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## Unruly urbanisation on Delhi's fringe

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## APPENDICES

### A Technical details on Remote Sensing analysis

#### *Data*

Two IRS-1B images were used from the dates May 28, 1995 and March 31, 1996. The sensor operates in a multi-spectral four-band mode with a spatial resolution of 25 metres. The March 1996 image is from before winter harvest, while the May 1995 image is from after that harvest. A subarea, covering the rural urban fringe north of urban Delhi, was extracted. This study area encompasses the rural area of Alipur Block situated in the National Capital Territory of Delhi.

#### *Preprocessing*

Both images were georeferenced and atmospherically corrected. Georeferencing was based on six control points. The co-ordinates were derived from GPS field measurements at intersections of roads and/or canals and map co-ordinates. Co-registration displayed a total RMS error of approximately 0.5 pixel. In order to compare the two images, atmospheric correction was carried out. Raw reflection values were converted into calibrated radiances by subtracting the offset value, i.e. the minimum grey value.

For classification purposes, two false colour images were generated based on the near-infrared band 4 (0.77-0.88  $\mu\text{m}$ ), the red band 3 (0.62-0.68  $\mu\text{m}$ ), and the green band 2 (0.52-0.59  $\mu\text{m}$ ) with a 0.5% saturation. Furthermore a vegetation change cover map was prepared using the NDVI (normalised difference vegetation index). The NDVI is the result of rationing the near-infrared spectral band and the red spectral band. It enhances the variation in vegetation cover and is therefore an ideal tool for land cover classifications.

#### *Classification*

An unsupervised clustering did not give any satisfactory results. This may be attributed to the high level of heterogeneity of the study area, resulting in a large number of mixed pixels and small classes. Therefore, a supervised classification was carried out using the maximum likelihood classifier. That criterion is based on the probability density function associated with a particular training site signature. Pixels of unknown class are assigned to the most likely class based on a comparison of its signature with the signatures of the training sites that were considered.

Fourteen different classes were selected using the March 1996 false colour image and field data. A scatter diagram of spectral band 4 versus spectral band 3, derived from the signatures of the training sites, showed a large overlap in reflectance of agriculture, woodland and other types of vegetation cover. Furthermore the plot indicated that sufficient classes were selected to explain most of the variance in reflectance.

To overcome the problem of overlapping classes, the image of May 1995 was classified through a supervised classifier with special reference to vegetation cover. As this image

was acquired after the harvest, implying the virtual absence of crops, a more accurate identification and classification of woodland was possible. This woodland class was used as an overlay for the March 1996 classification.

To further improve the classification results, a comparison was made between both NDVI images. To study the change in vegetation cover, the May 1995 NDVI image was subtracted from the March 1996 NDVI image. The resulting image was reclassified into three classes: a negative change, a positive change, and little or no change in vegetation. A negative change in NDVI indicates a decrease in areas with vegetation. No change in NDVI is an indicator for vegetated areas that do not consist of agricultural crop harvested in April. A positive change in NDVI implies the existence of agricultural areas, harvested in April, and areas with an increase in vegetation cover from 1995 to 1996. These agricultural areas were used as an overlay for the March 1996 classification.

Finally, the land-use map consisting of fourteen classes was resampled into seven general classes. The results were carefully validated by a comparison with the detailed site descriptions from the field survey.

## B Statistical analyses with basic household surveys

Tables with the figures in Chapter 5.

