

3-D Digital Modelling using Multi-Spectral Remote Sensing Imagery: A Study of Million+ City, Faridabad, Sub-Region of Central NCR, Haryana State, India

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Objectives and Research Questions

The main objectives of the present study are mentioned as follows:

- to geovisualize population pressure on urban landscape;
- to identify spatio-temporal patterns of urban land transformation;
- to developed 3-Dimensional urban landscape simulation model;
- to suggest suitable strategies for urban and regional development.

The present study has also been enquired to the process of urban sprawl which is a challenging task for the urban development authorities, therefore, seeks to answers a number of research questions in detail which are mentioned as follows:

- How has the urban population growth took place in the past century?
- What are the geospatial patterns of land use from 1972 to 2009?
- Which are the impacting factors responsible for the urban sprawl?
- What are the most suitable strategies for urban development?

So, the present research has made an attempt to help urban planners and policy makers.



Study Area

- ❑ Faridabad City is situated between 28° 20' to 28° 13' north latitudes and 77° 13' to 77° 19' east longitudes.
- ❑ The city is located in the southern part of Haryana State.
- ❑ It is located at about 32 kms. from the National Capital Territory (NCT) Delhi.
- ❑ The city is bounded on the north by Delhi State, on the east by Agra and the Gurgaon canals and on the west by the Aravalli Hills.
- ❑ The River Yamuna flows very near to the city at its northern side and moves away as it goes southern side as is evidenced by the Figure.
- ❑ The present geographical area of Faridabad City is 207.88 sq. km.



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Study Area ...

