3 LAND-USE DYNAMICS

3.1 Land uses observed in the rural-urban fringe

Rural-urban fringes are characterised by a wide variety of land uses (Ramachandran 1989, Yadav 1987, and Thakur 1991). Ramachandran's chapter about the rural-urban fringe is most specific about developments around Indian cities, particularly Delhi: "the city has penetrated, in some cases deeply, into rural areas to a distance of 10 to 15 kilometres. As one moves out of a major city along one of the arterial roads, one observes new residential colonies, a considerable amount of vacant land, partially developed residential plots, a few factories, commercial squatters on either side of the road, and further away from the city, storehouses, cold storage plants, timber yards and brick kilns" (1989, pp. 293-294). Ramachandran also notices large areas used as sites for quarries, claypits, sand and gravel pits, sewerage disposal tanks, and garbage dumps (p. 317). Yadav (1987) draws particular attention to the mix of intensively cultivated land in combination with unused (speculative) land and the progressively built-up land. Thakur (1991) furthermore finds infrastructural use typical for a rural-urban fringe, noting a number of agricultural responses to increasing urban pressures on land.
The land-use typology described in next section has much the same features as mentioned in the literature cited above. In order to make a limited and consistent land-use classification, some categories are combined. Others are determined by the specific requirements of this study.
A land-use map that shows the influence of urbanisation on the land of individual villages is essential to visualise the influence of urbanisation on the land. Moreover, such a map is also essential for the 'site' where socio-economic changes occur (see Chapter 2 and 5).

3.2 The heterogeneity in types of land use: a mix of urban and rural features

The land-use types are categorised according to their position along the spectrum from rural to urban. Naturally, the classification involved some arbitrary choices, as rural and urban characteristics interfere with one another. In this classification, functional aspects are more important than morphological ones. For example, a village settlement is classified as urban land in terms of land use. But because rural people live there, there is a rural dimension to it as well. Apart from the socio-economic features of land use related with urbanisation, Some of the physical characteristics are also mentioned, which is particularly important for the interpretation of the remote sensing map.
Typically rural land uses include agriculture for staple crops, forests, and common lands. These uses correspond to the traditional land-use pattern as a part of the agricultural livelihood of the village population. More commercially grown crops (horticulture and flowers) have a more direct link with the urban market. Of the combined class of 'forested land', some types have urban links. The other types of land use have more obviously urban dimensions. One of these, namely vacant land is an intermediary land use. Another type, built-up land, lies at the urban end of a rural-to-urban continuum.

1. Agriculture staple crops

Agriculture still commands the largest area in Alipur Block. It mainly includes the cultivation of wheat and fodder in *rabi* (winter season) and paddy and fodder in *kharif* (summer season). This cropping pattern is very common in north India. During the last three decades, an intensification has been going on in the 'green revolution belt', consisting of Punjab, Haryana, and western Uttar Pradesh. Delhi is located in the centre of this belt. High-Yielding Varieties (HYVs) were introduced on a massive scale in the 60s and 70s (Bayliss-Smith and Wanmali 1984). Better irrigation facilities, chemical inputs such as fertilisers and pesticides, and expertise are the main factors that have augmented the harvests of wheat, paddy, and fodder. Roughly, there is more agricultural land at the less accessible locations, since places that are well accessible (close to the city, close to the roads) tend to change into urban land uses or lie vacant.

2. Horticulture/floriculture

The cultivation of vegetables and flowers is clearly expanding. The most common vegetables cultivated are cauliflowers, potatoes, green beans, radishes and eggplant. The flowers that are cultivated are mostly marigolds and different varieties of roses. This category of land use is unlike staple-crop agriculture with respect to the growing seasons, market orientation, revenues from harvests, and labour inputs. Its market orientation has a more direct link to the urban markets. The farmer attempts to bring the product to market when the demand is high; e.g. in the case of flowers, the peak sales would be at the time of religious festivals. The crops are generally high-value, voluminous, heavy, and perishable. A location close to the city is a clear advantage for perishable crops, and the costs of commercialisation are generally lower. Therefore, the spatial advantage of a rural-urban fringe location is greater than for staple crops, for which there are government-controlled prices and large rural market centres, such as Narela and Sonepat. The revenue from horticulture per unit of land is much higher than for staple crops, although there is more risk involved and much higher labour requirements. The area under horticulture is expanding at the expense of land used for staple-crop production, whereas horticulture is disappearing at places that are subject to urban pressure.

3. Forest/common land/orchards

It was convenient to take these three land uses together because of their small size and similar physical features. It is a kind of residual category of rural land, although in functionality there are some differences. There are only two small patches of *forest* in the Alipur Block: near Narela town and between the villages of Zindpur and Khushk. These areas are approximately 70 and 40 hectares in size, adding up to merely one per cent of the total area. Indigenous tree species, such as *kikar* and *babul* predominate, since they are fit for semi-arid conditions. The forests are managed by the government of Delhi (Forest Department) after legislation was passed in 1982 at the national level to preserve the forests. Before that, the forests were part of the common lands of the villagers. Officially, the villagers are no longer allowed to take any firewood from the forests. But since cattle are nowadays kept in the stable, and propane and kerosene increasingly supplement traditional fuels (wood and cow dung), the social impact of this restriction is limited. The condition of the forests is nevertheless poor.

Common land is usually covered with trees and bushes. The village pond can also be considered part of the common land. The common lands are traditionally owned and administered by the village community, represented by the Panchayat, for collective needs including cattle grazing and bathing, firewood collection, and space for drying cow dung cakes. Common lands have decreased for the same reasons as mentioned for the forests. They are scattered throughout the area, usually adjacent to or very near the village settlements. Some villages do not have any common land, or do not have any left. Some village residential areas have expanded at the cost of the common land. On paper, the Delhi government administers the common lands. As a consequence, they are often used for locating government facilities such as schools and clinics.
Orchards, which in some cases can be more accurately described as plantations, are forested lands kept for a wide variety of purposes. The production of fruits and wood is one, often combined with small patches of tree and plant nurseries. Orchards are part of the traditional land-use pattern. Increasingly, 'outsiders' keep orchards on a commercial basis, making use of the proximity of the city for easy marketing. Most of the plantations that are planted with poplar and eucalyptus trees are kept for speculative purposes. The revenue from the wood products is quite low, but the land continuously increases in value, while the tax-exempt status is maintained by preserving the agricultural designation of the land.