### 5.4 Agricultural assets per socio-economic group

	Agricultural occup.			Commuting		
	Gr. I	Gr. II	Gr. III	Gr. I	Gr. II	Gr. III
Mean	0.37	0.11	0.03	0.37	0.47	0.42
n	165	104	68	165	104	68
St. dev.	0.32	0.23	0.17	0.37	0.44	0.42

Differences:      = significant

	Gr. I	Gr. II	Gr. III	Gr. I	Gr. II	Gr. III
Gr. I	0	<span style="background-color: #cccccc;">0.26</span>	<span style="background-color: #cccccc;">0.34</span>	0	-0.11	-0.05
Gr. II		0	0.08		0	0.05
Gr. III			0			0

### 5.5 Occupational characteristics per socio-economic group

	Agricultural occup.						Commuting					
	Khushk	Jagatpur	Sungarpur	Zindpur	Ibrahimpur	Nangli P.	Khushk	Jagatpur	Sungarpur	Zindpur	Ibrahimpur	Nangli P.
Mean	0.41	0.24	0.30	0.28	0.25	0.10	0.42	0.29	0.45	0.29	0.40	0.51
n	36	52	38	51	48	112	36	52	38	51	48	112
St. dev.	0.35	0.19	0.31	0.37	0.32	0.25	0.38	0.30	0.46	0.38	0.42	0.46

Differences:      = significant

	Khushk	Jagatpur	Sungarpur	Zindpur	Ibrahimpur	Nangli P.	Khushk	Jagatpur	Sungarpur	Zindpur	Ibrahimpur	Nangli P.
Khushk	0.00	0.17	0.11	0.13	0.16	0.31	0.00	0.13	-0.04	0.13	0.02	-0.09
Jagatpur		0.00	-0.06	-0.04	-0.01	<span style="background-color: #cccccc;">0.14</span>		0.00	-0.16	0.00	-0.10	-0.22
Sungarpur			0.00	0.03	0.05	<span style="background-color: #cccccc;">0.21</span>			0.00	0.16	0.06	-0.05
Zindpur				0.00	0.02	<span style="background-color: #cccccc;">0.18</span>				0.00	-0.11	-0.22
Ibrahimpur					0.00	<span style="background-color: #cccccc;">0.16</span>					0.00	-0.11
Nangli P.						0.00						0.00

### 5.8 Living standard per socio-economic group

	Living standard						
	Khushk	Jagatpur	Sungarpur	Zindpur	Ibrahimpur	Nangli P.	
Mean	26.5	22.0	25.2	25.1	29.5	21.9	
n	36	52	38	51	48	112	
St. dev.	12.9	11.2	12.2	14.7	17.1	16.5	

Differences:      = significant

	Khushk	Jagatpur	Sungarpur	Zindpur	Ibrahimpur	Nangli P.
Khushk	0	4.5	1.3	1.4	-3.1	4.5
Jagatpur		0	-3.2	-3.1	-7.6	0.0
Sungarpur			0	0.1	-4.4	3.2
Zindpur				0	-4.4	3.2
Ibrahimpur					0	7.6
Nangli P.						0

5.10 Agricultural assets of households per village

	A g r i c u l t u r a l o c c u p .			C o m m u t i n g		
	No land	>0-1 ha.	>1 ha.	No land	>0-1 ha.	>1 ha.
M e a n	0 . 0 9	0 . 3 6	0 . 4 1	0 . 4 7	0 . 3 5	0 . 3 3
n	1 8 7	6 4	8 6	1 8 7	6 4	8 6
S t . d e v .	0 . 2 2	0 . 3 1	0 . 3 2	0 . 4 6	0 . 3 7	0 . 3 4
<b>D i f f e r e n c e s :</b>						
						= s i g n i f i c a n t
	No land	>0-1 ha.	>1 ha.	No land	>0-1 ha.	>1 ha.
N o l a n d	0	- 0 . 2 7	- 0 . 3 2	0	0 . 1 2	0 . 1 4
> 0 - 1 h a .		0	- 0 . 0 5		0	0 . 0 1
> 1 h a .			0			0

5.11 Occupational characteristics per village

land sale: only group I

	Living standard			Living standard		
	No land	< 0-1 ha.	> 1 ha.	No land	< 0-1 ha.	> 1 ha.
Mean	20	30	30	28	31	40
n	187	64	86	121	27	22
St. dev.	12	15	17	14	14	23

