GIS-Based Spatial Information Integration, Modeling and Digital Mapping: A New Blend of Tool for Geospatial Environmental Health Analysis for Delhi Ridge

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Key words: GIS, Geospatial Modeling, Digital Mapping, Environment, Sustainable Development.

ABSTRACT

GIS has emerged as promising tool for prioritising and analysing geospatial environmental issues for sustainable development. Because environment management and land use conflicts are spatial, any rigorous analysis of environment and land management alternations must include consideration of the spatial interactions between people and their environment. In view of this, there is population management need in Delhi, which has been grown many-folds during the 20th Century. Population is primarily responsible for the present-day widely debated issue of environmental crisis. Earlier, the ridge vegetation cover is functioning as a green lung for the Delhi. Nevertheless, the ridge forest cover has failed to meet reduction target for greenhouse gases emission due to constant concrete jungle sprawl over the periods. Also, there is a rapid increase in the level of air pollution due to the rapid expansion of the urban and industrial activities. So, over the Delhi Ridge, there is less concern for ecological imbalance, especially in the face of rapidly growing population. However, the low-cost measures to maintain as well as increase future flexibility of response to environmental management have been identified and implemented as part of an integrated approach for sustainable environment development for the Delhi Ridge.

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1. INTRODUCTION

The main focus of present research is to provide an understanding of spatial data integration into the Geographic Information System (GIS) along with their modeling strategies to promote more effective digital mapping in the present fast changing field of information technology (IT) environment. GIS along with Remote Sensing (RS) technology provides an excellent spatial information and framework for understanding the fundamental principles of spatial analysis. Since the past 100 years or so, the scientists from different disciplines: geographers, ecologists, environmentalists, and climatologists deliberated the theme of environmental degradation, and anthropogenic ecological imbalance due, for instance, to deforestation and reforestation. But in the recent past, due to the rapid development in the Geographical Information System (GIS) and Remote Sensing (RS) technologies, it has become possible to monitor environmental degradation and their restoration through the computer simulation and modeling at the global and the micro-regional levels (Blackburn and Milton, 1997). So, the GIS and RS technologies have been used to form the basis for cost-effective technologies for broad scale evaluation of many environmental monitoring problems including land use and land condition assessment (Kontees et al., 1993 and Wharton, 1987) and ecological restoration, including forestry management (Skidmore, 1989).

Rapid population growth and urbanisation are expected to further increase in the Delhi by 2010. The atmospheric pollution is increasing largely because of diverse human activities in the Delhi's environment. The ridge is at risk to the impacts of environmental degradation. In contrast to historical precedent, a proactive approach is to be recommended towards ecological hazards and changing levels of risk with time. Low-cost measures to maintain or increase future flexibility of response to environmental degradation need to be identified and implemented as part of an integrated approach to environment management for the Delhi Ridge. The Delhi's population, one of the principal drivers to environmental stress has grown by about 33.45 per cent per year since 1901 during the 20^{th} Century. Other trends include increases in atmospheric CO_2 and ozone depletion. Now, at micro-regional level attention is focused as never before on environmental issues. A number of steps being taken by the government of Delhi to promote non-conventional energy sources. The use of such sources is not gaining ground as expected in Delhi, due to high initial costs; concerted efforts are needed to achieve this goal. The use of non-conventional sources could reduce... energy-related CO_2 emissions 11.8 per cent below 1988-89 levels by the year 2005-2006 (Maji, 1995).

However, to sustain economic growth, energy systems must increase economic productivity and competitiveness, put more people to work, and lessen environmental degradation. At the

beginning of the new millennium, state-of-the-art energy systems are in transition from liquid oil to (gaseous) methane/natural gas. This new "Age of Energy Gases" will and with totally clean hydrogen, using basically the same infrastructure as natural gas (Hefner, 1995) help in ecological restoration for the Delhi Ridge. However, the scientists are working to quantify the relationship between population and emissions of greenhouse gases. Their modeling indicates that population may be a key variable for stabilizing atmospheric CO_2 in the long term, and that the CO_2 target chosen will affect the extent to which population policies help meet the goal. Based on land surface temperatures, and on the deforestation, concludes that the more recent warming is best explained by the effect of greenhouse gases. The primary evidence for this interpretation is the dominance of the deforestation over Delhi Ridge since the beginning of the 20^{th} Century. Although environmental degradation may have a wide range of adverse impacts on land, water, air and forest resources; but a bigger threat may come from other factors, such as population growth, technology, economic, social and political conditions (Ott, 1997). However, Delhi's population continues to grow rapidly and changes in urban and industrial development ensue disruption of ecological system.