4. Vacant land
Vacant land is all unused land with no clear designation, though often it is in the middle of a process of conversion. This land may be covered with bushes and grass, but it might also be completely barren. Many plots of vacant land are kept for speculative purposes and are therefore left vacant for extensive periods. Rising land prices induce some of the landowners to discontinue agriculture, construct a boundary wall, and leave the plot temporarily unused. The owners include wealthy city dwellers as well as local landowners who have abandoned farming. Some village households keep empty plots for possible future construction. The agricultural designation can be maintained in connivance with the *Patwari* (local land registrar) who can be induced to record false information on land use. Vacant land frequently emerges out of former excavation sites and brickfields when the owner is either unable or unwilling to reclaim the land for agriculture. In particular, it may be found near roads and adjacent to villages, where the land values are rising steeply. But vacant land is also found along the riverbanks, due to the seasonal risk of flooding.

5. Farmhouse
Farmhouses are large country estates, the owners of which have little or no intention of using the land for agriculture. They range from small houses with a few trees to luxurious mansions surrounded by a garden. The name farmhouse is deliberately retained to suggest agricultural land use, because the owner intends to maintain it as untaxed agricultural property. A farmhouse is usually constructed by a wealthy urban industrialist, trader, politician, or professional based in Delhi. The legalities involved are also relatively simple if certain legal requirements are met. Most of the farmhouses occupy at least two acres, which is the minimum acreage according to the land-use regulations (Hindustan Times 8-3-1997). In the research area, the farmhouses are built for four main

reasons. First, it is a profitable way to invest undeclared income. The location of the land at the city's fringe practically ensures that the value of land will rise sharply, making the investment lucrative. Second, a farmhouse can be used to launder black money by claiming non-existent agricultural revenues. Third, it serves as a place to hold celebrations and parties, adding to the status of members of the urban elite. Finally, some farmhouses accommodate businesses, such as light manufacturing, garment sweatshops, and illegal shops to market a large variety of products (also observed by Soni 1998). The government is presently considering easing regulations concerning farmhouses (Hindustan Times 23-1-1996). Some authors, mostly in the area of journalism, report environmental problems relating to these estates. Often, the owners extract large amounts of groundwater from the soil (Soni 1998). They are also said to be straining municipal amenities without paying the charges (the Hindu 23-10-1997). Farmhouses may be found at many places in Alipur Block, although they are concentrated along particular roads. There are many on the Alipur-Narela road, quite a few in the Hamidpur-Bakhtawarpur area, seven on the land of the villages Mukhmelpur and Zindpur, and three or four in the Burari-Ibrahimpur area.

6. Brick kiln

Brick kilns are a typical feature of rural-urban fringes. Large numbers of kilns are found in the rural areas near Delhi. Approximately 70 were counted in Alipur Block during the survey. Even though they take up little space, brick kilns form a separate land use because they are dependent on adjacent agricultural land for loam. Figure 3.1 expands on the issues relating to brick kilns. In Alipur Block, there are six brick kilns near Mukhmelpur, three on the land of Hamidpur, more than 20 between Ghoga, Narela, and Lampur, and more than 30 in the area around Pooth Kurd. Most soils in Alipur Block are suitable for making bricks, except for soils close to the river, where it is too sandy. The first requirement is the availability of the right kind of loam, which is raw material for bricks. The clustering of the production makes it easy for contractors to compare the quality and the prices of bricks. At the same time, the brick kilns depend on relatively inexpensive agricultural land. As a result, there are none very close to the city or adjacent to the major transport routes. In 1997, by order of the Supreme Court, all kilns within the NCT boundary were forced to close down for being polluting industries.

7. Excavation

Loam excavation fields for the brick kilns interact with agricultural land in a rather complex way (see Figure 3.1). They are invariably located within half a kilometre of the kilns, since the heavy sun-dried bricks are transported by hand and with donkey carts. A type of excavation that takes less space is sand mining. These sites are mostly exploited to supply the sand needed for construction in urban areas. Most sites for sand excavation are in the riverbed, where there is little competition with agriculture. However, at some places, sand is also dug in agricultural land at former brickfields, where sand emerges at the surface after the top layer of loam is taken off. These places are left unused afterwards because the depth (up to 12 metres) causes seasonal waterlogging. At less deep former excavation sites, the farmers only manage to cultivate a winter crop.