Differences:      = significant

	No land	< 0-1 ha.	> 1 ha.	No land	< 0-1 ha.	> 1 ha.
No land	0	<span style="background-color: #cccccc;">-10</span>	<span style="background-color: #cccccc;">-10</span>	0	-4	-12
> 0-1 ha.		0	0		0	-8
> 1 ha.			0			0

5.12 Living standard per village

	Land			Landschl			Calle		
	Nuclear	Joint	Other	Nuclear	Joint	Other	Nuclear	Joint	Other
Mean	064	1.13	000	019	025	000	089	292	015
n	152	165	20	152	165	20	152	165	20
Stdev.	152	188	000	064	085	000	127	533	067

Differences:      = significant

	Nuclear	Joint	Other	Nuclear	Joint	Other	Nuclear	Joint	Other
Nuclear	0.049	<span style="background-color: #cccccc;">0.064</span>		0.006	0.019		0.202	<span style="background-color: #cccccc;">0.074</span>	
Joint		0.113			0.025			0.277	
Other			0			0			0

5.15 Agricultural assets per category of ownership of agricultural land

	Agricultural occup.			Commuting		
	Nuclear	Joint	Other	Nuclear	Joint	Other
Mean	0.19	0.27	0.05	0.44	0.39	0.35
n	152	165	20	152	165	20
St. dev.	0.31	0.30	0.22	0.48	0.36	0.49

Differences:      = significant

	Nuclear	Joint	Other	Nuclear	Joint	Other
Nuclear	0	-0.08	0.14	0	0.04	0.09
Joint		0	0.22		0	0.04
Other			0			0

5.16 Occupational characteristics per category of ownership of agricultural land

Only group I

	Living standard			Living standard		
	Nuclear	Joint	Other	Nuclear	Joint	Other
Mean	26.2	23.7	15.6	34.6	27.3	-
n	152	165	20	65	100	0
St. dev.	17.2	12.8	8.8	17.9	13.7	-

Differences:      = significant

	Nuclear	Joint	Other	Nuclear	Joint	Other
Nuclear	0	2.5	10.7	0	7.2	-
Joint		0	8.1		0	-
Other			0			-

5.17 and 5.19 Living standard per category of ownership of agricultural land  
land sale: only group I

	Living standard			Living standard		
	No land	>0-1 ha.	>1 ha.	No land	>0-1 ha.	>1 ha.
Mean	20	30	30	28	31	40
n	187	64	86	121	27	22
St. dev.	12	15	17	14	14	23

Differences:      =significant

	No land	>0-1 ha.	>1 ha.	No land	>0-1 ha.	>1 ha.
No land	0	-10	-10	0	-4	-12
>0-1 ha.		0	0		0	-8
>1 ha.			0			0

5.21 Agricultural assets per category of demographic structure

	Land			Land sold			Cattle		
	Nuclear	Joint	Other	Nuclear	Joint	Other	Nuclear	Joint	Other
Mean	0.64	1.13	0.00	0.19	0.25	0.00	0.89	2.92	0.15
n	152	165	20	152	165	20	152	165	20
St. dev.	1.52	1.88	0.00	0.64	0.85	0.00	1.27	5.33	0.67

Differences:      =significant

	Nuclear	Joint	Other	Nuclear	Joint	Other	Nuclear	Joint	Other
Nuclear	0	-0.49	0.64	0	-0.06	0.19	0	-2.02	0.74
Joint		0	1.13		0	0.25		0	2.77
Other			0			0			0



5.22 Occupational characteristics per category of demographic structure

	Agricultural occup.			Commuting		
	Nuclear	Joint	Other	Nuclear	Joint	Other
Mean	0.19	0.27	0.05	0.44	0.39	0.35
n	152	165	20	152	165	20
St. dev.	0.31	0.30	0.22	0.48	0.36	0.49

Differences:      =significant

	Nuclear	Joint	Other	Nuclear	Joint	Other
Nuclear	0	-0.08	0.14	0	0.04	0.09
Joint		0	0.22		0	0.04
Other			0			0