2. OBJECTIVES AND HYPOTHESES

The main objectives of the study are mentioned as follows:

(i) to examine ecological and social systems;
(ii) to assess geospatial environmental degradation; and
(iii) to explore suitable strategies for population-environment nexus.

By ascertaining the above objectives, this study discusses the environmental degradation risks arisen due to the wide spread human interference with nature. Besides this, suitable control measures are to be suggested to minimise the adverse developmental impact on the environment.

The present research is based on the assumption that development should take place without destroying the environment. What is important is the sustainability of development over a long drawn period of time rather than the ephermal nature of development the gains of which will only be availed by the present generation. Hence, a composite picture of the developmental impact on the environmental degradation and ecosystem will be developed with a view to developing prognostic models of man-nature interaction in the ecologically sensitive Delhi ridge.

3. DATABASE AND METHODOLOGY

The new technological tool Geographical Information System (GIS) provides an up-to-date spatial information for the detection of change and the spatial pattern of an attribute along with strategic modeling and mapping solutions in this fast changing World. Further, developments and applications of integrated GIS approaches should help provide solutions for many of the emerging geospatial environmental problems at local, regional, national and global levels, and may become the preferred environment for modeling through GIS

technology. Therefore, this study combines spatial information for healthy environment management from the GIS databases to draw conclusions that could not be obtained from the analysis of the historical records alone.

The Indian Remote Sensing (IRS) satellite data for LISS (linear imaging self scanning) and PAN (panchromatic) sensors have been used in the present study for two different periods of time for the forest cover change detection and their comparative analysis. Several vegetation indices have been used to enhance spectral vegetation characteristics from the visible and near-infrared regions of electromagnetic spectrum. (Tucker, 1979 and 1986; Jackson, 1983 Defries and Townshend, 1994 and Gupta, 1997). The NDVI is the most commonly used vegetation index and is obtained using the following equation:

$$\mathbf{NDVI} = \frac{\mathbf{(a2-a1)}}{\mathbf{a2+a1}} \qquad (1)$$

Where: **a2** = Band2 (Near-Infrared Band or NIR)
a1 = Band1 (Visible Band or VIS)

Based on this index, the quantification of estimation of vegetation cover has been worked out for the study area. The ground truth verification was carried out by field visits with the help of landuse maps, Survey of India toposheets, Forest maps etc. Apart from this, the non-spatial information like forests, population, pollution, quarrying/mining, industries and urbanisation have also been collected from the different secondary sources. These data have been compiled and integrated with the spatial information. Thereafter, it has been feasible to workout a number of strategic modeling and mapping for the sustainable environment development for the Delhi Ridge.

4. STUDY AREA

Delhi Ridge is located in the heart of the Delhi has been selected for the present study. The geographical coordinates i.e. the latitudinal and longitudinal extent and the geographical features i.e. the physiographic divisions and physical features of the study area are presented in the Figure 1 and 2. Both figures reveal that the entire ridge is rocky and undulated with partially flat plain.

