

GIS Based Integrated Approach for Monitoring and Modeling of Hyper-Urbanization for Sustainable Environmental Development in Delhi

Madan MOHAN, India

Key words: Population Growth, Hyper-Urbanisation, Landuse/Landcover, Forest, Sustainable Development.

SUMMARY

Delhi is one of the most historic capitals in the world. It is also one of the greenest capitals. Until 1911, Delhi was a regional town. The concentration of population in Delhi started to increase with the foundation of New Delhi, south of Shahjahanabad by the Britishers in 1912. However, ever since 1912, the Delhi is continuously growing and swelling in term of population due to huge in migration throughout the country. The Delhi's Population has grown continuously during the 20th Century and reached to 13.78 million persons in 2001. The population of Delhi is estimated to rise to 22.42 million persons by 2021. The urban workers participation rate in terms of the proportion of workers to total population in Delhi was 31.92 per cent in 1991. It is noteworthy to point out that the non-workers comprise a large proportion of 68.08 per cent of the urban population in Delhi in 1991. The cheapest means of passengers transport in Delhi are the buses provided by the Delhi Transport Corporation (D.T.C.) and the Delhi Metro which is under construction. The significance of the environment was routinely mentioned in heavy words in the Master Plans of Delhi - MPD-1962, MPD-2001 and MPD-2021. However, in Delhi, land environment is under stress due to the increasing pressure of population. Urban Population, industry and commerce are causing acute and serious environmental problems in Delhi. The increasing pace of urbanisation has resulted into the large scale agriculturally productive land degradation in Delhi. There is also widespread natural vegetation destruction all over the Delhi Ridge resulting into the shrinkage of 'Green Lung' of Delhi. So, the Delhi is losing its share of greens cover. Sustainable urban development is the most important concern for Delhi's current environmental crisis at the threshold of the 21st Century.

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1. INTRODUCTION

The Delhi's Population has grown by 13.38 million persons during the 20th Century for instance it was 0.41 million persons in 1901 which was increased to 13.78 million persons in 2001. The population of Delhi is estimated to rise to 22.42 million persons by 2021. The major cause anticipated for this rise is the high in-migration rate due to better employment opportunities in Delhi in comparison to neighbouring states. In Delhi, land environment is under stress due to the increasing pressure of population. Population growth and in-migrated poor people, industrial growth, inefficient and inadequate traffic corridors, poor environmental infrastructure, etc. are the main factors that have deteriorated the quality of life in Delhi. Besides this, the number of census towns has grown from 29 in 1991 to 62 towns in 2001. Whereas the concentration of population in these towns has grown from 8.47 million persons in 1991 to 12.82 million persons in 2001. Likewise the Delhi's urban area has grown from 200.52 km² in the 1951 to more than 658.34 km² in 2001. The urban density has grown from 1,812 in 1921 to 19,473 persons per sq. km in 2001. However, this process of urbanisation is mainly occurring at the expense of productive agricultural land. Most areas under coarse and loamy soils with good to moderate moisture retention capacity have been converted to urban use, leaving less fertile land for agriculture. Over the years, area under cultivable wasteland has also increased. Further, increased land price due to urbanisation has made agriculture less profitable, and the cultivable land is kept fallow prior to merging it with the urban zones. Besides, the designated urban landuse practices are also not being followed, though various urban development plans have been delineated in the past (Khan et. al. 1999). Therefore, with the development of small and medium size towns in the National Capital Region (NCR), the urban growth would come under control in Delhi.

In the late 1950's and early 1960's, detailed studies on urbanisation were conducted with a view to prepare the Master Plan for the development of Delhi and its environs. With a view to properly channelise the urban growth, the Master Plan for Delhi brought forward the concept of National Capital Region (NCR). The NCR is comprised by the Delhi, the districts of Faridabad, Gurgaon, Karnal, Mahendragarh, Panipat, Rewari, Rohtak and Sonapat in Haryana, the districts of Bulandshahar, Meerut and Ghaziabad in Uttar Pradesh and the Alwar, Behror, Kishangarh and Mandawar in Rajasthan. The National Capital Region Planning Board (NCRPB) and the Delhi Development Authority (DDA) have prepared the National Capital Region (NCR) Plan and Master Plan for the National Capital Territory of Delhi (NCTD), respectively, with a 20-years perspective based on broad landuse categories and traffic corridors. Both plans could not achieve the desired results because of the lack of clear policies and strategies and also because of poor implementation and monitoring. Recent studies supported by the World Bank have proposed a long-term strategy for urban

