Geospatial Information for Urban Sprawl Planning and Policies Implementation in Developing Country's NCR Region: A Study of NOIDA City, India

Dr. Madan Mohan
*Assistant Professor &
Principal Investigator, MRP-UGC*
**JMI Central University, New Delhi**

Research Objectives:

The objectives of the study are mentioned as follows:

i.   **to detect the spatial patterns of land use land cover changes over the periods;**

ii. **to examine the impact of population growth trends and patterns on urban sprawl;**

iii. **to see the impact of industrial development on urban sprawl;**

iv. **to explore suitable strategies for sustainable urban development.**

Research Questions:

i. What are the spatial patterns of land use land cover during 2001 to 2006?

ii. How the spatial urban sprawl growth impacted rural-urban fringe of NOIDA city?

iii. How are processes of economic development and industrialization boosted by the national and multi-national companies?

iv. Which are the suitable strategies for sustainable urban development for one of the fast growing city NOIDA?

Workflow Diagram of Methodology
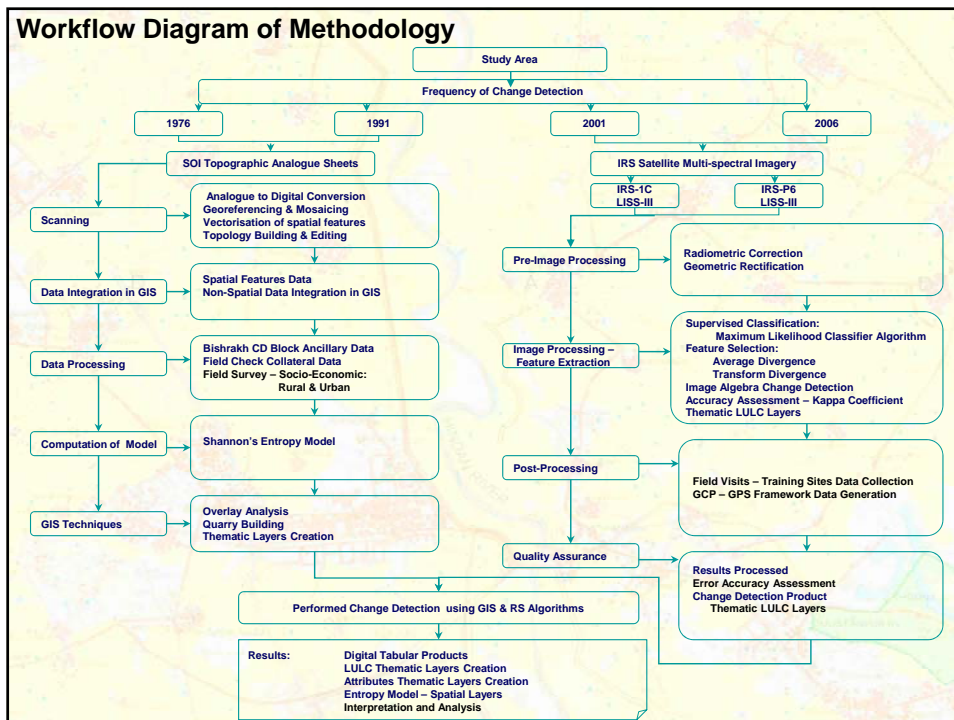
Entropy Model

Shannon's Entropy Index:

$$H = -\sum_{i} p i \, log\,(p i) \qquad -\sum_{i} p i \, log\,(1/p i) \qquad (10)$$

Max. or Min. Average Information

$$H_{max/min} = -\sum_{i} (1/n) \, log_{e} (1/n) \qquad = - \, log_{e}(1/n) \qquad = log_{e}(n) \qquad (11)$$

Shannon's Entropy Model
(ratio of eqn. 10 & 11)

$$E = H/H_{max/min}$$

$$E = -\sum_{i} p i \, log_{e}\,(p i)/ log_{e}(n) \qquad -\sum_{i} p i \, log_{e}(1/p i)/ log_{e}(n) \qquad (12)$$

$$E = \frac{Shannon's\ Entropy\ Index}{Max.\ or\ Min.\ Average\ Information}$$

Where:
$p i$ = proportion of variable occurring in the ith zone
n = total number of classes in the region