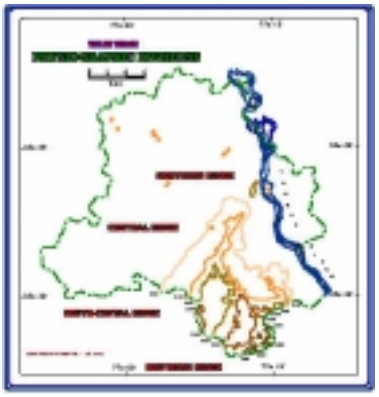

Figure: 1

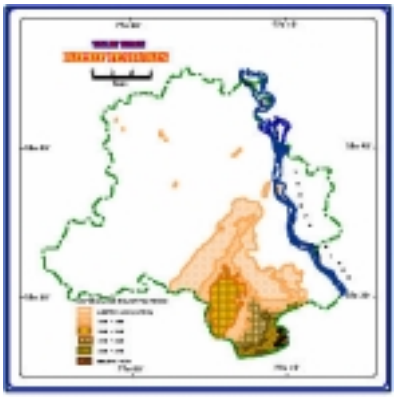

Figure: 2

The 32 kms. long Delhi Ridge is an inseparable part of Delhi. The Delhi Ridge spread over an area of 7,777 hectares is a continuation of the Aravalli's, which extends into Delhi from Haryana at the Tughlaqabad-Bhatti mines — Dera-Mandi axis moving northwards covering areas of the Asola Wildlife Sanctuary, parts of Delhi Cantonment and Lutyens Zone terminating at Delhi University covering the Kamla Nehru Ridge (Thapliyal, 1987). However, sources point out that from the original area of the ridge which was 15,046 hectares — the total area has come down to 7,777 hectares. The Aravalli Hills belong to the most ancient mountain chain in India. The hills came into existence at the close of the Dharwar Era. Basal quartzite, conglomerates, shales, slates, phyllities and the gneisses comprise Aravalli Hills (Wadia, 1976). The ridge achieves a height of 318 meters near Bhatti, which is probably the highest point as is revealed by the comparative analysis of the Figures 5 and 7. A number of small rivulets drain this hilly region. A semi-arid climate prevails in the region throughout the year.

Naturalists and ridge lovers have found a wide spectrum of plant species here. There are the native ones like the Babul (Acacia Arabica) and Ber (Jujube). There are the exotic varieties of Vilayti Kikar (Acacia) and Neem (Margosa Tree). Amaltash, Palash, Flame of the forest and an orchid species bring vibrant colours to the forest during different seasons. However, the geographers and environmentalists feel quite strongly that it is high time to save the ridge... from us. A close examination of the ridge revealed that it is a wonderful slice of nature. It is a repository of the Delhi's future and a sobering reminder of what Delhi might have looked a few decades ago until it was run over by wheels and concrete. More than 200 species of birds have been spotted in this tropical thorn forest. Earlier, their number was 300 and more (Dahiya and Krivov, 1999). It is having about 70 species of butterflies and large varieties of animals and insects. Unbelievable as it might seem, the forest even housed lions, tigers and leopards some 70 years ago. However, it is observed that all-over Delhi Ridge there has not been much change in the vegetation cover with the exception of the potential reforested areas where dense vegetation cover has found been increased over the periods.

5. PRESSURE OF POPULATION ON ENVIRONMENT

Delhi's Population, one of the principal drivers of environmental stress has grown by 13.38 million as against 0.41 million persons in 1901 to 13.78 million persons in 2001. In other words, the Delhi's population has been grown by about 33.45 per cent per year since 1901 during the 20th Century. The Figure 3 reveal facts regarding the population growth for Delhi, this portrays a rising trend all through during 1901-51.