development planning of NCR Delhi by adopting a comprehensive approach in the context of National Capital Region planning. Such a comprehensive sustainable development of environmental planning approach should first individually address all the important issues for instance (i) policies on industrial estates; (ii) environmental aspects associated with the relocation of large number of hazardous units among 0.13 million small industrial enterprises; (iii) larger housing requirements to accommodate the housing needs of growing population; (iv) slum upgrading at site or shifting of the existing squatter population clusters (now exceeding 1,100 in number); (v) rejuvenation of degraded land as well as preservation of remaining meager forests; (vi) enlarging green and open areas following modern urban sustainable development codes; and (vii) protection of monuments and cultural heritage buildings. After addressing each such issue in its proper perspective, a comprehensive integrated policy on all future landuse norms should be evolved.

2. OBJECTIVES AND HYPOTHESES

The main objectives of the study were as follows:

- to analyse the pre- and post-colonial processes of urbanisation;
- to assess the process of rural-urban fringe expansion;
- to examine the urbanisation activities impact on the environment; and
- to explore the suitable strategies for sustainable urban environmental development.

This study has also attempted to test the following hypotheses:

- Increasing pressure of population in urban areas responsible for expansion of unorganised and tertiary sectors and thus leading to hyper-urbanisation.
- Unplanned urban sprawl is caused by increasing pressure of population thus leading to shrinkage of productive agricultural land in disregard of its impact on the urban environment.

3. DATABASE AND METHODOLOGY

This study is primarily based on the secondary sources of data collected and computed while keeping in view the specific objectives of the study. The data for the pre-colonial periods have been collected from the Gazetteers of India. The post-colonial period's data have been collected from the different volumes of the Census of India. There are number of implications of hyper-urbanisation on the environmental degradation such as the deforestation of natural vegetation, landscape's physiological destruction, illegal land encroachment and shrinkage of productive agricultural land etc., All these implications in attribute form have also been gathered from the various secondary sources. Thus, the present study has been supported by the secondary sources of data generated through the extensive literature survey and the records of Land and Development, Department of Urban Development Ministry, Revenue Department, Forest Department and Delhi Development Authority, etc. for the Delhi State. Whereas the GIS software's like the ARC/INFO, ArcView and GeoMedia have been used for geographical

analysis, integration and presentation of the spatial and non-spatial data. These tools are more effective for monitoring and modeling of the hyper-urbanisation and for determining its implications on the environmental degradation and planning for sustainable environmental development.

4. HISTORICITY OF URBANISATION

Delhi is one of the most historic capitals in the world and two of its monuments such as the Qutub Minar and Humayun's Tomb which have been declared World Heritage Sites. It is also one of the greenest capitals. The Delhi lying between 28^o 25' and 28^o 53' north latitude and 76^o 50' and 77^o 22' east longitude. For the visitor, it serves as a perfect introduction to the cultural wealth, the complexities and dynamism of India. However, it is noteworthy nodal hub of all the social and economic activities. It was built seven times on different sites throughout the history. The Delhi is historically the "eighth city" on or around this site, on the banks of the Yamuna River (Mohan, 2002). The previous seven cities do not exist anymore, except as remnants of historical ruins, or as part of present day Chandni-Chowk. What happened to the earlier seven cities? What happened to Indraprastha (1450 B.C.), Surajkund (1024 A.D.), Qila Rai Pithora (1170 A.D.), Siri (1302 A.D.), Tughlakhabad (1320 A.D.), Jahanpanah (1334 A.D.) Shahjahanabad (1648 A.D.)? Reasons for their demise range speculatively from lack of sufficient water, to epidemics, to migrations, to poor governance, to land encroachment, to ...? In addition, presently formed the New Delhi (1912), of course, is eighth one. All these cities shifted from one site to another over a time within the periphery of a triangle area lying between the last ridge of the Aravalli range and the river Yamuna to the east.