$$p i = x i / \sum_{i} x i$$

Where:
$x i$ = observed value in the ith zone in total of n zones

Degree of Dispersal

$$\Delta E = E(t + 1) - E(t) \qquad (13)$$
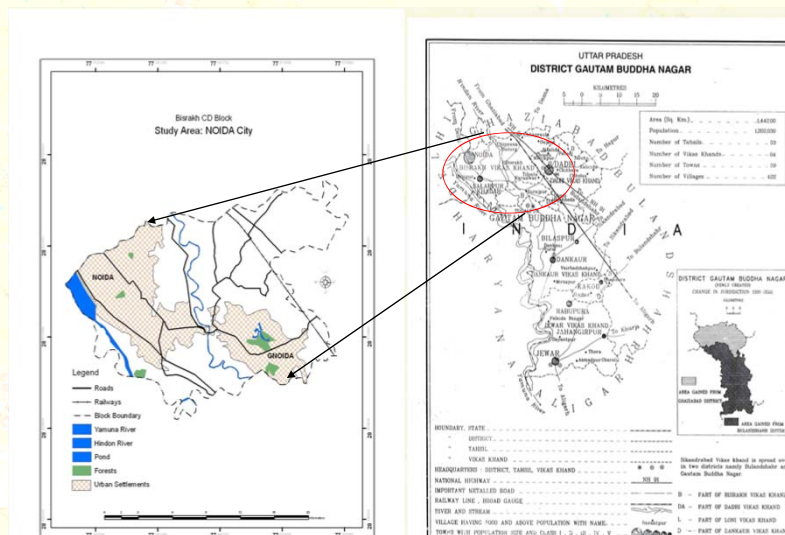
Where:
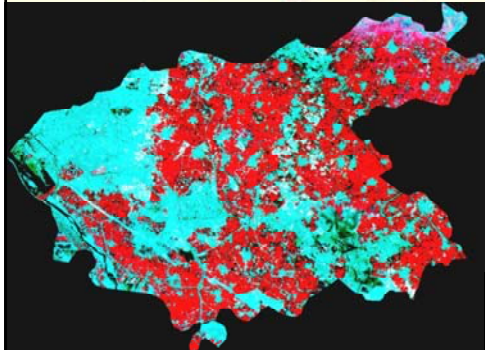ΔE = rate of change of entropy
$E(t + 1)$ = final entropy
$E(t)$ = initial entropy
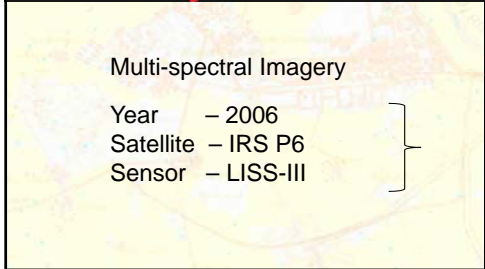

Study Area: NOIDA City

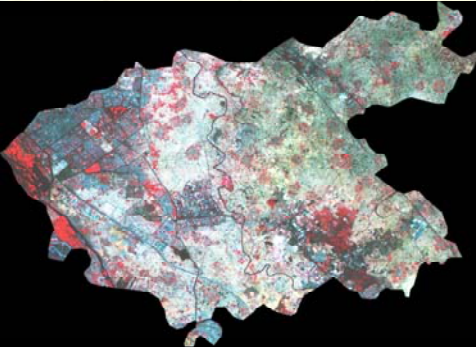## Sub-Set Imagery of Study Area: 2001 and 2006

Multi-spectral Imagery

Year   – 2001
Satellite – IRS 1C
Sensor – LISS-III

Multi-spectral Imagery

Year   – 2006
Satellite – IRS P6
Sensor   – LISS-III

Origin of NOIDA City: 1976

Villages	Settlements Are (in sq km)	Perimeter	Area Perimeter Ratio
Agahpur	0.10	1.40	0.0645
Atta	0.10	2.10	0.0251
Bishanpura	0.10	1.00	0.0583
Chora Sadatpur	0.60	3.20	0.0599
Harola	2.00	2.30	0.0458
Makanpur	0.10	1.30	0.0459
Morna	0.20	2.00	0.0557
Nayabas	0.10	1.10	0.0614
Nithari	0.20	2.50	0.0388
Raghunathpur	0.06	0.90	0.0598
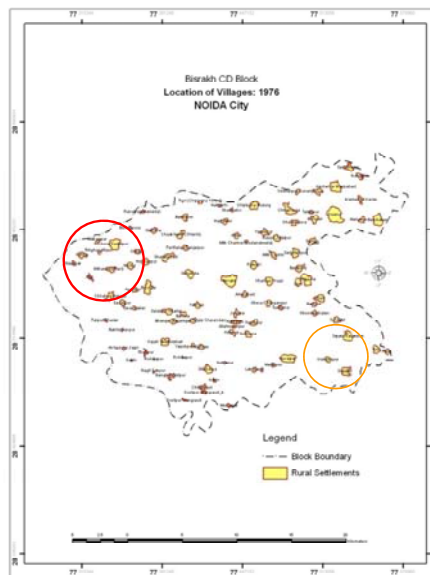
Land Use Land Cover Classification: 2001 and 2006
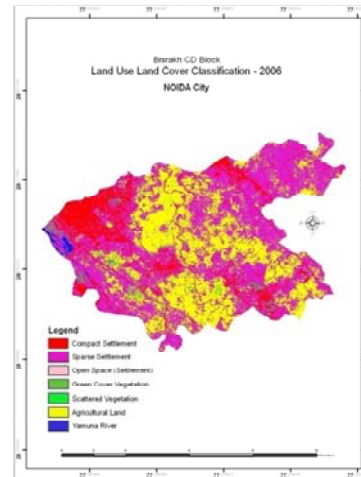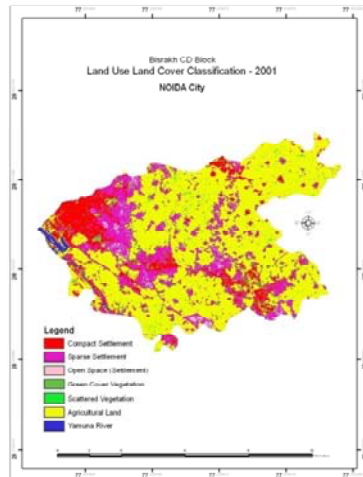
Pixel–Based Land Use Land Cover Classification: 2001