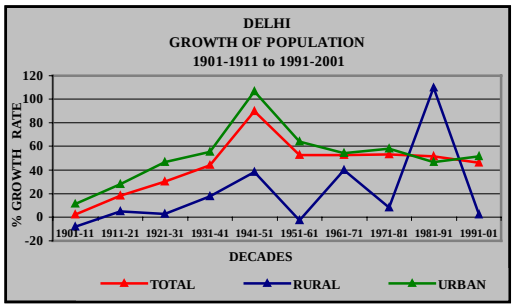

Figure : 3

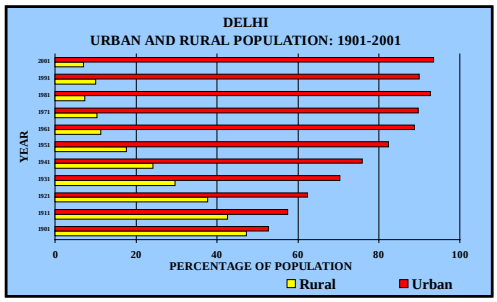

Figure : 4

There was not much change in Delhi's population during 1901-11 as it grew by just 1.98 per cent. The decade 1911-21 witnessed an increase by 18.03 per cent, whereas the population increased only marginally from 0.41 million in 1901. This increase may be mainly attributed to the shifting of capital from Calcutta to Delhi in 1912. The growth of population during 1921-31 and 1931-41 was 30.26 per cent and 44.27 per cent respectively. The partitioning of the country resulted in huge influx of displaced persons. The 1951 Census recorded a growth rate of 90 per cent for the decade 1941-51. During 1951-61, the growth rate fell to 52.44 per cent. During the next period, it again showed ascending trend, although marginally. Such growing tendency in population was due to the multiplication and intensification of services during the post-independence era. During 1971-81 decade, the population recorded a growth rate of 53 per cent. The main factors responsible for unabated growth of population in the Delhi are the expansion of commerce and trade; and the growing industrialisation, particularly, in the field of small-scale industries during the last three decades. During 1981-1991 period, the growth rate of population was 51.45 per cent. Such decline in population growth was resultant due to decline in urban growth rate of 46.87 per cent in 1981-1991 in comparison to the previous decade 1971-81 growth rate of 58.16 per cent. Furthermore, the growth rate of population was declined to 46.31 per cent during 1991-2001.

Since Delhi has remained a capital of the country for centuries and a hub of all social and economic activities. It has always been attracting in-migrants. This has resulted in excessive growth of its population, which is not due to natural increase alone, but more because of large-scale in-migration. Because of this, the Delhi is densely populated. It has recorded a growing density of population since 1921. At the time of partition of the country in 1947, Delhi attracted gigantic and unprecedented mass immigration of displaced persons. The highest density of population of 9,243 persons per sq. kms. was recorded during 2001 Census

which is the highest among all the States and Union Territories of the country, India. Within the Delhi itself, great variations in the density of population can be marked. Apart from this, the share of rural population is less than one-tenth of the total population with the continuous shifting of the ratio in favour of urban population. In 1901, Delhi had almost an equal distribution of population in the rural and urban areas as is evidenced by the Figure 4. In 1981, the share of urban population was 92.73 per cent, which slightly declined to 89.93 per cent in 1991. Whereas it was marginally increased to 93.45 per cent in 2001. However, the most striking characteristic of the population of Delhi is the predominance of in-migrants. Therefore, forest cover has been changed due to rapid expansion of the urban and industrial activities. These processes have resulted in the expansion of built-up areas on the one hand and large scale quarry and deforestation activities particularly over the Southern Ridge on the other hand. Consequently, the settlement expansion and land encroachment all over the Delhi Ridge is noticed as a recent phenomenon resulted due to the high population pressure in the Delhi.

6. ECOLOGICAL CONSEQUENCES OF QUARRYING

The quartzite rocks largely forming the ridge are exposed in many localities in Delhi and constitute a useful source of road metal and building construction materials. The rocks had been extensively quarried at Pharaganj, Kalkaji, Jhandewalan, Rohtak Road, Mehrauli, Lado Sarai and other places. The Delhi Ridge is scorched with quarries. A large quantity of 'Badarpur sand/quartzite' is quarried on a vary large-scale in Bhatti group of mines (around 12 quarrying pits) by the Delhi State Industrial Development Corporation (DSIDC) and subsequently by a separately formed organisation designated as the Delhi State Mineral Development Corporation (DSMDC) since 1983, of which production trends are shown in the Figure 9. A number of quarrying sites are shown in the Figure 7 where the quarrying operation is still conducted at the Dera-Mandi and Jonapur, Ghattorni, Rajokri, Tajpur and Gujiriwala in Bhatti group of mines by the private contractors/cooperative societies (Mohan, 1998 & 2000a). The main sources of air pollution are the dust particles and fuel smoke. The dust created by transportation, loading and unloading of waste, drilling and blasting has appreciable impact on the inhabitants and the plants.