5.24 Living standard per category of demographic structure

Only group I

	Living standard			Living standard		
	Nuclear	Joint	Other	Nuclear	Joint	Other
Mean	26.2	23.7	15.6	34.6	27.3	-
n	152	165	20	65	100	0
St. dev.	17.2	12.8	8.8	17.9	13.7	-

Differences:      =significant

	Nuclear	Joint	Other	Nuclear	Joint	Other
Nuclear	0	2.5	10.7	0	7.2	-
Joint		0	8.1		0	-
Other			0			-

## C Non-agricultural occupations encountered among the village population

The list below is derived from both the basic household surveys and the in-depth surveys. Since basic household questionnaires were sometimes coded, not all specific occupations of working members in the villages could be listed. Nevertheless, it provides a fair impression of the occupational diversification in Delhi's rural-urban fringe villages.

### *Group I:*

*Khushk:* 1 Police officer, 1 gardener in government service, 1 employee of DTC, 1 DTC driver, 1 scooter mechanic in Delhi in private sector, 1 civil servant unspecified, 2 construction contractors, 5 tempo drivers, 2 taxi drivers, 1 vegetable trader, 1 car mechanic in Delhi, 1 shopkeeper in the village, 1 shopkeeper in a nearby village, 2 employees of DWS, 1 gardener in a school in Delhi, 1 gardener in the Forest Department, 1 local electrician, 2 gardeners in a hospital in Delhi, 3 drivers of their own tempo, 1 car mechanic in another village, 1 government employee of the radio station in Delhi, 1 property dealer in a nearby town, 1 electrician in Delhi, 1 truck driver, 1 employee of the tax department in Delhi and local shopkeeper, 2 local shopkeepers, 1 employee of the Department of Law of Delhi Government, 1 teacher in a private school, 1 teacher in a private school and politician, 1 auditor in Delhi, 2 industrial workers in Delhi, 1 trader in milk in a nearby town.

*Jagatpur:* 1 employee of the Post Office in Delhi, 4 part-time milk collectors and transporters, 9 employees of the Water Supply Company in Delhi, 1 construction contractor, 1 civil servant (unspecified), 2 property dealers working in Delhi, 1 owner/driver of mini truck, 1 clerk in government service, 2 teachers, 1 manager at the Ministry of Education in Delhi, 2 drivers of private cars, 2 mechanics in DTC, 2 police constables, 1 army officer of the border security in Jammu, 1 clerk at the Ministry of Urban Development, 1 clerk in government service, 1 counter sales clerk at the government insurance company, 1 employee of the Health Department of the government of Delhi, 1 employee at the Sanitation Department in Delhi.

*Sungarpur:* 1 property dealer, 1 government contractor, 1 private bus driver, 1 medical doctor in Delhi, 1 employee of the Flood Control Department in Delhi, 1 tempo driver in Delhi, 1 driver on his own tempo, government employee in Delhi vegetable market, 1 businessman unspecified, 1 shopkeeper in nearby town, 1 teacher in nearby village, 1 teacher in Delhi, 1 manager of food grain mill in Delhi, 1 clerk in DTC, 1 government employee in nearby town unspecified, 1 transporter of milk to Delhi, 1 manager in Delhi unspecified, 1 employee of DESU, 1 taxi driver.

*Zindpur:* 1 Labourer in village water supply (government), 3 employees of the DTC (1 driver, 2 unspecified), 1 property dealer, 1 proprietor of shop selling kerosene oil in Delhi, 1 operator of brick kiln in rural area of Alipur Block, 1 clerk in a bank in Delhi, 1 professional wrestler, 3 teachers (1 at a college, 2 at a secondary school), 1 medical assistant (Delhi), 1 employee of Post and Telegraph Company, 1 clerk at a college (Alipur town), 1 bus owner (bus plying at the route from Palla village to Delhi Railway Station), 1 civil servant in Delhi (unspecified), 1 worker in village water supply.

