pollution (ward wise and along four major traffic corridors) of year 2006 has been collected from Madhya Pradesh State Pollution Control Board, LEA Associates South Asian Pvt. Ltd. and Egis BCEOM India Pvt. Ltd. As urban area has been taken into consideration for study purpose, the greenness in terms of grassland, trees along roads, parks, greenness inside the built up boundary has been considered. It is not possible to digitize individual tree of urban area, so Normal Differential Vegetation Index (NDVI) has been extracted from remote sensing satellite image, IRS P-6 LISS IV MX, year 2007.

Based on the survey conducted by M.P. Road Development Corporation for Bus Rapid Transit System in study area, four major traffic corridors have been considered the most congested road ways covering the vital area. These corridors encounter maximum traffic throughout the day. Buffers have been created around these corridors to study the impact of pollution on adjacent land use. Road traffic being the main cause of air and noise pollution, sample points data have been collected these four along corridors.

III. Methodology

The flowchart of the processing methodology is shown in Fig. 2. The details of the intermediate steps of flowchart along with the mentioned steps are explained below.

The sample data is interpolated by IDW to create surfaces. Hence by interpolation and extrapolation, the surface so generated is that of air and noise pollution in ward wise and along major traffic corridors separately. For the air pollution four surfaces are generated and for the noise pollution, two surfaces are generated. The maps so generated are shown as Fig 4(a) to 4(d). Classification of values of each map is done using ArcGIS 9.2 as per NAAMP. The whole surface is classified into four classes i.e. Low (L), Moderate (M), High (H), Critical (C). In the displayed map of carbon monoxide in Fig 4(c), the maximum value of CO is 4mg/cum. The concentration of CO is mainly due to traffic hence it is more along the major road traffic. It is high as even 4 mg/cum of CO causes harm to life. Still compare to traffic congestion (old Bhopal), the concentration has not gone up. This is due to the topography and the presence of water bodies. SPM is high due to traffic emission. It seems to be very high at certain areas like Shahjahanabad, Jahangirabad, PHQ, M. P. Zone etc. In very few places, the value lies in “Low” category. About 65% of the area has come under category “High” and only 10% of the area has value above 180 ug/cu.m.

The preventive measure should be taken mainly by traffic route changing. All the criteria maps so prepared with four classes (as mentioned in the Fig. 3(a) to 3(d)) are given fuzzy weights obtained from AHP analysis. In this study, Fuzzy Gamma operator has also been used. Thus all the maps can be combined using a suitable operator like Gamma operator. It is to be noted that a single operator would not suffice the combination of maps since it depends on the context of the type of data represented by maps [4]. The physical parameters covered are topography, land use, vegetation. Applying Fuzzy Algebraic Sum to SO2 layer, NO2 layer, SPM layer and CO layer along major roads [5].

Air Pollution along Roads = 1-[(1-Fuzzy SO2)*(1-Fuzzy NO2)*(1-FuzzySPM)* f(1-FuzzyCO)].The result of above operator will be larger or equal to the largest contributing fuzzy value showing increasive tendency [7]. The aspect criteria governs the wind direction and hence the dispersion of pollution. Similarly, the slope is an indicator of population density (less the slope, more is the population density). Since population density also effects the pollution dispersion. Hence, both the aspect and slope criteria are effecting the dispersion of pollution. Therefore the use of Fuzzy OR operator is justified. In the Fig 5, buffer of 50m is generated along four major traffic corridors of the study area. Thus four buffers each of 50m have been given Fuzzy weights. The area which is near to road is affected much by pollution. The effect decreases as one goes away from the road. Thus the buffer which is next to road is given fuzzy weight 0.9 and the one away from the road is given fuzzy weight 0.6. The study area which is not covered in the buffer region is given 0.5 fuzzy weights.

IV. Results

Much of the intermediate results have already been explained in the methodology section. Apart from final result not much is remained to be explained in this section.