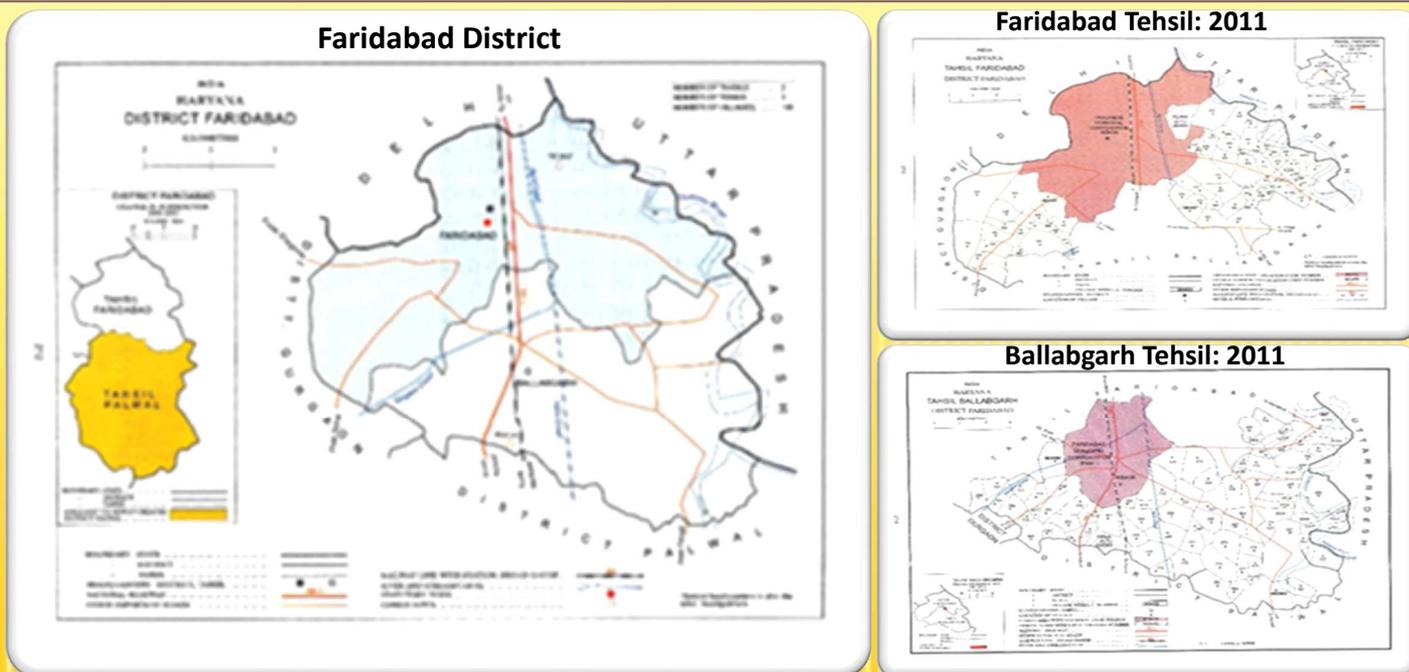


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Study Area ...

- It is well connected with both the roadways and the railways transport networks lines. The city evolved linearly along these two major transport corridors.
- The National Highway, NH-2 from Delhi-Mathura passes through the length of the city and is the central axis of Faridabad city.
- The city has strong transport network linkages with Delhi. It has importance both commercially and economically.
- Further, the NH-3 and NH-4 also pass through the city. It is connected with the Gurgaon District by the Gurgaon-Faridabad road.
- As part of NCR proposals, connectivity is proposed for further improvement through the western peripheral expressway (Kundli-Manesar-Palwal –“KMP”) and eastern peripheral expressway (Kundli-Ghaziabad-Palwal – “KGP”).



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Study Area ...

- ❑ The Faridabad City is one of the important million+ population city of the Haryana State in the Sub-Region of National Capital Region (NCR).
- ❑ In other words, the Faridabad city is the only million+ population city in the state and has Municipal Corporation.
- ❑ The city is an important industrial and trading centre in Delhi Metropolitan Area (DMA). Unfortunately, the city has reached a point where the lack of infrastructural facilities is having an impending impact on its horizontal and vertical growth.
- ❑ The pride of this million+ city, which it enjoyed earlier and more appropriately in the recent past years, was robbed by the emergence of the cities in its neighbourhood like the Gurgaon City, Haryana and the NOIDA City, Uttar Pradesh.



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Database

- ❑ IRS – National Remote Sensing Centre (NRSC), Indian Space Research Organization (ISRO), Department of Space (DOS), Hyderabad, India.
- ❑ Landsat – United States Geological Survey (USGS) website.
- ❑ Survey of India (SOI) open series topographic sheets numbers H43X3, H43X7, H43X8 and H43X12 drawn on scale of 1: 50,000 and 1: 25,000

The details of the remote sensing satellite imagery used in the present study is given in the Table below:

Date of Acquisition	Satellite	Sensor	Spatial Resolution (in meters)	No. of Spectral Bands	No. of Spectral Bands Used	Wavelength (in micrometers)
1972	Landsat-2	MSS	80	4	4, 5, 6	0.50-0.60 0.60-0.07 0.70-0.80
1997	IRS-1C	LISS-3	23.5	4	2, 3, 4	0.52-0.59 0.62-0.68 0.77-0.86
1999	Landsat-7	ETM+	28.5	7	2, 3, 4	0.52-0.60 0.63-0.69 0.76-0.90
		PAN	14.5	1	8	0.52-0.90
2006	IRS-P6	LISS-3	23.5	4	2, 3, 4	0.52-0.59 0.62-0.68 0.77-0.86
2009	Landsat-5	TM	28.5	7	2, 3, 4	0.52-0.60 0.63-0.69 0.76-0.90

Notes: Image courtesy of the U.S. Geological Survey (USGS), United States of America
Image courtesy of the National Remote Sensing Centre (NRSC), Hyderabad, India



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Database

- Census of India 2001 and 2011 – Primary Census Abstract, Final Population Total, Village and Town Directory and the Census Atlas – Faridabad District and Haryana State.
- Development plans and policies, records, reports and documents published by the States and Central Government departments and ministries have also been used in the present study.
- Department of Urban Development, Ministry of Urban Development, Govt. of India, New Delhi.