Class Name	Area	% Area
	(in Sq Km)	to Total
Compact Settlement	423.00	12.00
Sparse Settlement	587.50	16.67
Open Space (Settlement)	188.00	5.33
Green Cover Vegetation	211.50	6.00
Scattered Vegetation	47.00	1.33
Agricultural Land	1997.50	56.67
Yamuna River	70.50	2.00
Totals	3525.00	100.00

Source: **Computed from IRS-1C Satellite LISS – III Imagery**

Land Use Classification of NOIDA (Existing & Proposed)

Land Use Classification of NOIDA
(Existing & Proposed)

Land Uses Types	Area (in sq km)				
	1995	2001	2011	2011 (Revised)	2021
Residential	113.10	160.70	324.00	426.30	599.40
Commercial	13.20	3.60	66.00	31.80	52.40
Industrial	81.10	109.20	189.60	195.00	223.50
Institutional	15.20	57.10	78.20	80.10	134.40
Transport	36.50	101.30	130.20	129.80	264.40
Recreational/Public Utilities	9.20	20.80	54.00	117.70	177.60
Total Area	268.30	431.90	788.00	863.00	1274.10

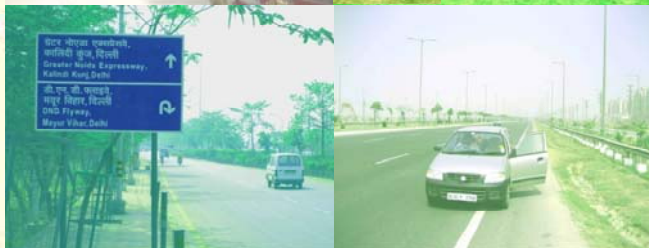| Land Uses Types	Area (in % to Total Area)				
	1995	2001	2011	2011 (Revised)	2021
Residential	42.15	37.21	41.12	49.40	47.04
Commercial	4.92	0.83	8.38	3.68	4.11
Industrial	30.23	25.28	24.06	22.60	17.54
Institutional	5.67	13.22	9.92	9.28	10.55
Transport	13.60	23.45	16.52	15.04	20.75
Recreational/Public Utilities	3.43	4.82	6.85	13.64	13.94
Total Area	100.00	100.00	100.00	100.00	100.00

Training Sites – Field Verification Checks:

NOIDA Golf Course

Greater NOIDA Expressway

River Yamuna & its Barrage

## Accuracy Assessment of LULC Classification: 2001 & 2006

Class Name	Producers Accuracy	Users Accuracy	Kappa Statistics
Compact Settlement	88.89%	94.12%	0.8712
Sparse Settlement	96.00%	92.31%	0.9367
Open Space (Settlement)	66.67%	65.43%	0.8341
Green Cover Vegetation	89.32%	90.00%	0.8556
Scattered Vegetation	79.86%	80.23%	0.9842
Agricultural Land	98.82%	98.82%	0.8964
Yamuna River	92.78%	95.13%	0.9154

Overall Classification Accuracy = 97.27%

Overall Kappa Statistics = 0.9595

Trends of Population Growth & Density in NOIDA City
(Existing and Proposed)

Year	Population	Area (in sq km)	Density (per sq km)	Growth Rate (%)
1981	35541	30.43	1168	-
1991	146514	90.43	1620	27.91
2001	305058	90.43	3373	51.97
2011	700664	90.43	7748	56.46
2021	915249	90.43	10121	23.45