The British built New Delhi, south of Shahjahanabad. In 1912, the British transferred the capital city from Kolkota (Calcutta) to Delhi. Delhi started growing faster under British control. In the latter half of the 19th century, the railways and metalled roads were built to link various parts of the Delhi. The postal services were also started. Some industries came to be located there. Commerce also developed, goods and commodities started coming in from distant places. Hence, Delhi once again became one of the largest commercial and cultural centers of India. The line of distinction between Old and New Delhi has begun to blur - north, south, east and west Delhi are more prevalent terms of demarcation. Therefore, several factors have contributed to this breathless pace of urban growth of Delhi. Industrialists, Entrepreneurs and migrant labourers from all over India have turned to Delhi in search of livelihood and success, and made it a commercial capital as well. The cultivated fields which till recently could be seen on the outskirts of the Delhi have been developed into residential colonies and commercial complexes. High-rise buildings now stand check-by-jowl with Delhi's 1,300 historical monuments. Villages such as Khirkee, Begumpur, Hauz Khas, Sheikh Sarai and Nizamuddin which grew around medieval Delhi's shifting capital cities have now been engulfed by the urban sprawl. Many of them, however, retain their old-world characteristics (Chauhan and Rashid 1993). However, Delhi made initially to cater to a population of 70,000, the total urban population of Delhi now exceeds 13 million persons.

5. PROCESSES OF URBANISATION

5.1 Pre-Colonial Urbanisation – Trends of Population

Urbanisation is the process of transformation of rural areas into urban areas due to industrialisation and economic development. The processes of urbanisation and economic development are interrelated to each other (Breese, 1978). Until 1911, Delhi was a regional town. Later on, in 1912 it became the capital city of the country, India which was established to the south of Shahjahnabad city. The concentration of population in Delhi started to increase with the foundation of New Delhi by the Britishers.

<i>YEAR</i>	<i>POPULATION</i>	<i>YEAR</i>	<i>POPULATION</i>
<i>1803</i>	1,50,000	<i>1865</i>	1,54,417
<i>1843</i>	3,30,000	<i>1881</i>	1,73,393
<i>1847</i>	1,60,279	<i>1891</i>	1,92,579
<i>1856</i>	1,82,000	<i>1901</i>	4,05,819

Table 1: Historical records of population of Delhi

During the colonial period (British rule), the population of Delhi during first sixty- two years from 1803 to 1865, has quite naturally increased from 1.5 to 3.30 lakhs persons respectively as it is also evidenced by the Table 1. In 1803, the Delhi was declared a province for the purpose of administration that is why the peace and order returned there, which was responsible for the increase in population. Thereafter, a period of political uncertainty such as the 1857 rebellion against British, prevailed which resulted a considerable decrease in population. Later on, the Delhi's population started to increase from 1.73 lakhs in 1881 to 1.93 lakhs in 1891. Furthermore, the population has grown to 4.06 lakhs in 1901. Whereas, there was not much change in Delhi's urban population during 1901-11 as it grew by just 11.13 per cent as is evidenced by the Table 2. The decade 1911-21 witnessed an increase by 27.94 per cent. This increase may be mainly attributed to the shifting of capital from Kolkata (Calcutta) to Delhi in 1912. The growth of urban population during 1921-31 and 1931-41 was 46.98 per cent and 55.48 per cent respectively. So, before 1931, urbanisation progressed in the northern and western parts of the walled city Delhi. The Figure 1 reveals facts regarding the urban population growth for Delhi, which portrays a rising trend all through during 1901-51.

5.2 Post-Colonial Urbanisation - Growth Trends of Urban Population

The scenario of urbanisation took a great turn during the post-colonial periods. The urban population started to grow from 1.44 million persons in 1951 to 8.47 million persons in 1991. Thereafter a sudden upsurge occurred in the urban population as it was grown to 12.82 million persons in 2001. Whereas the urban growth almost double to 106.58 per cent during 1941-51 in comparison to the previous 1931-41 period which recorded urban growth of 55.48 per cent as is clearly evidenced by the Table 2. The partitioning of the country resulted in huge influx of displaced persons in the urban areas.