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Research Methodology

- 3-D visualization of remote sensing images through digital processing and high precision DEM modelling.
- GIS spatial analysis tools have been applied to combine three-dimensional images directly for the design of urban landscape environment.
- Virtual reality technology is used to simulate three-dimensional flight, to preview urban landscape, and penetrate to simulation design on various aspects of urban landscape to greatly enhance the rationality and accuracy for 3-D modelling and city design for urban sprawl.
- 3-D digital urban modelling has also been generated using the CityEngine algorithm which was developed by the Environmental System Research Institute (ESRI), Redlands, California, United States.



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Research Methodology ...

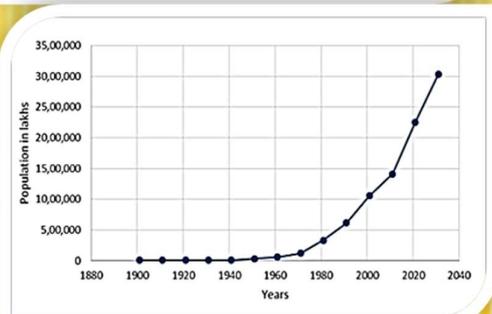
	Level-I		Level-II		Level-III
1	Built-up Land	1.1	Compact Settlements	1.1.1	Unplanned Residences
		1.2	Sparse Settlements	1.2.1	Planned Residences
				1.2.2	Industrial Units
2	Forests Cover Land	1.3	Unbuilt-up Space		
		2.1	Protected Forests	2.1.1	Natural Vegetation
		2.2	Reserved Forests	2.2.1	Tree Plantation
3	Water Body	3.1	River Channels	3.1.1	Yamuna River
		3.2	Canals	3.2.1	Agra & Gurgaon Canals
		3.3	Lakes/Ponds	3.3.1	Badkal Lake
4	Cultivated Land	4.1	Agricultural land	4.1.1	Cropped land
				4.1.2	Fallow land
5	Transportation Network	5.1	Roadways	5.1.1	Metalled Roads
				5.1.2	Unmetalled Roads
		5.2	Railways	5.2.1	Railways Tracks/Stations
6	Aravalli Hills	6.1	Hills Ranges	6.1.1	Undulating Terrain
7	Others	7.1	Wastelands	7.1.1	Barren lands
				7.1.2	Brick Kilns



Growth Trends of Population

- ❑ Faridabad as a town is known to have been founded in 1607 A.D. with the objective of protecting the highway which passed through the town.
- ❑ Faridabad city is developed in a planned way on modern town planning lines based on the urban-industrial development.
- ❑ During the initial periods of the 20th Century, the growth rate of population was highly fluctuated due to the occurrence of sever epidemic and natural calamities in the north western province of the India
- ❑ City population increased to three-fold 37,393 in 1951 as compared to 11,475 in 1941 due to the huge influx of in-migrants
- ❑ Later on, the city expansion was based on the planning in which more emphasis was given for the urban-industrial development. It has resulted into more population concentration as the population more than doubled in 1971 as compared to 1961.

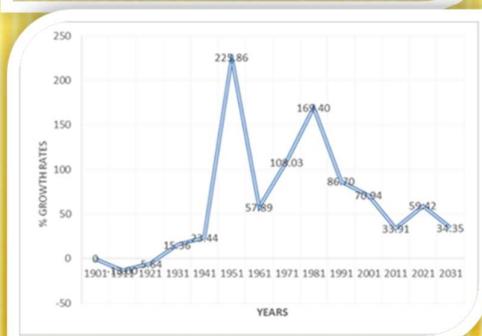
Year	Area (Km ²)	Population	% Growth	Density/Km ²
1901	-	9,816	-	-
1911	-	8,540	-13.00	-
1921	-	8,058	-5.64	-
1931	-	9,296	15.36	-
1941	-	11,475	23.44	-
1951	-	37,393	225.86	-
1961	25.75	59,039	57.89	2293
1971	25.75	1,22,817	108.03	4770
1981	178.24	3,30,864	169.40	1856
1991	178.24	6,17,717	86.70	3466
2001	198.75	10,55,938	70.94	5313
2011	207.88	14,14,050	33.91	6802
2021	207.88	22,54,233	59.42	10844
2031	207.88	30,28,501	34.35	14569



Growth Trends of Population ...