Figure 6 shows the final quality map processed by applying Gamma operator; the dark patches are the highly polluted areas which cover mainly the old Bhopal and the major traffic corridors.

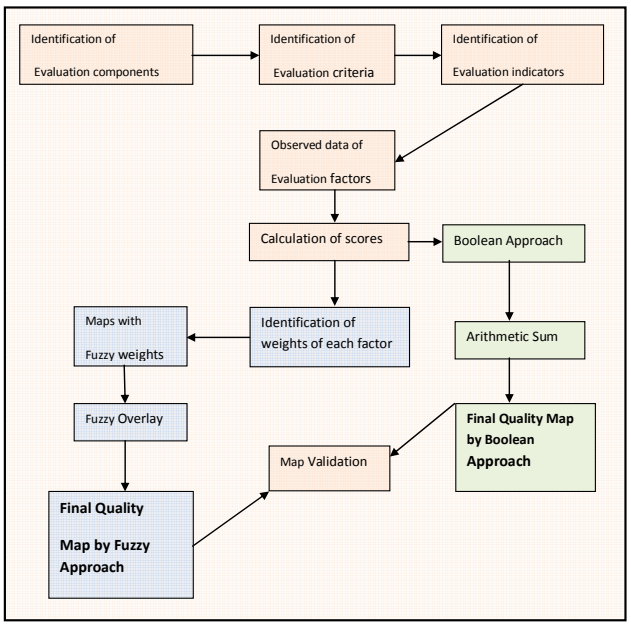

Fig. 2 Flowchart of the methodology followed to get the desired output of this work

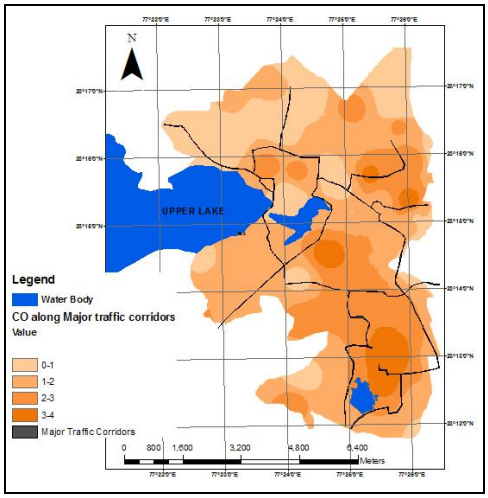

Fig. 3(a) CO criteria map along traffic corridors

V. Conclusions

The major traffic corridors which are considered in this study are main source of not only air pollution but also other types of pollution like noise and thermal. The pollution level effects the settlement developed near these roads which mainly includes residential and institutional buildings. The widening of road width can help to sustain traffic pressure.The road traffic can be diversed. Bhopal road development authority is making outer ring road which seems to reduce the traffic congestion where by reducing the traffic load as well as the pollution level. Such type of mapping is made possible by using temporal remote sensing satellite data of high spatial resolution. This type of study in future can help the environmental, transportation and town planners to plan their city properly.