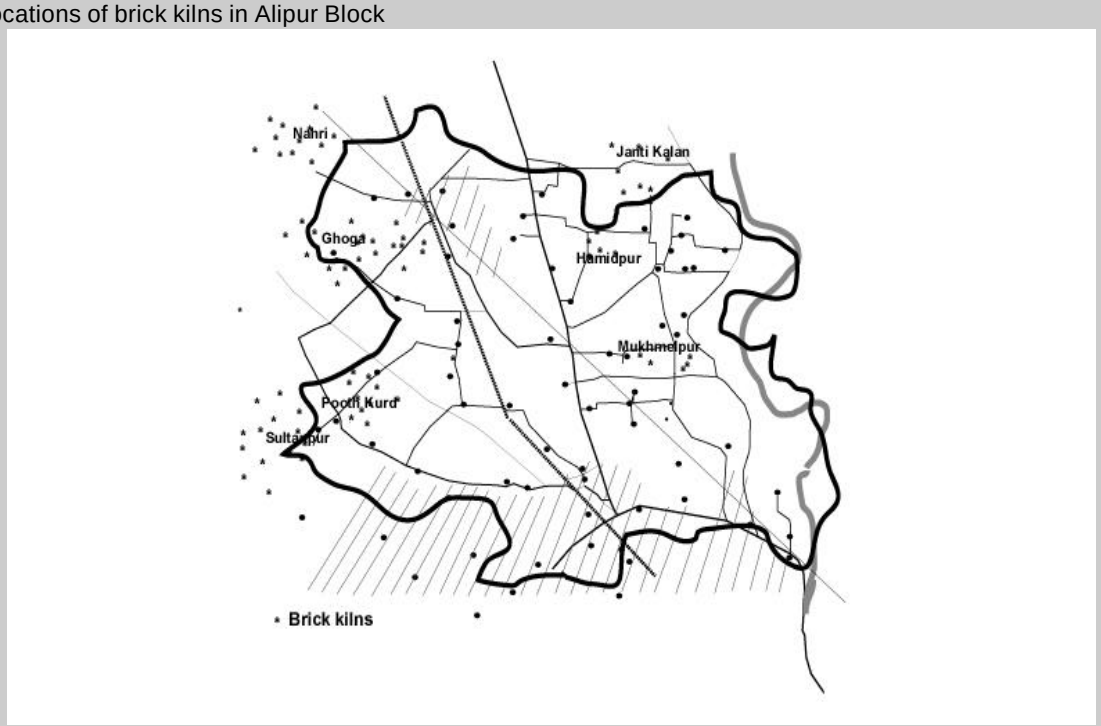
Figure 3.1 Brick kilns: the interaction between farmers and agricultural land

Brick kilns are never permanent, since they depend on the availability of loam. It is expensive to bring in this from a distant source. So when fields with loam are no longer available, the kiln owner will close down the operation and move it to shift to another location.[1]

The brick kiln itself occupies less than half a hectare. But the extra space needed to pile up bricks, for a tubewell, for the labour quarters and for other purposes adds one hectare. For loam digging, about five hectares is leased in, of which 1.5 hectares per year is used to a depth 1.5 metres. Consequently, every four years the kiln operator needs to lease fresh land. In most lease contracts, the brick kiln owner has to ensure that the land is made level again when the lease period comes to an end. It requires considerable effort for the farmer to restore the land to its previous agricultural productivity. There is not much choice for the landowner, usually a farmer: he can choose to lease out or to not lease out land to an operator of a brick kiln. This decision will depend on the local situation. If adjacent land is being excavated, one farmer's land will become elevated above its surroundings. Consequently, the connection with irrigation facilities may also become more difficult. The land will starts eroding, and fertilisers will be washed out into the lower fields. Therefore, the farmer has no realistic option not to lease out his land. He may just have to go along with the domino effect (Bentinck 1995).

Large stretches of land in Alipur Block have become depressed due to loam excavation. A newspaper article reported at least one example of excavation leading to seasonal waterlogging in colonies built on excavated land (Indian Express 4-2-1995). Nevertheless, more than half of the old brick kiln sites are eventually taken back into cultivation, although this may take some time. Other abandoned kiln sites remain vacant or are sold to outsiders. Eventually, they may become a site for a farmhouse, factory, or other urban function. A few kilns still remain as 'ruins'.

Locations of brick kilns in Alipur Block



[1] The issue of the brick kilns is visually illustrated on the enclosed CD-ROM.

8. Infrastructure

This is a combined type of land use with a public function. Infrastructure is usually owned and built by government agencies. It includes roads, canals, levees, garbage dumps, sewage treatment sites, broadcasting stations, and parks. In a rural-urban fringe environment, this type of land use takes up a significant amount of space, due to the high density required of infrastructure. It includes the following subtypes:

Roads are constructed, widened, and improved all over Alipur Block. The land for road building is usually acquired from local landowners. There is one major *railway line* crossing Alipur Block from north to south. *Canals and drains* are found throughout the area. In more remote rural areas, such waterworks are built almost exclusively for agricultural purposes (irrigation canals and drainage). In Alipur Block, however, there are various other functions associated with drainage and the supply of water to the city. *Dams* are constructed on the Yamuna side; there is also one crossing the flood-prone area from east to west. After the 1976 floods, the levees were widened and raised, mainly to protect the city from floodwaters from the Yamuna during the monsoon. *Garbage dumps* (or 'sanitary landfills') are located right at the urban fringe. There are two large garbage dumps in Alipur Block: one near Bhalswa and another adjacent to Badli. *Water treatment plants* are also located directly at the urban fringe. Smaller wells (so-called 'Ranney' wells) are located at the Yamuna flood levee. *Broadcasting stations* occupy considerable space near Khampur (70 hectares) and near Nangli Poona (80 hectares). Other infrastructural land uses include smaller areas occupied by electricity relay stations and telephone exchanges, but those do not occupy much land and coincide with the built-up area.

9. Built-up area

This heterogeneous type of land use on the urban side of the spectrum can be broken down into the following subtypes:

Villages are physically expanding into the surrounding fields as a consequence of increased wealth and a growing population. Villagers usually build larger residences at the edge of the village. New *residential areas ('colonies')* are mainly owned and developed by outsiders, although sometimes the villagers themselves have a stake in the development as well. Basically, there are two types of settlements: unauthorised and planned (see Chapter 4). Formal planned development takes place in the south-west of Alipur Block (Rohini) and in the northern part around the town of Narela. Unauthorised colonies are expanding at many more places, of which development 'hotspots' are found near Burari and Pehladpur Bangar. *Factories* can be found at many places. The larger industries are located along the GT Road, the Alipur-Bakhtawarpur Road, and the Auchandi Road, and near Narela. There are vegetable oil refineries, rice processing and export industries, other food processing plants, cement factories, saw mills, and industries of many other kinds. Small businesses usually predominate in and near the settlements, as they need less space and cam establish premises within the existing residential areas. Many factories are located in and around the 'villages' of Samaipur (described at length in Chapter 6), Badli, Libaspur, Siraspur, and Shahabad-Daulatpur. Similar to the case of industry, *storehouses* are located adjacent to paved roads and usually require a considerable amount of space. This function depends on low-cost but well-accessible locations. Other land uses with structures on it include *commercial, recreational, and*

religious activities. Hotels, shops, and repair shops fall under this residual category. Shops and temples are mostly interspersed with dwellings in residential areas. *Schools and hospitals* are an important category of built-up land and are usually mixed with residential land.