- There has been very slow population growth rate until 1931-41 period and thereafter experienced a fast growth as it is registered of 225.36 per cent during 1941-51; because a large number of refugees were settled down in the town.
- Whereas the growth rate slowed down during 1951-61 period to 57.89 per cent. Thereafter, it was picked up during 1961-71 and 1971-81 which was more than 100 per cent as is evidenced by the Table and Graph.
- During the periods 1981-91 and 2001-2011 the growth rate was further decreased. However, overall it still signifies that the city has been growing to its full potential as it attained of 105.59 per cent of the assigned population as per of the National Capital Region (NCR) Plan – 2001
- In other words, the city population was increased to about 10.56 million persons in 2001, and become the first metropolitan city of the Delhi Metropolitan Area (DMA). In addition to this, the Faridabad City is identified as one of the important million+ population cities of the Central National Capital Region of the NCR.
- Faridabad City constitutes about 35.50 per cent of the urban population of Haryana Sub-Region of the Central National Capital Region of the NCR.

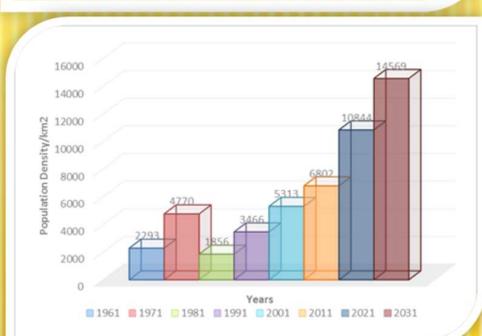
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Growth Trends of Population ...

- Faridabad City accounted for the density of population of 2,293 in 1961 which was increased to 3,466 persons per sq. kms. in 1991 and further increased to 5,313 in 2001 as is evidenced by the Table and Graph.
- Recently, there has been observed that the areas within Faridabad district towards Gurgaon city have been on high demand for fast paced urban growth and economic development; because the real estate activity has picked-up considerably in the region.
- For instance, the private builders and colonizers have developed and are in the process of developing large number of apartments, housing complexes and institutions in this transitional zone between the Faridabad and Gurgaon cities.
- Thus, it is responsible for the on-ward march of the process of urban sprawl in the area.

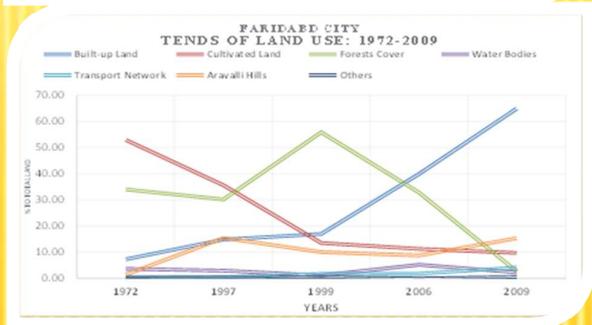
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Trends of Urban Land Use

- ❑ The urban land use classification has been worked out using multi-spectral satellite imagery based on the supervised classification algorithm of the image process for the period of 37 years from 1972 to 2009 for the Faridabad City.
- ❑ The multispectral high-resolution satellite imagery were classified into seven thematic classes as the Built-up land, Cultivated land, Forests cover, Water bodies, Transportation network, Aravalli hills and others. The pixel-based land use classification computed for the five periods 1972, 1997, 2000, 2006 and 2009 is presented in the Table and Graph.