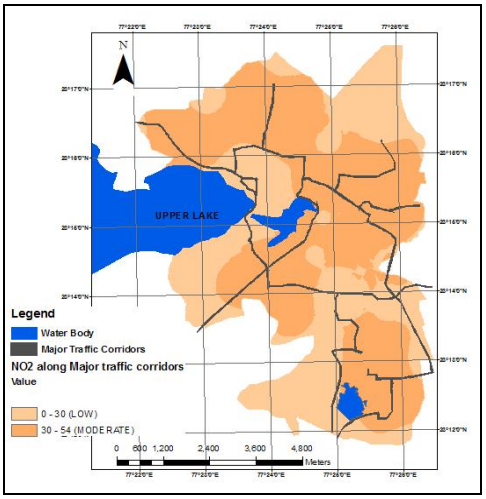

Fig. 3(b) NO_2 criteria map along traffic corridors

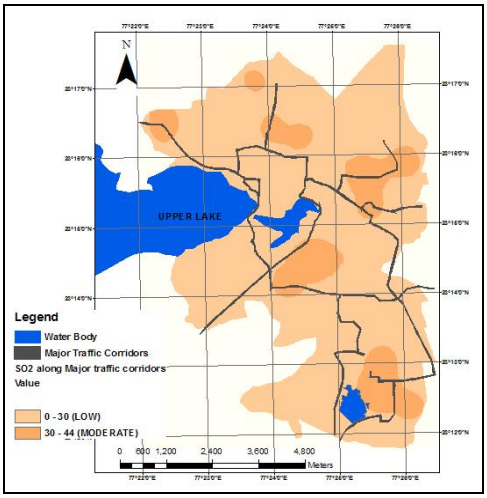

Fig. 3(c) SO_2 criteria map along traffic corridors

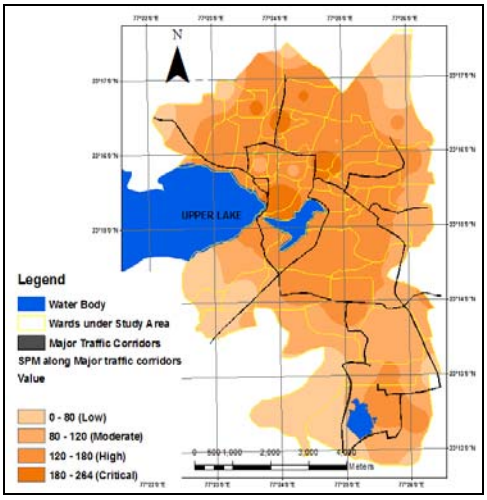

Fig. 3(d) SPM criteria map along traffic corridors

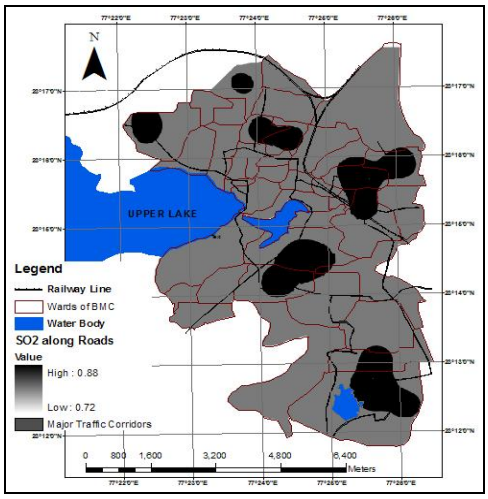

Fig. 4(a) SO_2 map showing fuzzy weights

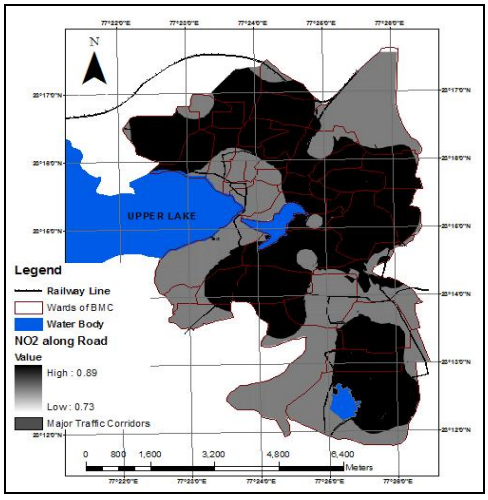