NOIDA City
Trends of Population Growth: 1981-91 to 2011-21

NOIDA City
Trends of Population Density: 1981-2021
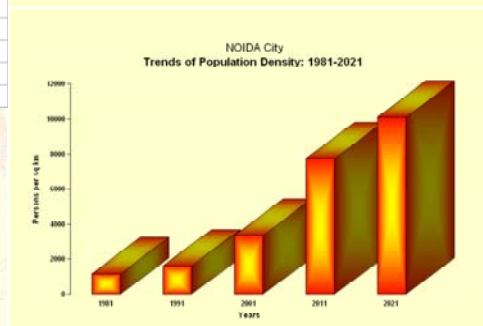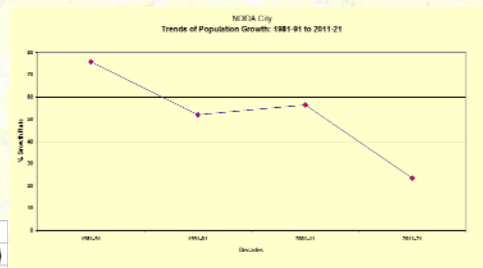
Industrial Estates in NOIDA & Greater NOIDA: 1999

| Industrial Estates	Area	No of Plots/	No of Plots/	Management
	Developed	Sheds	Sheds	Agency
	(in Acres)		Allotted	
NOIDA				
Industrial Area Phase-I, II & III	2432.95	7070	6895	NOIDA
NOIDA Export Processing Zone	310	251	200	Min of Comm.
Total	*2742.95*	*7321*	*7095*	
GNOIDA				
Surajpur Site-A	289	2	2	UPSIDC
Surajpur Site-B	303.3	493	402	UPSIDC
Surajpur Site-C	206.8	608	472	UPSIDC
Surajpur Site-IV	135.2	338	300	UPSIDC
Surajpur Site-V	360.9	953	684	UPSIDC
EPIP	200	404	42	UPSIDC
Udyong vihar	623.8	@623.8	*186.6 (29)	GNOIDA
Sector-31 Kasna	100.7	@100.7	*81.98 (47)	GNOIDA
Sector 40-41	239.4	@239.4	*212.8 (3)	GNOIDA
Udyog Kendra	452.5	@452.5	*207.5 (17)	GNOIDA
Toy City	70.9	@70.9	*31 (121)	GNOIDA
Mahila Udhyami Park	13.3	@13.3	*10.7 (57)	GNOIDA
Total	*2995.8*	*4298.6*	*2632.58*	
Grand Total	5738.75	11619.6	9727.58	

Source: **Compiled from the NCR Regional Plan 2000**

NOIDA City
## Workers Classification by Industrial Categories: 1991

Industrial Categories	Workers Classification	Workers	% Workers to Total
I	Cultivators	3425	7.09
II	Agricultrual Labourers	1782	3.69
III	Livestock, Forestry, Fishing, Hunting and Plantations, Orchards & allied activities	414	0.86
IV	Mining and Quarrying	12	0.02
Va	Household Industry	626	1.29
Vb	Other than Household Industry	13619	28.17
VI	Constructions	4404	9.11
VII	Trade and Commerce	7024	14.53
VIII	Transport, Storage and Communications	2039	4.22
IX	Other Services	14995	31.02
	Total	**48340**	**100.00**

NOIDA City
Industrial Workers Classification: 1991
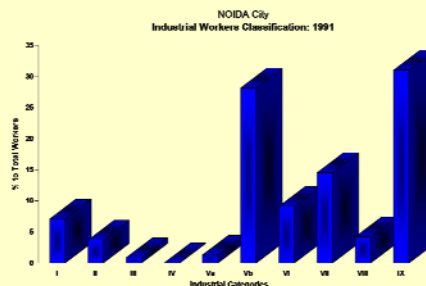
Patterns of Urban Sprawl: 1991 & 2001
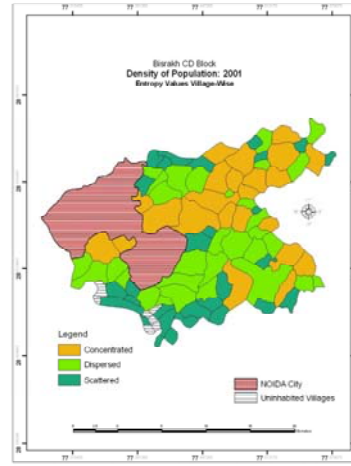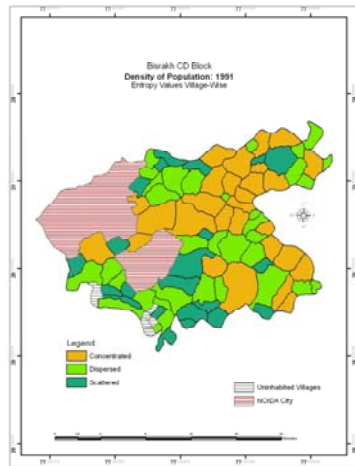
Spatial Patterns of Population Density: 1991 & 2001
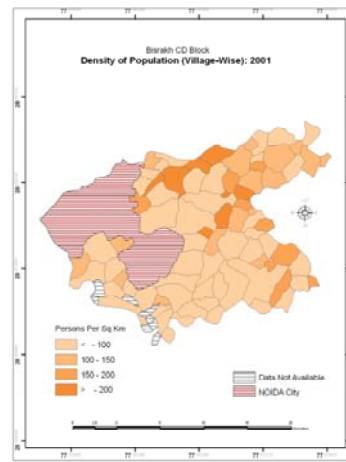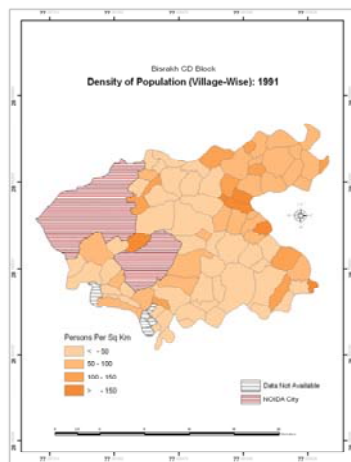
Urban Sprawl Growth Trends of NOIDA City: 1976 to 2006