Water bodies are not listed in the classification of land use, because they are either too small or form part of other land uses. Larger water bodies are only found as part of the Yamuna River and Bhalswa Lake.

3.3 Using remote sensing to map land use

3.3.1 Advantages of remote sensing and reasons for its application

The available maps do not satisfy the mapping needs of this research. The topo sheet maps of the Survey of India are outdated and do not distinguish the above types of land use. The precision of these maps is not satisfactory either. Due to the diversity and heterogeneity of the landscape of a rural-urban fringe, it is difficult to rely on secondary sources. Preparing maps on the basis of one's own land-use survey is both difficult and time-consuming without 'remotely sensed information' (aerial photographs and satellite images). Since the land is flat, it is otherwise hard to get a good overview of the land. The interpretation of satellite images has partially solved this problem. On that basis, it was possible to generate village maps (Figure 2.5) that show the 'site' of each village. Furthermore, the remote sensing (RS) classification shows how the physical land-use features are related with the above land-use types. That exercise thus provides grounds for environmental impact of land-use change, such as land degradation.
This section compares the results of the RS classification with the land-use types. The RS analysis as such is not treated in this text but is presented in Appendix A and on the CD-ROM (also in Bentinck et al. 1999, and de Vries et al. 1999). Nonetheless, some basic characteristics and limitations of using RS should be explained here. Two images are used: one from May 1995 and one from March 1996. The images date from before and after the harvest, which takes place in April each year. The ground-truth verification dates from 1996 and 1997. In some cases, this is later than the RS images, but the amount of deviation is small. A Global Positioning System (GPS) was used to carry out gound-truth verification and to gather information to interpret the image. The GPS indicates the approximate location of each type of land use in a part of the total image (see rectangle in Figure 3.2). Furthermore, RS does not classify objects in the field if they are smaller than a certain size, in this case approximately 20 by 20 metres (the resolution of the images is 25 by 25 metres per pixel).
Obviously, the satellite's sensor cannot detect socio-economic features such as ownership and function of land. Its power lies in its capacity to distinguish physical features, and to store the information in digital files. Basically, RS registers differences in densities of vegetation, the type of vegetation, the type and structure of the soil, and the humidity of the ground surface. RS is an appropriate technique when the requirements are consistent with these physical characteristics. Land-use mapping with the help of RS is only

partially successful because the socio-economic aspects of land use do not necessarily correspond to the physical characteristics of the land. Table 3.1 shows that there is a significant degree of overlap in the physical characteristics of the land-use types, while other types of land uses are characterised by a mix of various physical characteristics. Figure 3.2 shows the results of the RS analysis for the whole of Alipur Block. The interpreted sub-area in Figure 3.3 clarifies how the types of land use relate to the RS classes.

3.3.2 The generated remote sensing classification compared with the types of land use

The RS classes that seemed to be closest to the land-use types in Section 3.2 are briefly described below. The classification is based on the physical characteristics, the percentage of the total area in Alipur Block that is covered, and the dates of RS images used. Ground-truth verification reveals where each RS class can be found and shows up the inaccuracies of the classification. It also illustrates the complexities of generating a consistent RS interpretation on land use in a rural-urban fringe area like Alipur Block.

A. Staple-crop agriculture (45 per cent)
Using images from the pre- and post-harvest dates resulted in a quite accurate classification of agricultural land while under the winter (*rabi*) crop, which is mainly wheat. This includes only a small part of horticulture and floriculture, since these crops often have different growing and harvesting seasons. The analysis is based on a seasonal difference in vegetation with a gap of nine months. Therefore, it may also include small areas of land where other vegetation has grown during the past year, although this deviation is very small.

B: Flower cultivation (2 per cent)
RS was not capable of classifying all horticultural land and flowers. It did provide an indication of where a flower crop was growing at the time of the image used (March 1996). The variety of vegetation types is large and the harvesting seasons are irregular. Nevertheless, the small patches of class B in Figure 3.2 indicate where horticulture and floriculture is common.

C: Woodland (11 per cent)
Woodland includes areas with a high density of vegetation that does not share much seasonal variation (trees, sometimes mixed with shrubbery). The date of observation for this RS image is May 1995. The area falling into this class largely corresponds to land-use type 3. But woodland is also visible at infrastructural sites where high-density vegetation dominates; for instance, woodland is found around the radio broadcasting stations and along levees, drainage channels and roads. Infrastructure is often mixed with class D because the density of vegetation varies. This is also true for common lands and, to a lesser extent, vacant land. In many areas, the data show orchards and plantations. Since class C encompasses quite a variety of land uses, it is spread quite evenly over the whole area, though concentrations occur where there is forest and infrastructure.

D: Other vegetation (18 per cent)
This class includes the land that had a medium coverage of vegetation in March 1996, but excludes areas in class A, such as grass and light shrubs. Class D appears in many types of land use, or vacant land, at farmhouses (the garden), and on horticultural land. Also, class D is relatively common along transport routes where much vacant land is present.

E: Built-up and barren (25 per cent)
This includes land that is dry, which means that it has little or no vegetation and a small amount of surface moisture. In practice this class comprises both built-up and barren land. It is not possible to differentiate these land covers because the satellite's sensor cannot register sufficient difference in reflection between built-up and barren land. Class E refers to all built-up land (except the larger patches of greenery within settlements), part of the vacant land, and the excavation sites that were in use at the time of the observation (March 1996). Class E also includes a small area of barren cultivated land that is not cropped at the time, most of which lies in the riverbed. Farmhouses also show small patches of class E, but only when the houses are large or where another kind of paved surface is present. Since most of class E shows urban land use, it indicates a high degree of urbanisation of land.