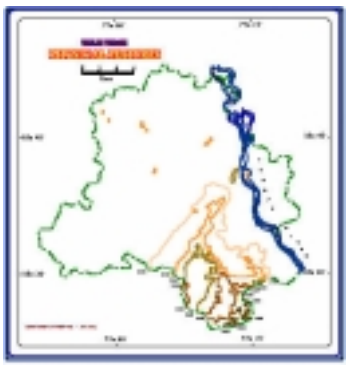

Figure: 5

Figure: 6

Figure: 7

Figure: 8

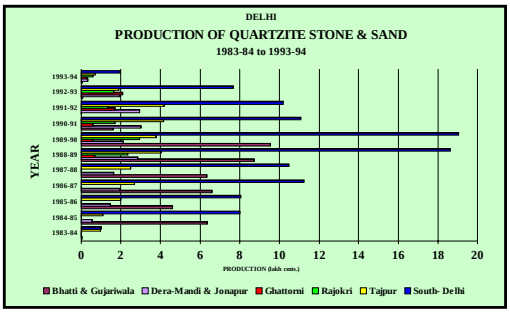

Figure: 9

The Delhi Ridge had a thin vegetation cover before quarrying activities, which is witnessed by the Figure 6; but, now, due to the quarrying activities, the vegetation left is almost negligible in the area. Consequently, the large-scale quarrying and the removal of natural vegetation have laid the land bare. The implications of quarrying over the Delhi Ridge are not that severe as are usually associated with the opencast quarrying, but even considering certain parameters, the impact is appreciable as is revealed by the Figure 8. The British planted trees after very deep and detailed study of the Delhi Ridge area and its environment. Therefore, the Delhi Ridge forest should not be treated as an isolated pocket of forest. In the present scenario, it is not possible to protect and conserve the entire Delhi Ridge without launching a popular people's movement.

7. ECOLOGICAL CONSEQUENCES OF INDUSTRIALISATION

The Delhi Ridge is getting sick due to the air pollution by the smoke belching chimneys of furnaces and factories; the chemical and mineral industries with scant regard for environment. Despite the master plan and the NCR (National Capital Region) plan, the Delhi is fast growing in terms of population and industries. The comparative analysis of the Figures 10 and 11 proved to the fact that due to heavy transportation the exhaust gases pollute the environment badly of the Delhi.