Census Year	Population (in millions)			% of Population		% Decadal Variation		
	Total	Rural	Urban	Rural	Urban	Total	Rural	Urban
1901	0.41	0.19	0.21	47.24	52.76	-	-	-
1911	0.41	0.18	0.24	42.50	57.50	1.98	-8.24	11.13
1921	0.49	0.18	0.30	37.68	62.32	18.03	4.62	27.94
1931	0.64	0.19	0.45	29.67	70.33	30.26	2.59	46.98
1941	0.92	0.22	0.70	24.21	75.79	44.27	17.72	55.48
1951	1.74	0.31	1.44	17.60	82.40	90.00	38.10	106.58
1961	2.66	0.30	2.36	11.25	88.75	52.44	-2.52	64.17
1971	4.07	0.42	3.65	10.30	89.70	52.93	39.93	54.57
1981	6.22	0.45	5.77	7.27	92.73	53.00	8.01	58.16
1991	9.42	0.95	8.47	10.07	89.93	51.45	109.86	46.87
2001	13.78	0.96	12.82	6.99	93.45	46.31	2.13	51.36

Table 2: Decadal Variation of Population in Delhi

Thereafter during 1951-61, the urban growth rate fell to 64.17 per cent. During the next period 1961-71, it again showed descending trend, although marginally. Such declining tendency in urban population growth rate in Delhi was due to the multiplication and intensification of services during the post-independence era in the rural-urban fringe of National Capital Region (NCR) of Delhi. So, such decentralisation of services and industries towards the fringing areas of the Delhi was responsible to some extent the dispersion of urban population. Later on, the main factors responsible for unabated growth of urban population in the Delhi are the expansion of commerce and trade; and the growing industrialisation, particularly, in the field of small-scale industries upto the 1971-81 decade.

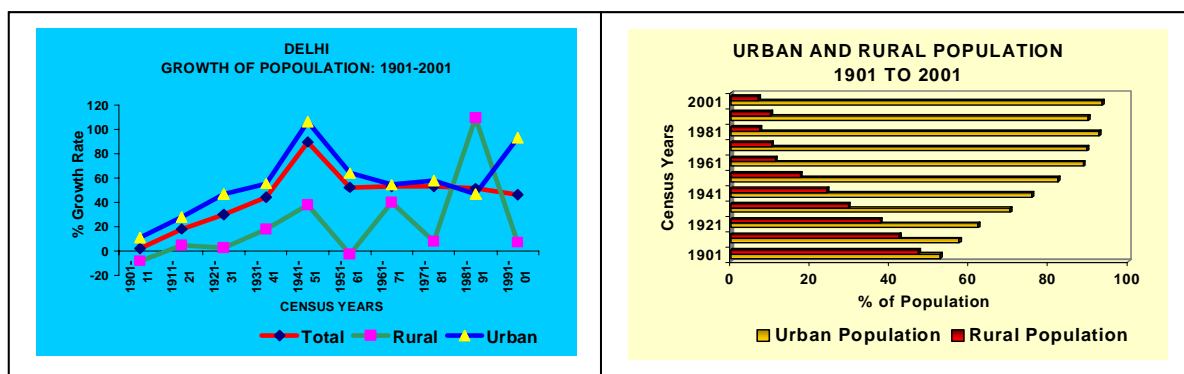


Figure: 1

Figure: 2

During 1981-1991 period, the growth rate of urban population was 46.87 per cent. Such decline in population growth was resultant due to high growth of rural population of 109.86 per cent during the same period. Later on the rural population highly declined to 2.13 per cent on the one hand and urban population growth increased to 51.36 per cent on the other hand

during 1991-2001. However, it is noteworthy to point out that Delhi had almost an equal distribution of population in the rural and urban areas in 1901; but gradually it was continuously decreased over the periods of time till to present 2001 as is evidenced by the Figure 2.

6. GROWTH TRENDS AND PATTERNS OF POPULATION DENSITY

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 as is evidenced by the Table 3. 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 9,294 persons per sq. kms. was recorded during 2001 (see Figure 3) which is the highest among all the States and Union Territories of the country, India (Census of India, 2001). Within the Delhi itself, great variations in the density of population can be marked as is evidenced by the Figure 4.