F: Brick kiln (less than 1 per cent)
All brick kilns show up on the RS map with a surprising accuracy. Only two other objects (two storage facilities) mistakenly appear as class F. This class is very small in terms of occupied land. However, keeping its impact on change on agricultural land in mind, brick kilns comprise a very important aspect of land use (see Figure 3.1).

G: Wetland (1 per cent)
This small class refers to shallow water with or without vegetation growing in it. Class G is associated with excavation sites at places where land has become waterlogged. Smaller water bodies, such as village ponds and drains, are not visible because they are overgrown by vegetation or are too small. There is not much surface area covered by wetlands. Class G can be found at the former excavation sites of Mukhmelpur, Ibrahimpur, and at the outer border of Rohini. Another concentration can be found at the edges of Bhalswa Lake, where the water is shallow.

H: Water (2 per cent)
Class H includes water bodies of approximately one metre or more in depth. In Alipur Block, water is limited to the Yamuna River and part of Bhalswa Lake. Other deep waters, such as canals, are not wide enough to show up consistently as class H. Actually, they are more frequently represented by classes B and C.

Table 3.1 Comparison of the observed types of land use and the RS classification

	Remote sensing classification On the basis of vegetation				On the basis of soil and water			
Types of land use	A Agriculture	B Flowers	C Woodland	D Other vegetation	E Built-up/ barren	F Brick kiln	G Wetland	H Water
1. Agriculture staple crops	X							
2. Horticulture		X		X				
3. Forest/ commons/orchard			X	X				
4. Vacant			X	X	X		X	
5. Farmhouse			X	X	X			
6. Brick kiln						X		
7. Excavation					X		X	
8. Infrastructure			X	X	X			
9. Built-up area					X			

Description of the physical features on which the RS classes are based:

A: a difference in vegetation: a high level of vegetation in March 1996 and no (or little) vegetation in May 1995 (harvesting takes place mid-April)
B: a specific type of vegetation that radiates a different reflection in March 1996
C: the highest degree of vegetation in May 1995
D: the remaining vegetation after classifying A, B, and C
E: dry land with little or no vegetation in March 1996
F: a specific reflection caused by dust of 'baked' loam
G: a high level of humidity, or high humidity combined with vegetation
H: the highest level of humidity

Some conclusions may be drawn regarding the usefulness of the RS analysis in this study. For one thing, it is clear that the application of RS analysis is difficult for the type of landscape concerned here. The heterogeneity, the rapid pace of change, and the wide variety of land uses make it impossible to generate a map directly from the RS observations. Along with the maps, the table helps to clarify the problems encountered because of overlap and imprecision of the RS classification with respect to the observed land uses. In short, the classification was successful in distinguishing some features (agriculture for staple crops, brick kilns). Areas under horticulture and floriculture were more difficult to extract due to the irregular harvesting patterns. Built-up land is hard to distinguish from barren land. Vacant land and farmhouses are also difficult categories to distinguish with RS only.
Nevertheless, when RS images are supplemented with thorough ground information and an understanding of the RS classes, satellite image interpretation is useful as a method of land-use mapping, as demonstrated in Figure 3.3. The village maps in Chapter 2 (Figure 2.5) were drawn with the help of the RS analysis described above.