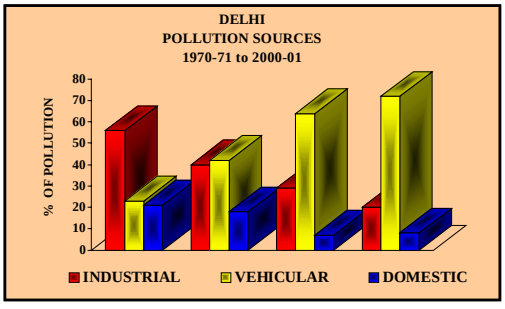

Figure: 10

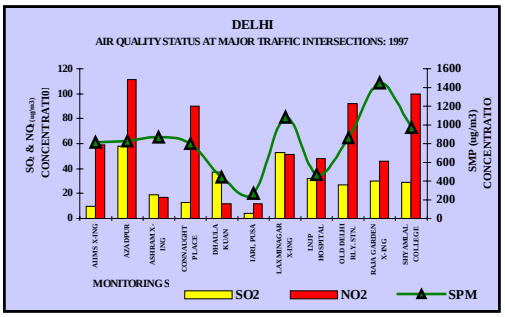

Figure: 11

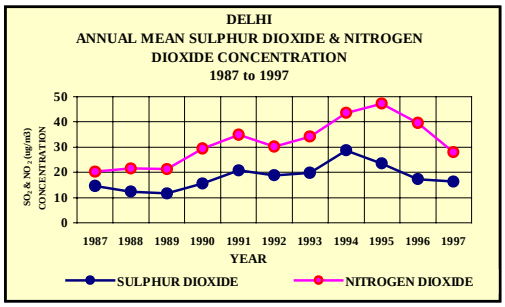

Figure:12

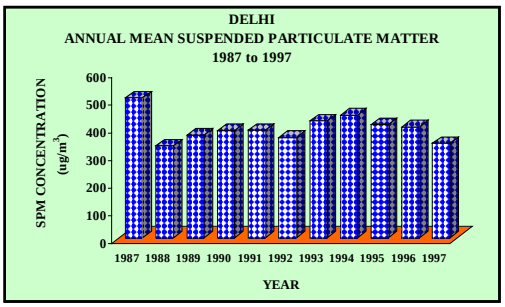

Figure: 13

Figure: 14

Figure: 15

The rapid industrialisation, high volume of traffic and power plants have further aggravated to the air pollution in Delhi as is witnessed by the Figure 14 and 15. For instance, the Indraprastha and Badarpur Thermal Power Plants fly-ash emission continues to precipitate the air pollution in many areas over Delhi. So, all these activities have resulted in the continuous release of the environmentally hazardous gases like the sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon dioxide (CO_2), carbon monoxide (CO) and the suspended particulate matter (SPM). All these gases and particulate's constuients concentration in the atmosphere for the period 1987-97 with their yearly trends is presented in the Figures 12 and 13. The permissible limit of the air pollution for human beings to inhale is 250 ppm. Whereas in Delhi residential areas, it is generally 400 to 500 ppm. Moreover, in the industrial areas it is as high as 900 ppm. that is almost equal to the pollution level at the ITO (income tax office) bridge in New Delhi where it is reported to be at the level of 1,000 ppm. However, Delhi is the seventh most polluted city in the world at present.

8. FOREST VEGETATION MAPPING

The highest value of NDVI is 0.4509 as observed in 1999, which has increased from 0.3929 in 1989. This increasing tendency indicates that the vegetation cover has increased over the southern ridge. Almost similar condition of vegetation cover has also been found for the other divisions of the Delhi Ridge as is revealed by the Table 1.

Sl. No.	*Physiographic Divisions*	*NDVI Min.*		*NDVI Max.*	
		1989	*1999*	*1989*	*1999*
1.	**Northern Ridge**	-0.1563	-0.4869	0.3489	0.3940
2.	**Central Ridge**	-0.0539	-0.6410	0.3012	0.3519
3.	**S-Central Ridge**	-0.1211	-0.5235	0.2946	0.3871
3.	**Southern Ridge**	-0.1892	-0.7601	0.3929	0.4509

Table 1: NDVI Statistics by Physiographic Divisions.

The vegetation cover over the Delhi Ridge has marginally been increased from 18.79 per cent in 1989 to 19.67 per cent in 1999. Among the Delhi Ridge divisions, the Northern Ridge has the highest vegetation covered area of 62.27 per cent while the Central Ridge is covered with the vegetation of 47.02 per cent. The South-Central and Southern Ridges were covered with the vegetation of 32.67 per cent and 13.31 per cent respectively. The sparse and dense vegetation covers have grown to 9.23 per cent and 7.0 per cent in 1999 over the entire ridge. The plantation of trees under the different forestry plans has been taken place over the Delhi Ridge. Besides this, the Central Ridge recorded an increase in the scattered and sparse vegetation of 19.28 per cent and 13.48 per cent respectively during 1989-99. Similarly, over the South-Central Ridge, the sparse and dense vegetation covers increased to 10.88 per cent and 8.89 per cent in 1999. Over the Southern Ridge, the sparse and dense vegetation increased to 6.10 per cent and 8.59 per cent in 1999. The detailed analysis of the IRS imagery has revealed the presence of a dark/black patch along the Southern Ridge, which has been interpreted as big hole as is shown in the Figure 16. In 1999, dense vegetation was located in the five major locations over the Delhi Ridge. Out of these, three of them such as the Hauz Khas and the Deer Park (Forest) located over the Central Ridge and the Asola Wild Life Sanctuary on the Southern Ridge. These come under the protected forests. In addition to this, due to reforestation within the Jawaharlal Nehru University (JNU) campus, a rich growth of vegetation cover has been developed as is shown by the Figure 17 and 18. The sparse and dense vegetation occupied nearly 0.757 sq. km. and 0.152-sq. km. area in 1999 over the South-Central Ridge. There is found an increase in dense vegetation cover of 2.24 per cent during 1989-99 while the sparse vegetation recorded no significant change in its proportion. The land encroachment is one of the major causes responsible for decrease in vegetation covered areas.