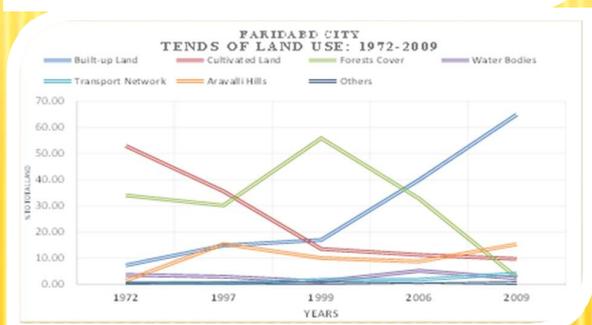
Classes	Years				
	1972	1997	1999	2006	2009
Built-up Land	7.31	14.90	17.02	39.94	65.02
Cultivated Land	53.00	35.64	13.56	11.32	9.77
Forests Cover	34.08	30.26	55.89	32.89	2.71
WaterBodies	3.67	3.00	1.14	5.21	2.33
Transport Network	0.20	0.43	1.79	1.85	4.21
Aravalli Hills	1.36	15.50	10.11	8.79	15.39
Others	0.38	0.27	0.48	0.02	0.57
Total	100.00	100.00	100.00	100.00	100.00



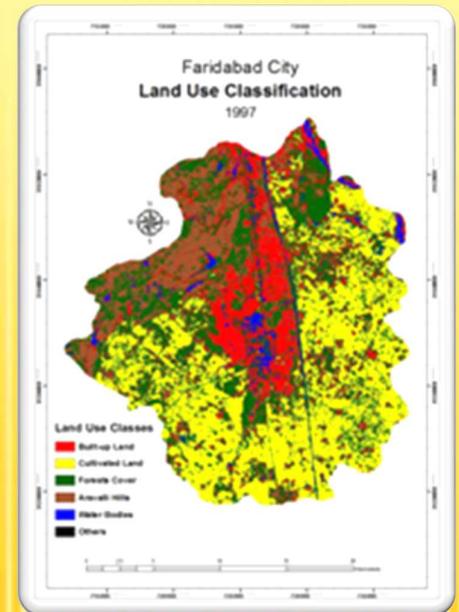
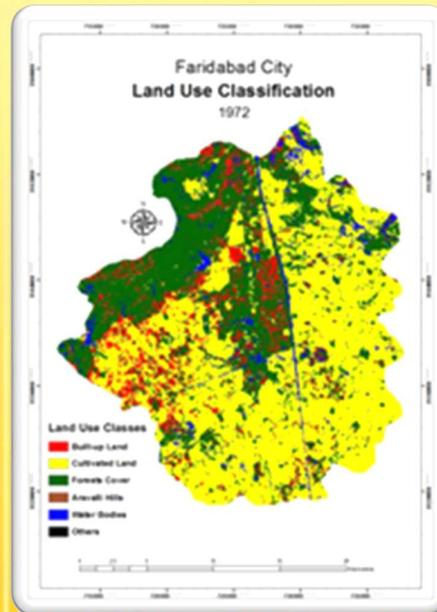
Trends of Urban Land Use

- ❑ The cultivated land comprises the largest proportion of 53.00 per cent of the total geographical area in 1972. Over the periods its proportion has been declined significantly, particularly from 1997 onwards from 35.64 per cent to 13.56 per cent in 2000 and 11.32 per cent and 9.77 per cent in 2006 and 2009 respectively.
- ❑ The land use classification result brought out significant facts as the proportion of built-up land has continuously been increased over the periods such as it is increased for about more than nine-fold from 7.31 per cent in 1972 to 65.02 per cent in 2009. The built-up land comprises by both the compact and sparse settlements. This is due to the stiff competition from the twin cities of Gurgaon and NOIDA cities of the Central NCR Region.