Year	Sources	Area (in sq km)			% Growth
		NOIDA	GNOIDA	TOTAL	Rate
1976	SOI	34.10	0.00	34.10	-
1991	SOI	46.80	34.20	81.00	57.90
2001	IRS	79.20	49.60	128.80	37.11
2006	IRS	92.30	52.45	144.75	11.02

Source: **Survey of India, Topographic Sheets**
Indian Remote Sensing Satellite Imagery

Spatial Urban Sprawl Growth Patterns of NOIDA City: 1976 to 1991
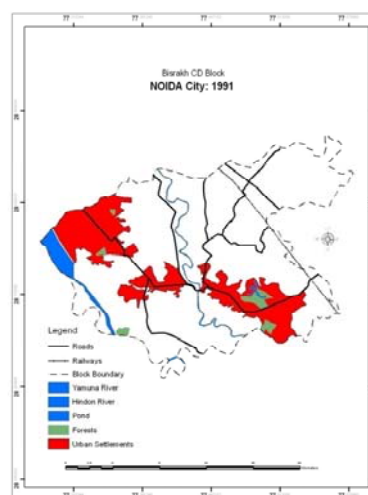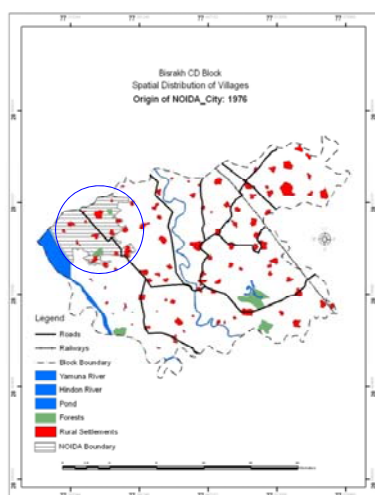
Source: **Survey of India, Topographic Sheets**
Indian Remote Sensing Satellite

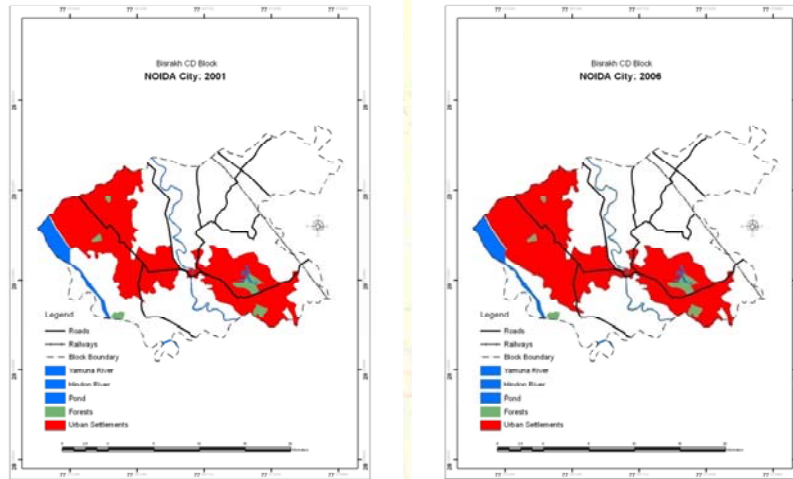**Spatial Urban Sprawl Growth Patterns of NOIDA City: 2001 to 2006**