Fig. 4(b) NO_2 Map showing Fuzzy weights

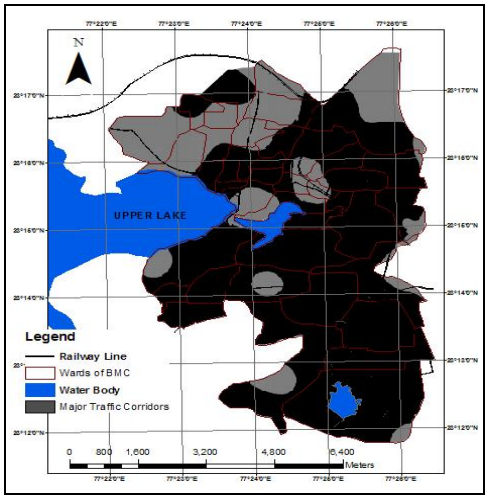

Fig. 4(c) CO Map showing Fuzzy weights

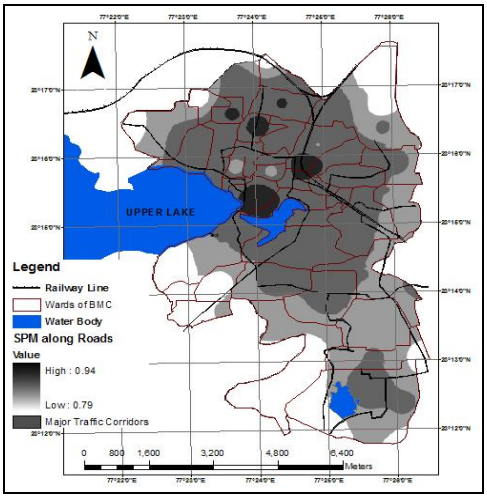

Fig. 4(d) SPM Map showing Fuzzy weights

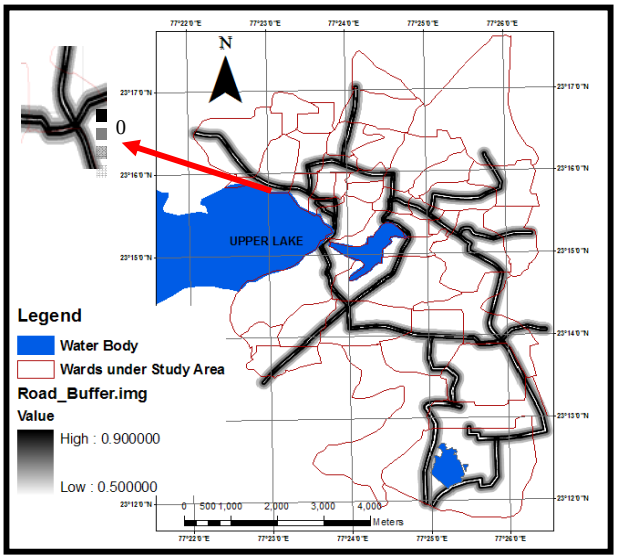

Fig. 5 Road Buffer Map with Fuzzy weights

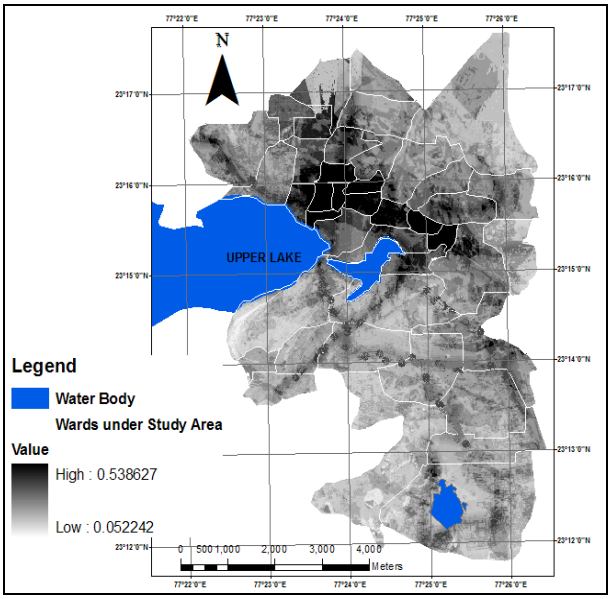

Fig. 6 Mapping of Air quality of urban roads of Bhopal.

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