AREA S	YEARS								
	1921	1931	1941	1951	1961	1971	1981	1991	2001
<i>Urban</i>	1812	2639	3470	7167	7225	7822	9746	12361	19473
<i>Rural</i>	-	-	-	237	259	411	507	1190	1208
<i>Total</i>	318	429	634	1165	1792	2738	4194	6352	9294

Table 3: Decadal Variation in Population Density (per sq. kms.) in Delhi

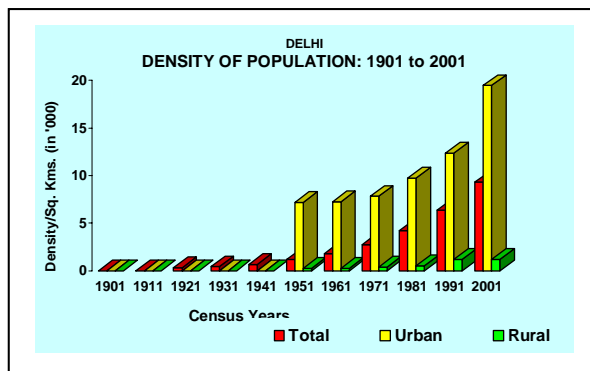


Figure: 3

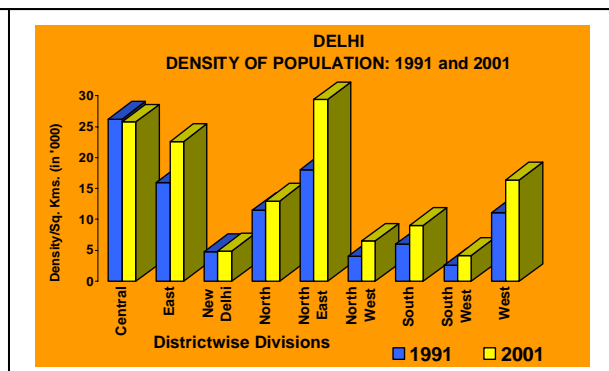


Figure: 4

However, the most striking characteristic of the population of Delhi is the predominance of in-migrants. Therefore, the landuse/landcover changed dramatically, particularly the forest cover due to rapid expansion of the urban and industrial activities (Sengupta, and Venkatachalam, 2001). These processes have resulted in the expansion of built-up areas on the one hand and large scale quarrying and deforestation activities particularly over the

Southern Ridge on the other hand. Thus, the above mentioned facts prove to the second hypothesis that the rapid expansion and sprawl of urban areas is thus resulting into multiple deterioration of environment in Delhi.

7. OCCUPATIONAL STRUCTURE OF POPULATION

7.1 Classification of Workers

The urban workers participation rate in terms of the proportion of workers to total population in Delhi was 31.92 per cent in 1991. While taken into consideration of its classification then there was almost an equal proportion of 31.82 per cent as the main workers in the urban areas. Whereas the marginal workers proportion was very negligible of 0.10 per cent. It is noteworthy to point out that the non-workers comprise a large proportion of 68.08 per cent of the urban population in Delhi in 1991. Almost a similar trend of classification of workers was found to exist for the rural areas over the period from 1981 to 1991 as is evidenced by Table 4.

CLASSIFICATION OF WORKERS	TOTAL		RURAL		URBAN	
	1981	1991	1981	1991	1981	1991
<i>Total Workers</i>	32.19	31.64	30.15	29.12	32.35	31.92
Main Workers	31.93	31.51	28.49	28.75	32.20	31.82
Marginal Workers	0.26	0.13	1.66	0.37	0.15	0.10
Non-Workers	67.81	68.36	69.85	70.88	67.65	68.08
<i>Total</i>	100.00	100.00	100.00	100.00	100.00	100.00

Table 4: Classification of Workers

7.2 Workers by Economic Sectors

The total main working population of Delhi can be bracketed into three broad sectors of economy, viz: (1) primary; (2) secondary; and (3) tertiary. Under primary sector come activities related to direct produce from the earth, e.g. agricultural produce, animal husbandry and mining and quarrying. In the secondary sector come manufacturing, processing, repairs and servicing at household and other than household industry and construction. The tertiary sector covers trade and commerce; transport, storage and communications; and other services.