Source: **Survey of India, Topographic Sheets Indian Remote Sensing Satellite**

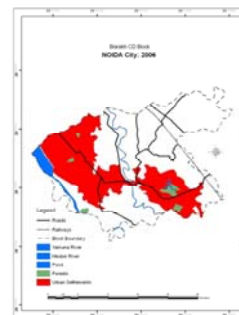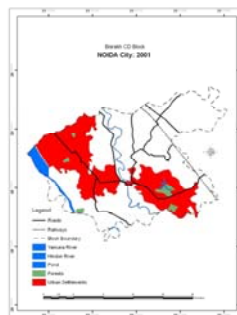**Origin & Spatial Urban Sprawl Growth Patterns of NOIDA City: 1976 to 2006**

Years	Sources	Area (in sq km)			% Growth
		NOIDA	GNOIDA	TOTAL	Rate
1976	SOI	34.10	0.00	34.10	-
1991	SOI	46.80	34.20	81.00	57.90
2001	IRS	79.20	49.60	128.80	37.11
2006	IRS	92.30	52.45	144.75	11.02
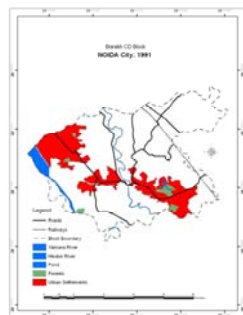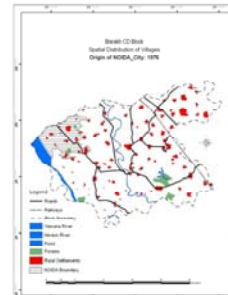
Spatial Growth Patterns of NOIDA City Region: 1976 to 2006

Bisrakh CD Block
Sprawl of NOIDA_City: 1976 - 2006

Legend
- 1976
- 1991
- 2001
- 2006

Legend
- Roads
- Railways
- Block Boundary
- Yamuna River
- Hindon River
- Pond
- Forests
- Rural Settlements
- NOIDA Boundary

Impacting Factors of Urban Sprawl - NOIDA City

HH Socio-Economic Profile

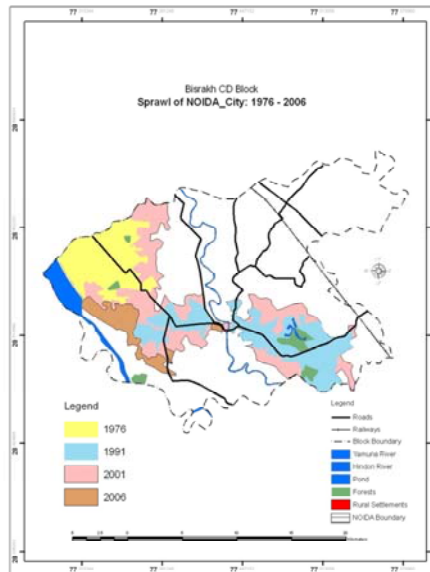| Size of Household				Monthly Income			
No of Persons	Frequency	Percent	Cumulative Percent	Income in Rs	Frequency	Percent	Cumulative Percent
2 to 4	3	12	12	10 to 20 k	10	40	40
4 to 6	8	32	44	20 to 40 k	11	44	84
> than 6	14	56	100	40 to 80 k	4	16	100
Total	25	100		Total	25	100	

Nature of Accommodation				Distance to Work Place			
Types of Accommodation	Frequency	Percent	Cumulative Percent	Distance (in km)	Frequency	Percent	Cumulative Percent
Own Property	18	72	72	Less than 5	11	44	44
Purchased Property	7	28	100	5 to 10	14	56	100
Total	25	100		Total	25	100	

Duration of Living				Work Place			
No of Years	Frequency	Percent	Cumulative Percent	Name of Place	Frequency	Percent	Cumulative Percent
Less than 5	7	28	28	NOIDA	15	60	60
More than 15 (Original Inhabitants)	18	72	100	GNOIDA	7	28	88
				Others	3	12	100
Total	25	100		Total	25	100	

Households Occupational Structu				Means of Convenience			
Kinds of Occupations	Frequency	Percent	Cumulative Percent		Frequency	Percent	Cumulative Percent
Government	4	16	16	Own Vehicle	15	60	60
Self Employment	7	28	44	Public Transport	7	28	88
Other (Retired)	14	56	100	Private Tranport	3	12	100
Total	25	100		Total	25	100	

Source: **Computed from the Primary Field Survey**

Urban Development

Urban Settlement Growth

Duration in Years	Frequency	Percent	Cumulative Percent
Less than 5	7	28	28
5 to 10	3	12	40
More than 15	15	60	100
Total	25	100	

Urban Growth

Reasons	Frequency	Percent	Cumulative Percent
Govt. Policies	22	88	88
Authoried Builders	3	12	100
Total	25	100	