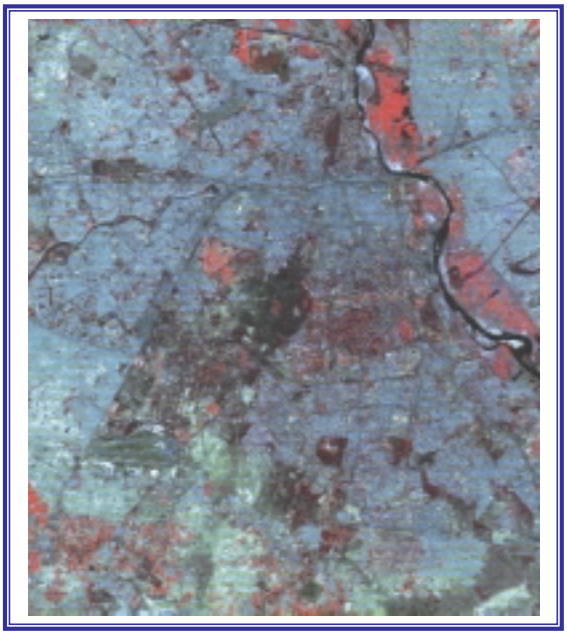

Figure: 16

Figure: 17 and 18

So, widespread deforestation and land encroachment activities have been responsible for the fragile ecological system degradation over the Delhi Ridge. This being the case, conservation and sustainable utilisation of forests need information on the location, rate and type of change in the vegetation cover, as well as an understanding of the human activities in order to avoid the possible ecological imbalance. The development of forest cover all over the ridge, as a carbon dioxide absorbing zone is also considered important, to reduce the ecological damages caused by wide spread land encroachment and deforestation. As a part of the ecological restoration program, the Forest Department and Delhi State Government, have envisaged ecological development of shelter belts all over the Delhi Ridge.

10. CONCLUSIONS AND SUGGESTIONS

Consequently, the ultimate goal is achieved with an understanding of spatial and descriptive data integration into the GIS environment, which has provided practical examples and strategies for more effective sustainable environment development. It can definitely be pointed out that this particular field of technology is expected to expand manifold in future leading to more efficient, comprehensive and effective for geospatial environmental solutions for different regional problems. In context to the geospatial databases much of the ridge area having already disappeared, the priority is to save whatever is left behind right now. It needs to be made mandatory for the leaseholders to grow plants in and around the leased areas. A scheme of developing the green barriers that may be jointly undertaken by the quarry owners (cooperative societies) and the government need also to be launched as already undertaken by the Delhi Development Authority (DDA) for the Bhatti group of mines. The DDA has already taken a lead in the ecological restoration of the Southern Ridge at the Bhatti Group of Mines by creating an artificial lake. The lake is about 1.82 km long and 243-m wide as

revealed from the satellite data. Water existing in the lake can be utilised for the nearby residential localities such as the Mahipalpur village, Vasant Kunj colony and the Mehrauli. Use of properly maintained vehicles could reduce the air pollution due to the exhaust gases emitting from them. The development of forest cover all over the ridge as a carbon dioxide absorbing zone is also considered important; to reduce the ecological damages caused by wide spread land encroachment and deforestation. Encroachers need to be severely punished, under the Forest law by imposing penalty as well as imprisonment. It will also be desirable to declare the ridge area as a National Park under the Wild Life Protection Act. 1972, just as it was done in the case of "Van Vihar" in the Bhopal and "Borivilli National Park" in Mumbai. The Delhi Ridge's upkeep need to be given to a Special Unit that may be created in the Forest Department. This Wing should comprise of specialists like the Forest Ecologist, the Environmentalist, Forester and the Horticulturist. Politicians ought to be keeping away from the Delhi Ridge affairs and enlightened citizens must form a Conservation Group on the lines of GREEN PEACE to monitor the activities in and around the Delhi Ridge. However, "let us save ecology from development no doubt but at the same time, let us save development from ecology as well" (Mohan, 2000b).