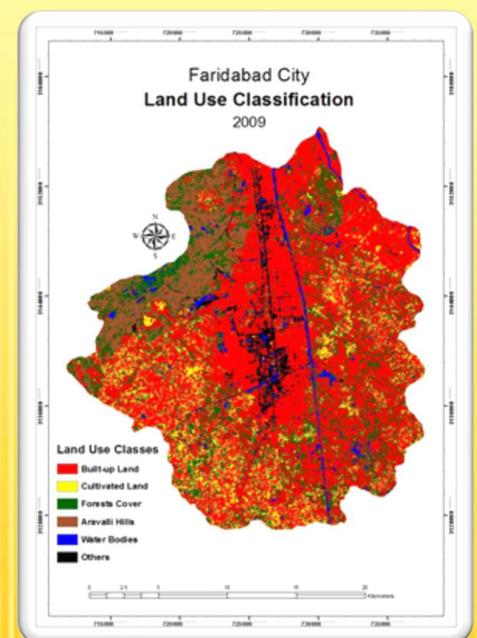
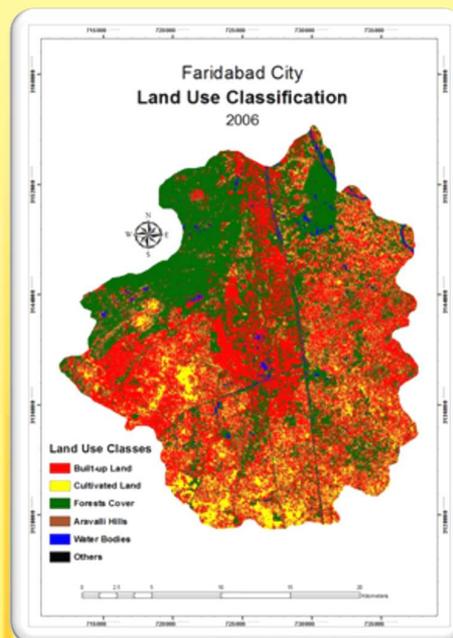
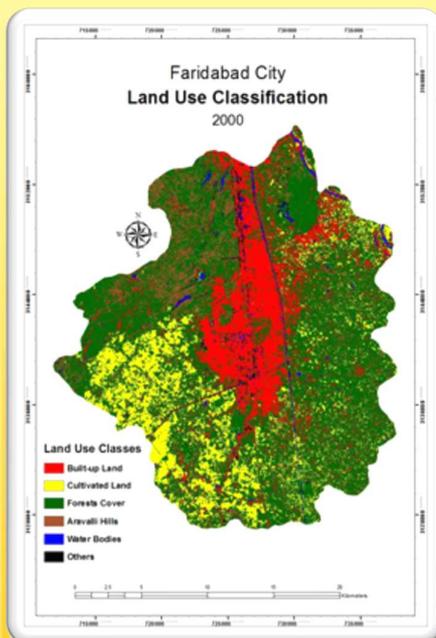
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Total	100.00	100.00	100.00	100.00	100.00



Spatial Patterns of Urban Landscape



Spatial Patterns of Urban Landscape ...



Urban Physical Landscape: EIA



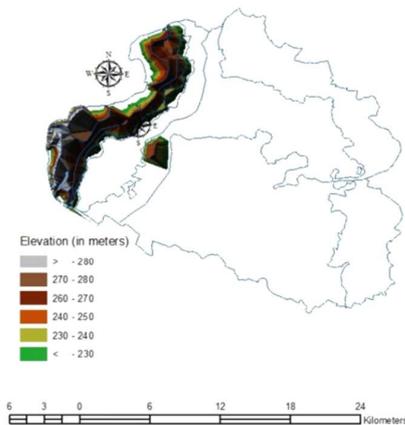
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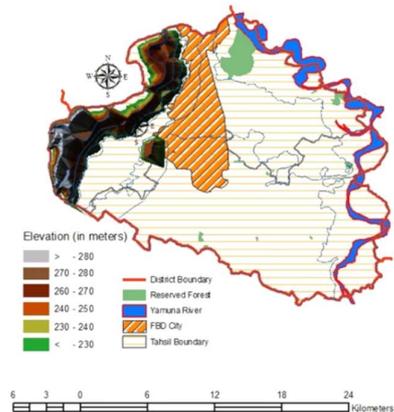