ECONOMIC SECTORS	TOTAL		RURAL		URBAN	
	1981	1991	1981	1991	1981	1991
Primary Sector	3.81	2.85	35.62	18.53	1.61	1.26
Secondary Sector	34.87	32.43	24.41	31.58	35.59	32.51
Tertiary Sector	61.32	64.72	39.97	49.89	62.80	66.26
<i>Total</i>	100.00	100.00	100.00	100.00	100.00	100.00

Table 5: Classification of worker by different sectors of economy

As is evidenced by Table 5, the main workers distribution among the different sectors of economy as the primary, secondary and tertiary were as 1.26 per cent, 32.51 per cent and 66.26 per cent, respectively of the total urban main workers in 1991, thus showing an overall predominance of the tertiary sector. The overwhelming concentration of 66.26 per cent workers in tertiary sector may help in measuring the index of progress and all-round development. Almost a similar pattern of workers distribution in different sectors of the economy is found to exist in the rural areas too as is witnessed by the Table 5. So, the economy of Delhi is mostly trade, industry and service-oriented. Manufacturing, public administration and trade account for the bulk of the total income of Delhi. Agricultural sector is not very important due to the fast pace of urbanisation process which is progressively reducing the share of cultivated land. Most prominent occupation is administrative services, followed by industrial employment and self-employment in trade and commerce. Thus economically, Delhi performs three functions viz., central administration of the country; servicing, commerce and trade. Delhi is also a dry-port handling all imports and exports of northern and central zones and is a centre for manufacturing and distribution of a variety of consumer and industrial goods. According to the functional classification criteria, Delhi remained a bi-functional town with the classification as a service-cum-industrial town in 1981. In 1991, imbibed by functional character with a somewhat deviation, Delhi also turned as an industrial-cum-service town. Similarly in 1991, the bi-functional character of Delhi almost remained unchanged.

7.3 Workers by Industrial Categories

The distribution of main workers among the industrial categories in Delhi is presented in Table 6. Due to the predominantly urban character of Delhi, a negligible proportion of 0.32 per cent of the total main workers was cultivators in 1991. Likewise, 0.81 per cent of the total main workers were gainfully engaged as agricultural labourers in 1991. Whereas in rural economy of Delhi, the role of agricultural labourers is quite important. But they do not get sufficient work round the year and, as such, their proportion has remained almost unchanged from 1981 to 1991. Only at the time of harvesting season, they remain gainfully employed as is evidenced by the Table 6.

Industrial Categories	Total		Rural		Urban	
	1981	1991	1981	1991	1981	1991
Cultivators	1.75	1.12	21.43	9.07	0.39	0.32
Agricultural Labourers	0.81	0.85	8.82	6.37	0.26	0.29
Livestock etc.	0.83	0.60	2.58	1.59	0.70	0.54
Mining & Quarrying	0.42	0.24	2.79	1.50	0.26	0.11
Household Industry	1.69	1.41	1.67	1.74	1.69	1.37
Non-Household Industry	26.95	23.22	18.86	21.02	27.51	23.44
Construction	6.23	7.80	3.88	8.82	6.39	7.70
Trade & Commerce	21.16	23.9	5.35	13.43	22.26	24.97
Transport, Storage & Comm.	9.00	8.30	8.04	9.28	9.07	8.20
Other Services	31.16	32.52	26.58	27.18	31.47	33.06
Total	100	100	100	100	100	100

Table 6: Percentage distribution of main workers by industrial categories

Besides this, the proportion of the main workers engaged in the livestock, forestry, plantation and allied activities at the 1991 was 0.54 per cent of the total main workers. The main reason for such a negligible proportion in these occupations has been due to the fast pace of urbanisation. In Delhi, not much reserved forests are left for the successful continuance of occupations like forestry. Besides, the rural folk finding the rearing of livestock not much remunerative for want of grazing fields and continuous rise in the cost of cattle feed like fodder etc. are thus giving it up in exchange of some other vocation. Hence, the number of agricultural labourers has decreased from 1981 to 1991 in rural areas. Beside this, the mining and quarrying category accounts for a very negligible proportion of workers.