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BIOGRAPHICAL NOTES

Dr. Madan Mohan, Lecturer in Geography, Jamia Millia Islamia, Department of Geography, Faculty of Natural Sciences.

Specialisation

Ecology, GIS and Remote Sensing Application to Urban and Regional Development.

Academic Qualifications

Ph.D., Geography (1998); M.Phil., Geography (1990); M.A. Geography (1987), Jawaharlal Nehru University, New Delhi; B.A. (Hons.), Geography (1985), University of Delhi, Delhi; Advanced Certificate in Computer Application (1997), NIIT, New Delhi.

National/International Awards

National Education Test (NET) was qualified for the award of Jounior/Senior Research Fellowships and eligibility for lectureship, conducted by the University Grants Commission, New Delhi.

Professional Experiences

Lecturer in Geography, Jamia Millia Islamia, 24th October, 2000 to date;
Jawaharlal Nehru University, 25th March, 1996 to 23rd October, 2000.

Selected Publications

Books:

Mohan, Madan (2000) ***Ecology and Development***, Jaipur (INDIA), New Delhi, Rawat Publications.

Research Papers/Articles:

Mohan, Madan (2001) "Spatial Data for Environmental Management: A GIS-Based Monitoring of Ecological Restoration for Delhi Ridge", in Muralikrishna, I.V. (ed.) ***Spatial Information Technology: Remote Sensing and Geographical Information Systems***, B S Publications, Hyderabad, Vol. II, pp. 546-553.

Mohan, Madan (2000) "Climate Change: Evaluation of Ecological Restoration of Delhi Ridge using Remote Sensing and GIS Technologies", in Beek, K.J. and M. Molenaar (ed.) ***International Archives of Photogrammetry and Remote Sensing***, XIXth ISPRS Congress Amsterdam 2000, The Netherlands, Vol. XXXIII, Part B7, Commission VII, pp. 886-894.

Mohan, Madan (1998) "Quarrying Activities on the Northern Flank of the Aravallis - An Environmental Impact Analysis", ***Indian Geographical Journal***, Vol. 73, No.2, pp. 130-140.

Research Papers/Articles Reviewed:

Mohan, Madan (1999) "Economic Analysis of Energy Use in Punjab Agriculture", ***ICSSR Journal of Abstract and Review: Economics,*** Vol. 1, No. 2, pp. 106-107.

_____ (1999) "Agricultural Exports, Poverty and Ecological Crisis: Case Study of Central American Countries", ***ICSSR Journal of Abstract and Review: Economics***, Vol. 1, No. 2, pp. 32.

Paper Presented in International Congresses/Conferences:

XIXth ISPRS Congress Amsterdam 2000, main theme was ***"Geoinformation For All"***, organised by International Society for Photogrammetry and Remote Sensing, held at Amsterdam, The Netherlands, 16-23 July 2000.

Fifth ICORG 2001 Conference, focal theme was ***"Spatial Information Technology"***, organised by Centre for Spatial Information Technology, Jawaharlal Nehru Technology University, Hyderabad, India, 2-5 February 2001.

Professional Societies/Organisations:

Life membership of the

National Association of Geographers, India, Department of Geography, University of Delhi, Delhi.

Association of Population Geographers of India, Department of Geography, Punjab University, Chandigarh.

Foreign Travels/Countries Visited:

The Royal Netherlands (Holland) was visited during the 16th to 23rd July, 2000, where I participated and presented a paper in the XIXth ISPRS Congress Amsterdam 2000.