Figure 3.2 The result of the remote sensing classification of Alipur Block

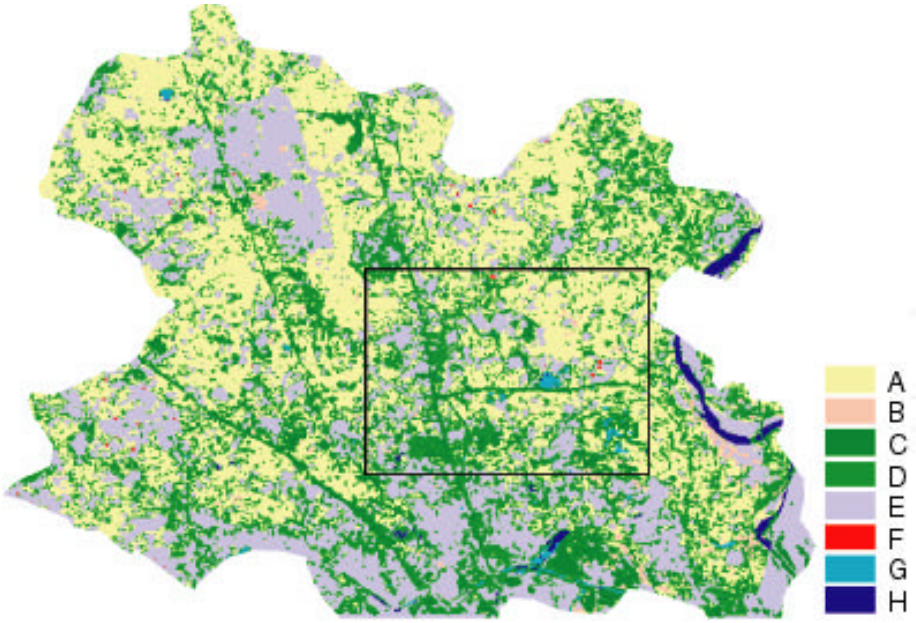


Figure 3.3 RS map of the study area with overlay of land-use types

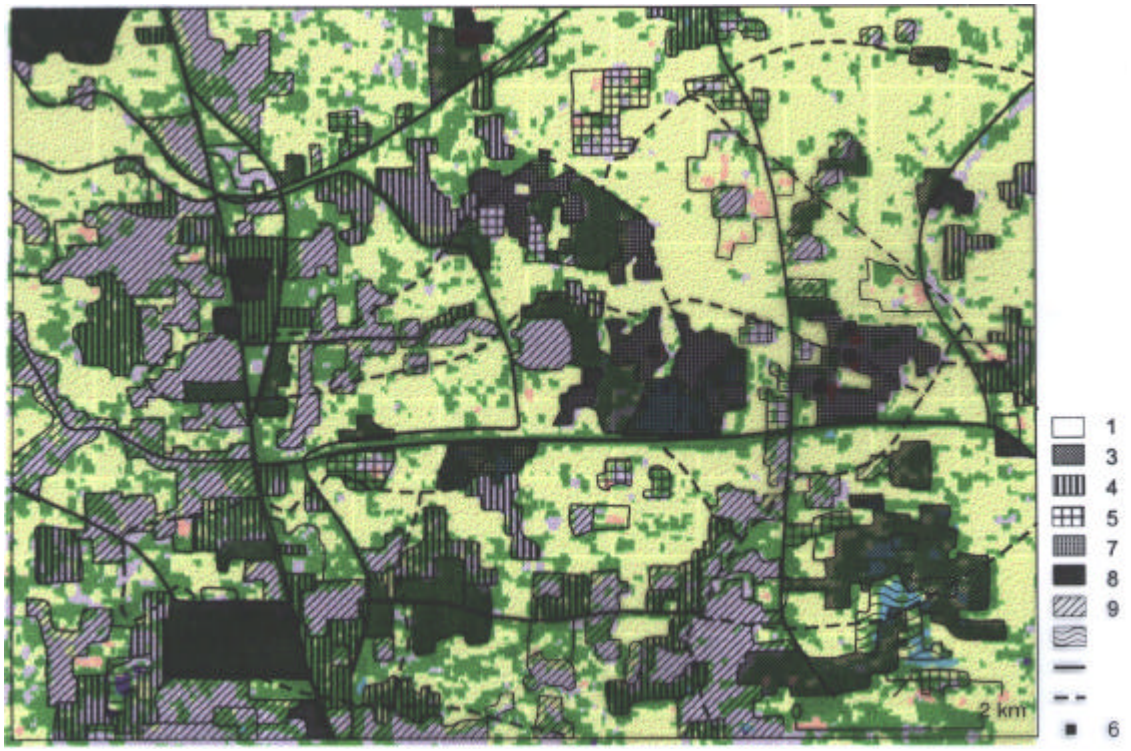


Figure 3.4 Most occurring land use changes in Alipur Block

Change from (in estimated hierarchy of importance)	Current land use	Change to (in estimated hierarchy of importance)
4. Vacant 7. Excavation 6. Brick kiln	1. Agriculture staple crops	9. Built-up 4. Vacant 7. Excavation 5. 'Farmhouse' 2. Horticulture/floriculture 8. Infrastructure 6. Brick kiln
1. Agriculture staple crops 4. Vacant 7. Excavation 6. Brick kiln	2. Horticulture/floriculture	9. Built-up 4. Vacant 5. 'Farmhouse' 8. Infrastructure 1. Agriculture staple crops
	3. Forest/commons/orchard	9. Built-up 4. Vacant 7. Excavation 5. 'Farmhouse' 8. Infrastructure
1. Agriculture staple crops 7. Excavation 3. Forest/commons/orchard 2. Horticulture/floriculture 6. Brick kiln	4. Vacant	1. Agriculture staple crops 2. Horticulture/floriculture 9. Built-up 7. Excavation 5. 'Farmhouse'
1. Agriculture staple crops 2. Horticulture/floriculture 4. Vacant 3. Forest/commons/orchard	5. 'Farmhouse'	2. Horticulture/floriculture 8. Infrastructure 6. Brick kiln 1. Agriculture staple crops
1. Agriculture staple crops 7. Excavation 2. Horticulture/floriculture 4. Vacant	6. Brick kiln	8. Infrastructure 4. Vacant 1. Agriculture staple crops 7. Excavation 5. 'Farmhouse'
1. Agriculture staple crops 4. Vacant 3. Forest/commons/orchard 2. Horticulture/floriculture 6. Brick kiln	7. Excavation	1. Agriculture staple crops 4. Vacant 5. 'Farmhouse' 2. Horticulture/floriculture 8. Infrastructure
1. Agriculture staple crops 2. Horticulture/floriculture 4. Vacant 3. Forest/commons/orchard 5. 'Farmhouse'	8. Infrastructure	
1. Agriculture staple crops 4. Vacant 3. Forest/commons/orchard 7. Excavation 5. 'Farmhouse'	9. Built-up	

3.4 The dynamics of land use: changes, effects and future developments

3.4.1 Most frequently occurring land-use changes

This analysis is based on observation and interviews. It is not based on RS, since similar longitudinal data sets that cover a sufficient time span are inconsistent with the recent images. Combining the results of this chapter with information from plans, newspapers, and the census data, a picture was drawn depicting the future of urbanisation in the study area.
Figure 3.4 shows the main changes in types of land use. Built-up land hardly ever changes back into another rural use, nor do infrastructure and farmhouses. Vacant land is the most transitional type of land use: many land use types can become vacant and many may follow it up. Some types of land use are by definition temporary, such as brick kilns and excavation sites. These activities are most likely to locate on agricultural land due to their specific physical and locational requirements. Built-up land, infrastructure, and to some extent farmhouses are typical 'end-uses'; they are only converted to other uses in exceptional cases.

3.4.2 Impact of urban land use on adjacent and nearby agricultural land

At a micro-scale, expanding urban land has some effects on nearby and adjacent agricultural land. The negative effects are certainly not major problems. Nevertheless, they are worth mentioning because they are indicative of the variety of problems that occur due to urbanisation. With the very high heterogeneity of land uses in the rural-urban fringe, it seems unavoidable that problems would arise. However, there are also positive effects, which show are mentioned afterwards:

Negative effects

1. Soil excavation is accompanied by the erosion of adjacent plots. Similarly, soil excavation disrupts the level grade of the land and thereby causes run-off of irrigation water, fertilisers, and pesticides. Usually, the problem is limited in scale and can be solved amicably between the owner of the brick kiln and the landowner. Sometimes, however, fertile topsoil erodes from the fields, leading to serious problems for the cultivator. There are cases of long-lasting legal conflicts that follow a situation like this.
2. There are disadvantages for agriculture when excavation causes the fields to be split up into smaller units. This happens when a farmer leases out part of his landholding to the brick kiln owner. Sand excavation sites cause similar problems, although there are only a few of these sites in the agricultural fields.
3. Excavation alters the local topography, which can have negative consequences on access to tubewells for irrigation. Higher fields adjacent to or nearby the excavations

might be cut off from the irrigation source. Dirt roads used for access to the kiln block the irrigation channels that run to fields of a nearby farmer.