Workers engaged in manufacturing, servicing and repairs at household industry was 1.37 per cent in 1991 as against 1.69 per cent in 1981. Whereas the proportion of workers engaged in manufacturing, processing, servicing and repair other than household industry was 23.44 per cent in 1991. In 1981, it was 27.51 per cent. The house-building activities in Delhi are steadily increasing in accordance with the fast pace of urbanisation. In construction category activities are mainly included masons, beldars and house building contractors. The contribution of construction workers to total main workers in Delhi was 7.70 per cent in 1991 which was slightly lower as 6.39 per cent in 1981.

Delhi has all along been a centre of numerous trade and business activities. On account of Delhi's favourable and central location, many trade and business activities flourished here. According to the house listing operations (1980), the number of census houses used as shops and business establishments (excluding eating houses) was reported as 90,354 or 6.19 per cent of the total occupied houses. Proportion of workers to total main workers engaged in the trade and commerce was 24.97 per cent in 1991 as against 22.26 per cent in 1981 Census. The cheapest means of passengers transport in Delhi are the buses provided by the Delhi Transport Corporation (D.T.C.) and the Delhi Metro which is under construction. There is a well developed network of road and rail transport in Delhi. The Food Corporation of India which was inaugurated on 14th January, 1965 with multifarious objectives in respect of food grains strategy, attempts to provide proper storage facilities for grain. The contribution of transport, storage and communications workers to total main working population at 8.20 per cent in 1991 seems to be quite nominal in Delhi. The corresponding percentage was 9.07 in 1981.

Finally, the other services category constitutes a wide variety of economically productive workers who have not already been covered by any of the preceding industrial categories. The type of workers that come under this category includes doctors, barbers, political and social workers, all government servants, teachers, priest, musicians as well as those working in private services like domestic servants etc. This category claims the highest proportion amongst all the categories. However, the proportion of workers of this category to total main workers has increased marginally from 31.47 per cent in 1981 to 33.06 per cent in 1991. Consequently, the first hypothesis is tested with the evidences cited above that the increasing pressure of population in Delhi which is largely absorb in the unorganised and tertiary sector activities is responsible for expansion of urban areas and thus leading to hyper-urbanisation.

8. STATE OF URBAN ENVIRONMENT

Urban Population, industry and commerce are causing acute and serious environmental problems in Delhi. There are many infrastructure facilities like the housing, water supply, roads networks, education, health services, etc., which have been unable to keep pace with the prevailing pace of urbanisation in Delhi. So, the land-environment is under intense stress, for instance the Delhi faces air pollution problems from three major sources as transport, energy, and industrial sectors. The maximum contribution of 72 per cent is attributed to vehicles, the fleet of which is growing rapidly. The number of registered vehicles has also increased nine-fold since 1970-71. This rise in registered vehicles is primarily due to the increase in personalised vehicles, which, in turn, has resulted in high pollution loads and large-scale congestion in Delhi. At the busy Bahadur Shah Zafar Marg intersection, the annual average carbon dioxide (CO) concentration ranged between 2.7 to 5.6 mg/m³ in comparison to standard of 2.0 mg/m³ for residential and other areas.

While the global movement is towards greening of the environment. Whereas the Delhi is losing its share of greens cover. Such as it has merely 88 sq. km of forest cover out of the total geographical area of 1,483 sq. kms. In other words, the forest covered area is representing only 5.93 per cent of the total area. The Delhi Ridge forests, which served as 'green lungs' for Delhi, have dwindled considerably in some pockets during the past periods mainly due to human interference in the form of encroachment for construction of buildings, roads, settlements, parks, grazing, and even garbage dumping (Kaur et. al., 2001). In spite of the fact that the significance of the ridge was routinely mentioned in heavy words in the Master Plans of Delhi – MPD-1962, MPD-2001 and MPD-2021 (plan preparation under process). However, ever since 1913, when the Delhi Ridge was first declared as a Reserved Forest, the battle for protecting it has continued in fits and starts.