Purpose of Construction

Kinds	Frequency	Percent	Cumulative Percent
Residential	4	16	16
Industrial	18	72	88
Commercial	3	12	100
Total	25	100	

Urban Amenities

Educational Facilities

Types of Accommodation	Frequency	Percent	Cumulative Percent
Colleges	3	12	12
School,Collges&Univ.	22	88	100
Total	25	100	

Health Services

Types of Services	Frequency	Percent	Cumulative Percent
Primary Health Centre	3	12	12
All of the above	22	88	100
Total	25	100	

Source of Drinking Water

Sources	Frequency	Percent	Cumulative Percent
Municipals	22	88	88
Electric/Hand Pumps	3	12	100
Total	25	100	

Electricity Power Breakdown (Hr

Number of Hours	Frequency	Percent	Cumulative Percent
2 to 4	15	60	60
4 to 8	10	40	100
Total	25	100	

Urban Amenities

Facilites	Frequency	Percent	Cumulative Percent
Post-Offices	3	12	12
Tel Connections & Commercial Banks	22	88	100
Total	25	100	

Social Infrastructures:

Nearest Shopping Complex

Distance in km	Frequency	Percent	Cumulative Percent
Less than 1	8	32	32
Less than 3	11	44	76
Less than 5	6	24	100
Total	25	100	

Recreational & Cultural Activities

Facilites	Frequency	Percent	Cumulative Percent
Stadium	3	12	12
Community Halls	14	56	68
All of the above	8	32	100
Total	25	100	

Industrial Development:

Industrial Development

Types of Industrial Establishments	Frequency	Percent	Cumulative Percent
Multi-National Companies	14	56	56
National & Multi-National Companies	11	44	100
Total	25	100	

Nature of Industrial Establishmen

Type of Industries	Frequency	Percent	Cumulative Percent
Medium Scale	14	56	56
Large Scale	11	44	100
Total	25	100	

Industrial Development

Types of Industries	Frequency	Percent	Cumulative Percent
Electronic Industry	13	52	52
Others	12	48	100
Total	25	100	

Infrastructure Development

Types	Frequency	Percent	Cumulative Percent
Roads	7	28	28
Railways	3	12	40
Metro	15	60	100
Total	25	100	

Proximity to Delhi

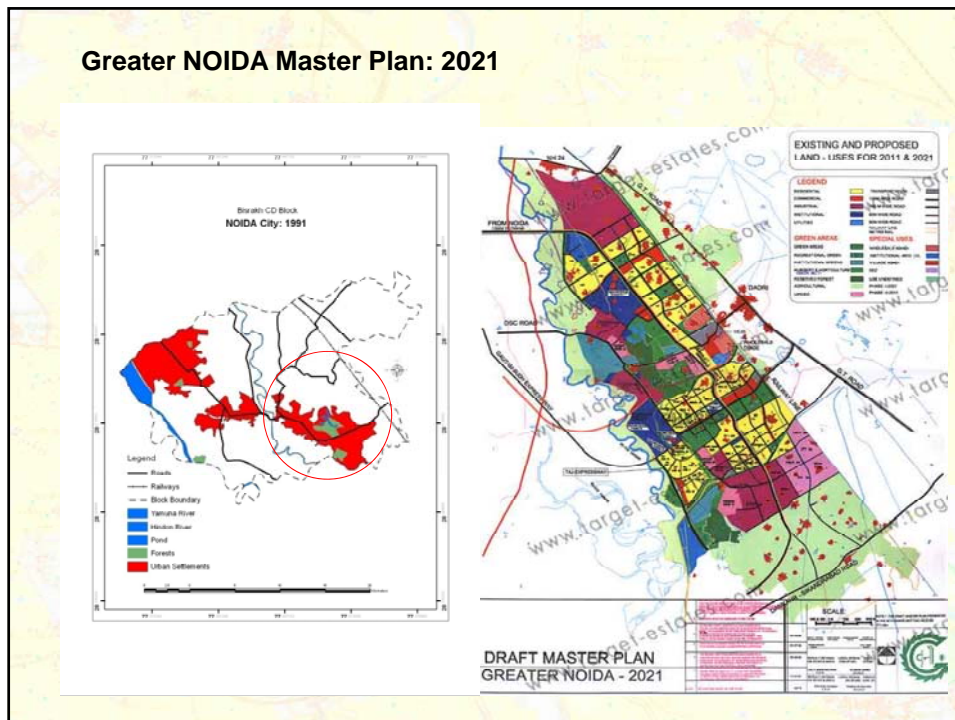| Workers	Frequency	Percent	Cumulative Percent
Skilled Workers	18	72	72
Semi-skilled Workers	3	12	84
Both of these	4	16	100
Total	25	100	