3-D Urban Landscape Model: Faridabad City

3-D Urban Landscape Model
Aravalli Hills



3-D Urban Landscape Model
Faridabad City



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Conclusions

- ❑ The 3-D urban landscape model represents the area under consideration fairly well and can be used for various planning and other urban development applications.
- ❑ Although the Faridabad city has locational advantages being very close to the south Delhi; but it is facing numerous problems, which may hinder its all-round urban development.
- ❑ The city is experiencing serious traffic bottleneck on the highway as inter-state traffic passes through this stretch of the transportation network. Further, within the city, most of the arterial roads are congested.
- ❑ The power and water supply is not very good and has not kept pace with the growing population and demand. The pollution in the city of Faridabad has broken all records. The fact is that the both air and water have been polluted to an alarming extent. Hence, the area along the highways are very much vulnerable to unauthorized development and may come in the way of planned development thereby putting enormous constraints on infrastructure development.



Conclusions ...

- ❑ The Faridabad city is slightly in disadvantageous position due to spread of the undulating topography of the Aravalli Hills, unlike the flat topography of Ghaziabad, NOIDA and Grater NOIDA cities of the Central NCR Region.
- ❑ So, the urban development authority has formulated the vision for a planned urban development of the Faridabad city. The Faridabad City Corporation is creating state-of-the-art infrastructure by providing incentive and encouragement to the investors both the public and private for creation of the quality infrastructure. At present, the city provides fair level of services.
- ❑ The 3-D urban landscape vision reflects the city's growth outlook both in terms of local potential, and to some extent its strategic positioning in the NCR region, especially near to the Delhi and also within the State's development framework.
- ❑ However, in order to achieve the overall vision for urban development, there should be balance in the priorities between growth related investments, poverty focused interventions and city management reforms for the urban development.



Recommendations

It is noteworthy to mention that in the Haryana sub-region, the pace of urban sprawl was much faster due to the govt. development plans and policies than in the other participating states of the NCR Region. The city has its own problems and often comes under the shadow of Delhi metropolis and unable to realize its own potential. Some of the major planning and developmental problems of Faridabad City are as follows:

- The economic base with declining industries and new economic activities coming-up in unplanned manner has disturbed the physical development of the city;
- the unauthorized colonization on agricultural land has resulted in unauthorized and uncontrolled development wherein there is an absence of basic infrastructure facilities on the one hand and it gives rise to numerous problems for planned development like regularization of colonies and augmentation of infrastructure services / facilities on the other.
- Furthermore, the lack of strict enforcement of Building Bye Laws and Master Plan provisions has also been responsible for haphazard development; the prevalence of non-conforming land use mainly in terms of offices, schools, hospitals, shops located in residential premises;



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Recommendations ...

- Due to absence of planned parking spaces, on-road parking of trucks, buses and other vehicles has created serious traffic and transportation problems;
- The absence of proper solid waste management has caused dumping of wastes into pits thereby resulting in pollution of land, air and water resources;
- The uneven distribution of water supply, absence of sewage system and drainage system has added to the woes of city infrastructure;
- The indiscriminate exploitation of ground water has led to drastic fall in the level of ground water. The absence of common Effluent Treatment Plan in the industrial areas of the city has led to mixing;
-
- So, the urban expansions are to be planned over the non-fertile agricultural land for sustainable urban and environment development which are the most important concerns for the new urban sprawling areas in the Haryana sub-region of the NCR at the threshold of the 21st Century;
- Moreover, the present research has made an attempt to help local, regional and state level land use planners and policy makers to better understand and address the issues attributed to urban sprawl.



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