*Ibrahimpur:* 1 labourer in sanitary works in Delhi, 2 shopkeepers of general stores, 1 employee of Delhi Police, 1 employee of Defence Ministry in New Delhi, 1 property dealer, 1 employee of Water Works Department in Delhi, 1 bus driver, shopkeeper and landlord, 1 employee of Telecom Company (government), 1 milk supplier, 1 owner/driver of a truck, 1 inspector with the Delhi Police, 1 employee in a hospital in Delhi, 1 driver of private cars, 1 pharmacist in government hospital in Delhi, 1 employee of DWS, 1 employee of DDA, 1 taxi driver, 1 guard at the sewerage company (government), 1 pharmacist at DTC, 1 teacher, 1 person running a food stall at the roadside, 1 journalist, 1 school principal, 1 professor in USA.

*Pehladpur Bangar:* wire factory owner, 1 property dealer, 1 businessman in import/export, 1 marketer for a factory in insulation material, 2 teachers in Delhi, 1 conductor in DTC, 3 mechanics in DTC, 2 drivers in DTC, 1 wheat shop owner, 1 pharmacist, 1 shopkeeper in

Samaipur, 3 local general store owners, 1 accountant with the Delhi Police, 1 gardener in DDA, 1 sorter at the post office, 1 worker for the Congress Party, 1 shopkeeper in dairy products, 1 owner of a beauty parlour, 1 clerk in the Publication Division of the central government, 1 watchman in the Education Department, 1 watchman in the Income Tax Department, 1 clerk in All India Institute for Medical Sciences.

*Nangli Poona*: 4 teachers in Delhi, 1 local teacher, 1 person running a small factory in his house, 2 employees of the DDA, 4 employees of DTC (unspecified), 1 mechanic at DTC, 2 bus drivers at DTC, 1 conductor of DTC, 1 bus driver of a private bus, 1 clerk at the Food and Civil Supplies Corporation (government), 1 employee of a hospital in Delhi, 1 labourer at a factory in Delhi, 1 owner of a local transport business, 1 person working at his father's local transport business, 6 constables with the Delhi Police, 1 employee of DWS in Delhi, 1 trader in leather goods, 1 animal doctor, 1 engineer in a private company in Delhi, 1 mailman in Delhi, 2 lawyers, 1 owner of a telephone shop.

*Group II:*

*Khushk*: 2 employees of Delhi Government unspecified, 1 employee of the Education Department, Delhi Government, 1 employee of Indian Navy in Delhi, 1 small trader in plastic waste.

*Jagatpur*: 1 employee of the Flood Control Department in Delhi, 1 shopkeeper in village, 2 politicians, 2 employees of Delhi Water Supply, 1 clerk at DWS, 1 auditor with a government institute in Delhi, 1 cashier in a bank in Delhi, 1 musician, 1 metal fitter in Delhi, 1 driver of private cars, 2 blacksmiths, 2 labourers in factories in Delhi, 1 property dealer in a nearby village.

*Sungarpur*: 1 government employee unspecified, 1 milk salesman, 1 industrial labourer in Delhi, 1 industrial labourer in nearby village, 1 local tea stall holder, 1 MCD gardener, 2 employees of local school, 2 employees of MCD in nearby villages, 2 employees of MCD unspecified, 2 employees of DESU in Delhi, 1 employee of DWS, 1 local barber, 1 sweeper in Supreme Court in Delhi, 1 labourer in an electronics factory in a nearby village, 1 tailor in nearby village, 2 shopkeepers in nearby village.

*Zindpur*: 1 operator of a tea stall in the village, 1 proprietor of a general store in the village, 1 teacher in Delhi, 1 owner and operator of school bus and truck, 1 employee of Delhi Police, one carpenter mostly in village, 1 property dealer in Delhi, 3 employees of a shop in electronic goods in Delhi, 1 tailor at his own home, 1 employee of the telephone company and making quilts in his house.