4. Some people claim that polluting brick kilns and factories have harmful effects on crops. The truth of this claim cannot be confirmed with certainty. However, it could be that the dust and pollution prevent the cultivation of some vulnerable products, such as mangos.
5. A surprising but probably minor complaint was mentioned by a few farmers whose fields are surrounded by brickfields (or vacant/built-up land). They claim that most birds flock to their fields, causing more damage than they would if the surrounding fields were cultivated as well.

Related positive and complementary effects

Related to point 2, the fields tend to become more accessible for trucks and tractors because of the roads that are constructed for brick kilns. Related to point 3, excavation can considerably reduce the problem of irrigation. For instance, excavation can help by levelling land that used to obstruct the local water management system because of its elevation.

Authorities and environmental groups frequently mention the depletion and pollution of groundwater as negative 'externalities' of urbanisation and the proximity of urban areas. In Alipur Block, the response of farmers does not suggest that this is serious. The reason is that this area benefits from the relative proximity of the Yamuna River, which allows sufficient freshwater to infiltrate the groundwater reserves. The pollution of nearby industrial areas affects the quality of hand pump water (as seen in Nangli Poona and Samaipur). The deeper pumped irrigation water is still fairly clean. The study area is probably not very representative of the grave groundwater problems in Northern India. For Delhi, newspapers report that in Najafgarh Block, both industry and excessive extraction of water by residents cause serious degradation of the groundwater resource (Times of India 5-5-1998).

Generally, local farmers have enough influence to demand compensation for damage to their land. But it is harder for small farmers who do not have much power to resolve these problems. There is a lack of legal instruments and institutions to protect or compensate a victim of negative externalities that are beyond the control of the disadvantaged 'actor'. Chapter 4 goes more deeply into the local-level politics. The local institutions provide the most appropriate framework for protecting the interests of groups and individuals.

3.4.3 Future developments concerning land in Delhi's rural-urban fringe

This section briefly explores the future of the land-use changes that may be expected to occur during the coming two decades, particularly in Alipur Block. The concern that urbanisation will take up a large amount of agricultural land is valid for Delhi as well (as mentioned by Barrow 1991 and Rodriguez 1995). Urban sprawl has implications at the regional and national level, as Figure 3.5 indicates. It can be concluded from the figures that the amount of land directly consumed by urbanisation is not very large in absolute terms. But not all of the land that has been removed from agriculture is included in the

data on land use (e.g., farmhouses and much of the vacant land are left out). Urbanisation is dispersing, binging with it a wide range of land uses other than agriculture. The identification of the types of land use in Section 3.2 reveals that there are many urban-related non-agricultural land uses that do not appear in the land-use statistics.

At the current rate of urban expansion, most of Alipur Block will be covered with urban land use in the coming two or three decades. Unplanned development will be an important component of that transformation. Nevertheless, there are plans to limit the unauthorised conversion of agricultural land into urban land. The planning authorities want the government to acquire additional stretches of land between Rohini and Narela and designate it for formal housing and industry (Times of India 22-2-1996). Other policies will force industry to move outside the present urban area of Delhi. In order to accommodate these industries and new ones, a large area near Bawana has been reserved for building a very large industrial area. Land acquisition has already taken place, and factories are expected to start operations within a few years. The total area reserved for industrial use there is very large (500 hectares, according to the Industrial Development Corporation 1998).

Figure 3.5 Estimation of 'consumption' of land by urban in Delhi and India

In the literature, there is some concern about the effects of urbanisation on the usually highly productive agricultural land around cities. A rough estimate of the extent of conversion of agricultural land into urban land can be made on the basis of census data about the growth of urban areas in the recent past.

Urban area of Delhi 1971:	446 km²
Urban area of Delhi 1991:	685 km²
Increase of urban area 1971-91:	239 km²
Population urban Delhi 1971:	3,647,000 inhabitants
Population urban Delhi 1991:	8,472,000 inhabitants

Consequently, Delhi accommodated 20,187 extra inhabitants per km² from 1971 until 1991.

If the present pattern continues, Delhi will need 420 km² extra 'village area' for the expected 17.6 million inhabitants in 2015 (Ansari and Von Einsiedel 1998). In fact, this is a modest estimate. A large part of the remaining rural area in the NCT of Delhi (783 km²) will be consumed in the process.

If the same figure of 20,187 inhabitants per km² is extrapolated to represent the increase in the urban population of India (500 million in 2015), urbanisation would consume 13,969 km² of 'rural' land. This is 0.42 per cent of the total surface (3,287,263 km²) of India. A large part of the expansion will stretch into good farmland.

Sources: Census of India 1991, Observer 1998.

If the current state of affairs continues, the spontaneous and unplanned construction on the eastern side of the GT Road will continue, despite contrary objectives of the Delhi Master Plan (DMP) (see also Section 2.1 and 4.2.2). The highest pressure on land is visible closest to the highway, where unauthorised commercial structures are mushrooming, especially storehouses and factories. Particularly the fields around Burari continue to disappear in favour of 'colonies'. The housing shortage is so serious that enforcement of the restrictions called for by the plans of the DDA would lead to serious social problems. The policy target of the DMP will therefore prove unrealistic (for a discussion of the mechanisms of unauthorised conversion of land, see Chapter 4).