Modern Transport Infrastructure Development:
Extension of Delhi Metro in NOIDA City

Urban Development Planning - NOIDA Master Plan 2021
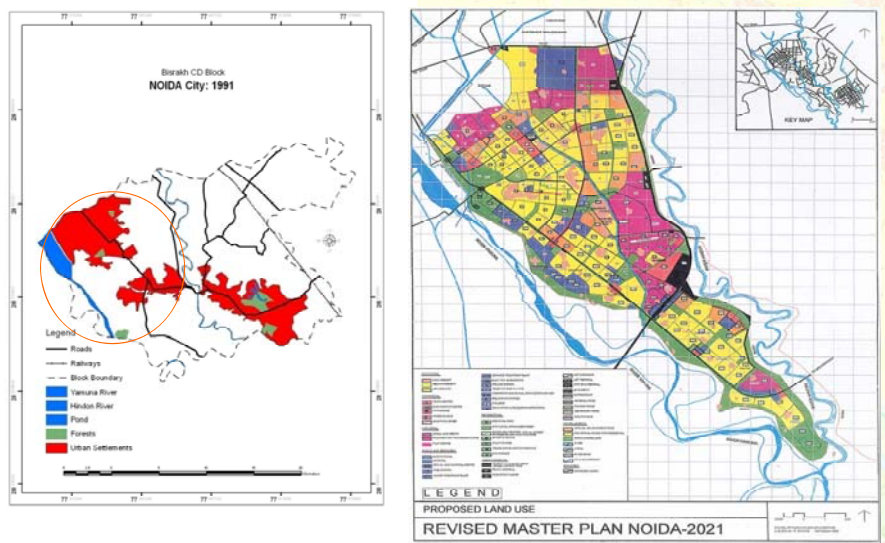
Greater NOIDA Master Plan: 2021

15

Conclusions :

An increase in the urban area comprises by the compact, sparse and open space settlements in NOIDA and GNOIDA.

There is scattered urban sprawl in the peripheral area i.e. the rural-urban fringe. The entropy values are the highest in this case among the number of villages surrounding to the NOIDA city.

The village Sadarpur Khadar has been agglomerated in the NOIDA City as an urban village in 2001.

There has come up the number of industries and settlement sites all along the recently built the Greater NOIDA Expressway.

A majority of 72 per cent has their own accommodation in urban village.

More than 72 per cent of the household are living more than 15 years because they are the original inhabitants of urban village of NOIDA City.

Urban amenities - the 88 per cent resident are satisfied with the type of educational facilities of school, college and university, primary health centres , municipal tape water supply etc.

56 per cent responses regarding the multi-national companies' establishment

Urban Sprawl factors - the govt. policies, educational institutions, amenities - health services, national and multi-national companies establishment

Recommendations:

Urban expansions is to be planed on the non-fertile agricultural land for sustainable urban and environment development.

Need for the spatial distribution of population which can reduce the pressure in the adjoining villages of the NOIDA city.

The process of urban sprawl is engulfing to the rural villages

The original inhabitants of the area are denied to avail such basic amenities

Balance social and economic development to the rural-urban fringe area.

So, people's opinion must be kept in the development planning process so that even sustainable urban development can taken place.

Selected References:

Jension, John R. (1996) Introductory Digital Image Processing: A Remote Sensing Perspective, New Delhi, Prentice Hall of India Pvt. Ltd.

Lillesand, Tomas. M. and Kiefer, Ralph W. (2002) Remote Sensing and Image Interpretation, New York, John Wiley & Sons, Inc.

Ansari, J.H., Sharma, A.K., Shaheer, M., Mahavir and Prakash, P. (2000) Revised Master Plan for Noida – 2021, School of Planning and Architecture, New Delhi.

Schowengerdt, Robert A. (1996) Techniques for Image Processing & Classification in Remote Sensing, Academic Press

Maguire D.J., Goodchild MF and Rhind DW (ed.) Geographic Information Systems: Principles and Applications, United Kingdom, Longman Scientifi & Technical

David Martin (1996) Geographic Information systems: Socioeconomic Applications, London, Routledge.

Yeh, A.G.O., and Li, Xia (2001). "Measurement and monitoring of urban sprawl in a rapidly growing region using entropy", Photogrammetric Engineering & Remote Sensing, 67(1), 83-90.

Zhang, Yan, Zhifeng Yang, and Wei Li. (2006) "Analyses of urban ecosystem based on information entropy", Ecological Modelling, Vol. 197, No. 1-12.

Reference Available On-line:
http://www.itc.nl
http://www.scirus.com
http://www.sciencedirect.com
http://www.sciencelink.jp
http://www.delhimetrorail.com
http://www.jmi.nic.in

Urban Sprawl Forms:
http://chesapeake.towson.edu/landscape/urbansprawl/