*Ibrahimpur*: 2 drivers of personal cars, 2 government employees (unspecified), 1 cleaner in government service, 2 shopkeepers in the village, 1 stenographer in Delhi, 1 person running vegetable shop, 1 repairman for hand pumps (irregularly employed), 1 mechanic in DTC, 6 construction labourers, 1 clerk in Income Tax Department in Delhi, 2 mobile vegetable sellers, 1 guard, 2 tailors in/near their own houses, 2 drivers of mini truck, 1 auto rickshaw driver, 1 person running a small poultry farm, 1 cycle repairman in village, 1 person running a tea stall in the village, 1 mechanic in Delhi, 1 photographer in Delhi, 2 brick kiln labourers, 1 headman of the PWD in Delhi, 1 textile trader, 1 childcare lady working in Delhi,

*Pehladpur Bangar*: 1 government hospital assistant, 1 photographer, 1 local mechanic, 3 local tailors, 1 upper divisional clerk in the Income Tax Department, 1 fitter in the railways, 1 servant in the school, 1 local welder, 1 peon at the Delhi Police, 1 telephone shop operator, 1 factory labourer in Delhi, 1 teacher, 1 local owner of a building materials shop, 1 peon at the PWD, 1 lower divisional clerk at the Central Government, 1 clerk at the railways, 1 peon at the Malaria Department in Delhi, 1 plumber in the military.

*Nangli Poona*: 4 shopkeepers in the village, 2 tailors in the village, 1 person selling pigs, 3 drivers of personal cars usually in Delhi, 1 social worker, 1 plumber working at New Delhi International Airport, 1 lock repairman working in Delhi, 2 auto rickshaw drivers, 1 bus driver for DTC, 1 assistant in a government hospital in Delhi, 1 head constable in Delhi Police, 1 constable with the Delhi Police, 1 mechanic working in Delhi, 2 labourers at MCD, 1 clerk in a bank in Delhi, 1 plumber in a government institute in Delhi, 1 shopkeeper in Delhi, 1 clerk at DDA, 1 electrician at DESU, 1 labourer in a local glass factory, 1 clerk in a library in nearby

village, 1 plumber at a college in Delhi, 1 owner of a small factory, 1 local tea stall owner, 1 vegetable seller in the village.

*Group III:*

*Khushk:* 1 labourer in spices factory in Delhi, 1 part-time female tailor.

*Jagatpur:* no data

*Sungarpur:* no data

*Zindpur:* 13 employees of a plywood factory in Delhi, 1 person pressing clothes in the village, 1 worker in storage of spare engine parts in Alipur, 1 person selling vegetables in the village, 2 truck drivers, 2 truck loaders, 1 labourer in a steel factory near Delhi, 1 labourer in a plastic factory near Delhi, 1 part-time labourer at brick kilns, part-time labourer at other factories, 1 owner of huts in the fields near the village drawing his income from the rent.

*Ibrahimpur:* no data.

*Pehladpur Bangar:* no data

*Nangli Poona:* 1 software engineer, 2 auto rickshaw drivers, 10 labourers at the local plywood factory, 2 labourers at the local sewer pipe factory, 1 labourer at a local tyre factory, 1 labourer at the local clothes mill, 1 labourer at local plastic factory, 1 watchman at a local factory, 1 carpenter working in Delhi, 9 labourers at a factory in Delhi, 1 tailor working in Delhi, 1 person running a shop of waste materials in the village, 4 local construction labourers, 1 car mechanic in Delhi, 1 local cycle rickshaw driver, 1 person running a local food stall, 1 supervisor in a steel factory in Delhi, 9 labourers on trucks, 1 musician beating drums at marriages, 2 truck drivers, 2 timber traders with a shop in Delhi, 1 watchman with the Delhi Police, 1 watchman of a private home in Delhi, 1 transporter of flowers to Delhi, 1 employee of MCD, 1 worker at a car parts shop in Delhi, 1 scooter mechanic working at a repair shop in Delhi, 2 labourers in PWD, 2 local mobile food sellers, 1 property dealer, 3 persons making boxes for lipstick in the village, 1 labourer at the Delhi vegetable market, 1 mason, 1 person running a factory in Delhi.

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