At the western part of Alipur Block, the DMP and subsequent plans intend to expand Rohini and Narela to create Rohini phase 4 and 5 and the so-called Narela sub-city. However, it is impossible for the DDA and other authorities to implement the

comprehensive plan for the whole area. The government is not able to 'freeze' urban development in these areas either. Most likely, the DDA and other development authorities will acquire the land in phases, leaving pockets of unauthorised construction as they are. Meanwhile, the unauthorised sector will be given ample space to continue to develop colonies on agricultural land. In addition, it seems inevitable that the authorities will have to provide the villagers with more space (that is, to expand the *lal dora*), now that the village settlements are bigger and their political force is growing. The present Rohini Township is already characterised by a mix of planned development, villages, and vast areas of unauthorised construction.

Apart from the strong presence of the unauthorised sector, there are also forces within governments that frustrate planning. The press regularly reports on the 'violation of the Delhi Master Plan' (The Hindu 1-4-1998) or 'developments against the spirit of the Delhi Master Plan' (Indian Express 3-4-1996). One such violation consists of the plan of the state Tourist Corporation to put in motels on the urban fringe along the main access roads. The Delhi Master Plan intends to keep these roads free of 'encroachments' up to 300 metres on both sides of these roads. However, the lobby for motels and other commercial services, from both the private sector and government agencies that are involved in the tourism industry, is too strong to resist.

Brick kilns are effectively banned from the NCT, but in the neighbouring states they continue to spread rapidly. Other urban land uses do not stop at the administrative borders either. The expansive nature of urban land uses, especially along the main transport routes, makes rural-urban land-use types increasingly relevant for areas that were previously beyond reach of the city.

The judiciary, especially the Supreme Court, is an emergent force in land-use planning (see also Chapter 4 and 6). This institution increasingly objects to certain land uses and conversions, referring to the DMP. The judiciary often rules against the interests of bureaucratic agencies and political groups. Some important verdicts include the removal of all 'encroachments' and polluting factories from 'unconforming areas'. Although interference from the Supreme Court is not always immediately effective, it can be seen as a new trend in city administration, a trend with considerable impact on spatial development. As a consequence of the above-mentioned diversity of forces in urbanisation and the weak political framework in which the DDA operates, it seems that planned urban development will appear only sporadically and with long delays.

3.5 Links with debates on urbanisation and land-use change

3.5.1 The usefulness of remote sensing (RS) in the rural-urban fringe

Closer monitoring of the land-use patterns in the urban fringe could contribute to more realistic and better-enforced land-use plans. Mapping processes of urbanisation with RS is a subject that as yet is not very well developed, although many sources cite valuable attempts (e.g., De Jong et al. 1998, Yeh and Li 1996, Mahavir 1996, Karstkarel 1997). The lack of recent and detailed spatial information on rural-urban fringes in developing countries justifies further efforts at RS analysis and mapping. Socio-economic

characteristics and physical features of the land have to be closely examined in order to apply RS in a reliable and useful way. Human geographers can contribute by analysing functional aspects of land use while collaborating with physical geographers, who have superior expertise on soil and vegetation structures and can interpret the reflections picked up by the RS sensors.
The experience of this study with RS shows that it does not fill all the gaps in information on land use. It is particularly important to be aware of the overlaps and inconsistencies that arise as a result of the high heterogeneity of land use. It should be recognised that the physical land cover does not necessarily correspond to the socio-economic realities. Automatic generation of RS maps can even lead to manipulation and misuse of the data. In some cases, regardless of the actual reliability of the results, the appearance of nicely designed and colourful maps gives people the impression that the analysis is based on one hundred per cent accuracy and truth. For example, an official publication wrongly identifies excavation land as built-up land (National Capital Region Planning Board 1999). Some scepticism is justified regarding perfect-looking RS interpretations. Besides, RS cannot help improve the quality of the crucial information on ownership of both rural and non-rural land. It therefore remains important to collect spatial information in the field.

3.5.2 The issue of land degradation from a socio-economic perspective

Fertile lands are being transformed from agricultural into urban land use. The rough calculations given in Figure 3.5 about the conversion of cultivated land due to urbanisation do not present an alarming picture. In absolute figures, however, the amount of rural land that is being taken up for urban expansion is considerable. The issue of land degradation for the local people however is played out on an entirely different level.
In a physical sense, land degradation can be defined as a reduction of physical qualities, e.g. density or type of vegetation and soil structure (Barrow 1991). The RS classification gives an ambivalent picture of this process. On the one hand, vegetation densities are reduced; in some conversions, the green cover is removed completely. Soils are excavated, and vast areas are losing their agricultural designation. On the other hand, expanding horticulture and floriculture improve the agricultural value of soils while sustaining high vegetation levels. Vacant land and (speculative) plantations and farmhouses, all manifestations of urbanisation, support many trees and other healthy vegetation.
The impact of brick kilns and loam excavations is sizeable and under-researched, but historical equivalents can be found in the literature. Barrow (1991) reminds us that in Europe this industry was also concentrated near urban agglomerations: “Brick-pits have been dug in many parts of the UK and Europe, for example around London. Once abandoned, these excavations have proved valuable for domestic refuse disposal and recreational use” (p. 229). Whether all excavations can be put to such a positive use in Delhi remains doubtful. The demand for construction materials in the contemporary metropolis of Delhi is much larger than in the European antecedents. Besides, the socio-economic mechanisms around the lease and excavation of land result in land remaining barren for extensive periods, during which the land is not used.

The interpretation of land degradation in a socio-economic sense, introduced in Section 1.2.2, disqualifies the idea that physical characteristics are the only relevant measure (Blaikie and Brookfield 1987). From this perspective, much of the urbanising land obviously continues to satisfy many uses and an increasing number of users, although this process is highly selective. The next chapters will show that in an overwhelming majority of cases, there is no general 'victimisation' of people during the conversion of land use. Land transactions take place in many forms. Both formal and informal compensation mechanisms operate in such a way that the local farming community is able to make a shift in their source of income. Nevertheless, Chapter 6 describes how the changes on land due to urbanisation cause environmental stress. The adverse environmental conditions at some places are the most obvious sign of environmental degradation in this study area.