9. CONCLUSION

The increasing pace of urbanisation has resulted into the large scale agriculturally productive land degradation in Delhi. There is also widespread natural vegetation destruction all over the Delhi Ridge resulting into the shrinkage of 'Green Lung' of Delhi. Sustainable urban development is the most important concern in Delhi's current environmental crisis. However, at this stage, Delhi lacks an integrated system and a relevant database to measure the environmental quality, to manage it, and also to evaluate the effectiveness of the management actions. Until such knowledge gaps are plugged, the action plans to ensure a sustainable environment development in Delhi cannot be initiated. Due to high population pressure and large industrial and commercial activities, the high economic proficiency of Delhi has now manifested itself as the root cause of serious environmental problems. Housing, water supply, transport network, drainage, education, health services, etc. have not been able to keep pace with the prevailing urban growth rates in Delhi. The World Bank study has also recognised the need for radical changes in urban development policies to reduce deficiencies in services, institutional restructuring, and making it more efficient and responsive to the changes. Consequently, the work carried out will add to our knowledge on the sustainable urban environmental development in Delhi.

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BIOGRAPHICAL NOTES

Academic Degrees: I graduated in Geography subject from the Delhi University (DU) with the B.A. (Hons.) degree in Geography in the academic year 1985-86. I pursued my career for higher education to earn the professional degrees of the Master of Arts (M.A.) in Geography and the Master of Philosophy (M.Phil.) with specialisation in the field of ‘Urbanisation and Economic Development’. The Jawaharlal Nehru University (JNU) awarded M.A. and M.Phil. degrees to me in the academic year 1987-88 and 1989-90 respectively. The degree of Doctor of Philosophy (Ph.D.) in the field of ‘Ecology and Development’ has awarded to me in the academic year 1997-98 by the Jawaharlal Nehru University, New Delhi.

Awards and Honors: I had qualified the National Entrance Test (NET) in the Human Geography subject for the award of Junior/Senior Research Fellowships (JRF/SRF) and eligibility for lecturership by the University Grants Commission (UGC), New Delhi.

Academic Positions held: Since the last three academic years i.e. the 24th October, 2000 to date I am working permanently as a Lecturer in Geography in the Department of Geography, Faculty of Natural Sciences, Jamia Millia Islamia (Central University), New Delhi. Earlier, during the periods 25th March, 1996 to 23rd October, 2000 worked with the Jawaharlal Nehru University, New Delhi.

Selected Research Publications: I have authored for a book on the theme of ‘Ecology and Development’, which has published in India in January 2000. I have also contributed by publication of number of research papers, which have been appeared in several reputed journals both at the national and international levels on the issues of Ecology and Development, Climate Change, Spatial Data for Environment Management, and GIS and Remote Sensing Application for Mapping and Modeling of Social Life Styles.

Membership of Professional Societies/Organisations: I am the life member of the two professional societies – the National Association of Geographer, India (NAGI); and the Association of Population Geographers of India (APGI); and the associate member of the Boovigyan Vikas Foundation (Foundation for Earth Sciences Development), New Delhi, India.

Paper Presented in International Congresses/Conferences: I had participated and assisted in organization of the International Symposium on the theme of ‘Population Growth in Developing Countries’ held at New Delhi in 1993 in Jawaharlal Nehru University (JNU) in association with the International Geographical Union (IGU), France. In addition to this, I had also participated in the XIXth ISPRS Congress Amsterdam 2000, The Netherlands on the theme of “Geoinformation for All”; the Vth ICORG 2001 International Conference, Hyderabad, India, on the theme of “Spatial Information Technology”; the XXII FIG 2002 International Congress on the theme of “Geomatics and Property Valuation for Global Sustainable Development”, Washington, D.C. United States of America; and the FIG Working Week 2003 and 125 Anniversary of FIG Congress, main theme was “Still on the Frontline”, Paris, France.

Foreign Travels/Countries Visited: I have traveled and visited to foreign countries like the Royal Netherlands (Holland), Amsterdam in 2000; the United States of America (USA), Washington, D.C. in 2002; and the France, Paris in 2003.

CONTACTS

Dr. Madan Mohan
Jamia Millia Islamia (Central University)
Department of Geography, Faculty of Natural Sciences, Jamia Millia Islamia (Central University)
New Delhi
INDIA
Tel. + 91 11 2601 1290, Res, + 91 11 2698 1717 Ext. 3310 & 3312
Fax + 91 11 2698 0229
Email: roshnlal@ndb.vsnl.net.in, Res.; drmdnmohan@yahoo.com, Off.
Web site: <http://www.jmi.nic.in>