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Landuse/Land Cover Change in Mumbai-Navi Mumbai Cities and Its Effects on the Drainage Basins and Channels – A Study Using GIS

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ABSTRACT

The Mumbai-Navi Mumbai cities (Bombay and New Bombay) are among the highest populated cities in the country. The population pressure has caused drastic landuse change in the last seventy years. Multi-date data from SOI topographical maps and Landsat TM digital data have been used to study the landuse change. The change has been quantified using a GIS. It was observed that 55% reduction in forest/agricultural land, while a 300% increase in built-up land has taken place in the last seventy years. This has affected the natural drainage system of the cities, causing flooding during monsoons. The quantum of drainage basin area and stream length, in the ten basins which drain the area, under influence of built-up land was found by using a map overlay of the drainage network map and landuse map of 1994. The results shed light on the extent of drainage network disruption within these two neighbouring cities.

Introduction

One of the most effective agents of change in a metropolitan city like Mumbai is mankind. With a concentrated industrial, trading, transport, economic and administrative base, Mumbai has been growing very fast. It had a population of 11 million in 1981 (BMC, 1993) which is expected to cross 20 million by 2001. This may have an adverse effect on the ecology and environment of the region. The greatest impact of this steep rise in population is seen on the landuse patterns, which in turn has effected the natural drainage of the area.

The present paper aims at quantifying the change in landuse and its effects on the drainage basins and drainage network using simple map

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overlay techniques (Bonham-Carter, 1994) available in any GIS environment. The problems arising due to these changes have also been studied.

The Study Area

Mumbai the capital of Maharashtra state and the principal industrial and commercial centre of western India, is actually a group of islands located near the coast of north Konkan (18°53'N-19°19'N, 72°45'E-73°E). The Mumbai island originally consisted of seven separate islands, separated from one another by swamps. These swamps were reclaimed, giving rise to a single landmass at the end of the 18th century. This land mass is the old Mumbai city (Bombay). The Salsette island to the north and the Trombay island to the east were separated from the Mumbai island by the Mahim and Mahul creeks respectively.

The Madh and Gorai islands to the west were separated from the Salsette island by the Malad and Manori creeks respectively. The amalgamated islands of Mumbai, Trombay, Salsette, Madh and Manori have collectively been termed the Mumbai area for this study. This area is separated from the mainland by the Thane creek to the east and the Vasai creek to the north.

The Navi Mumbai city is an amalgamation of the Vashi-Rabhade-Nerul-Belapur townships located on the mainland to the east of the Mumbai area between latitude 19°N and 19°15'N and longitude 73°E and 73°5'E.

The study region measures 859.99 sq. km and falls in the Survey of India (SOI) topographical map numbers 47 A/15, 16, 47 B/13 and 47 E/4 as shown in Fig. 1.

Methodology

For any GIS based analysis the primary input is numerical data. Since spatial information which is collected in any landuse study is represented in a map, these maps have to be digitised. The topographical maps of the Mumbai and Navi Mumbai area surveyed in 1925 and later in 1967 were used to obtain the landuse information in these two years, which were used to generate the landuse maps for these two years (Fig. 3a, 3b). The latest landuse patterns i.e. for 1994 were delineated using Landsat 5, TM digital data on bands 2, 3, 4 and 5 for 10th December 1994. The landuse pattern was obtained by applying a minimum distance to mean classifier to the four band data and the resultant was reclassified to give the landuse map for 1994 (Fig. 3c). The drainage network in the area (Fig. 2) was traced from the 1925 topographical maps and was digitised.

GIS Analysis

The IDRISI ver. 4.0, a grid based GIS package was used for the digitizing and data analysis. The area within the various landuse categories were also calculated by using the spatial analysis module in the IDRISI software. The resolution of all the data used was 30 m, so as to match the spatial resolution of the satellite data.

The methodology adopted for determining the effect of built-up land on the drainage network and drainage basins was a simple overlay technique. The area under built-up land in the ten drainage basins which fall in the study area and the stream length in built-up land (order wise: using Strahler's scheme of ordering (Strahler, 1968) was also found by using the map overlay and spatial analysis module of Idrisi.

Results and Discussion

Landuse change

Analysis of the multidate data spanning almost seventy years (1925-94) shows that drastic reduction of about 55 per cent in forest/

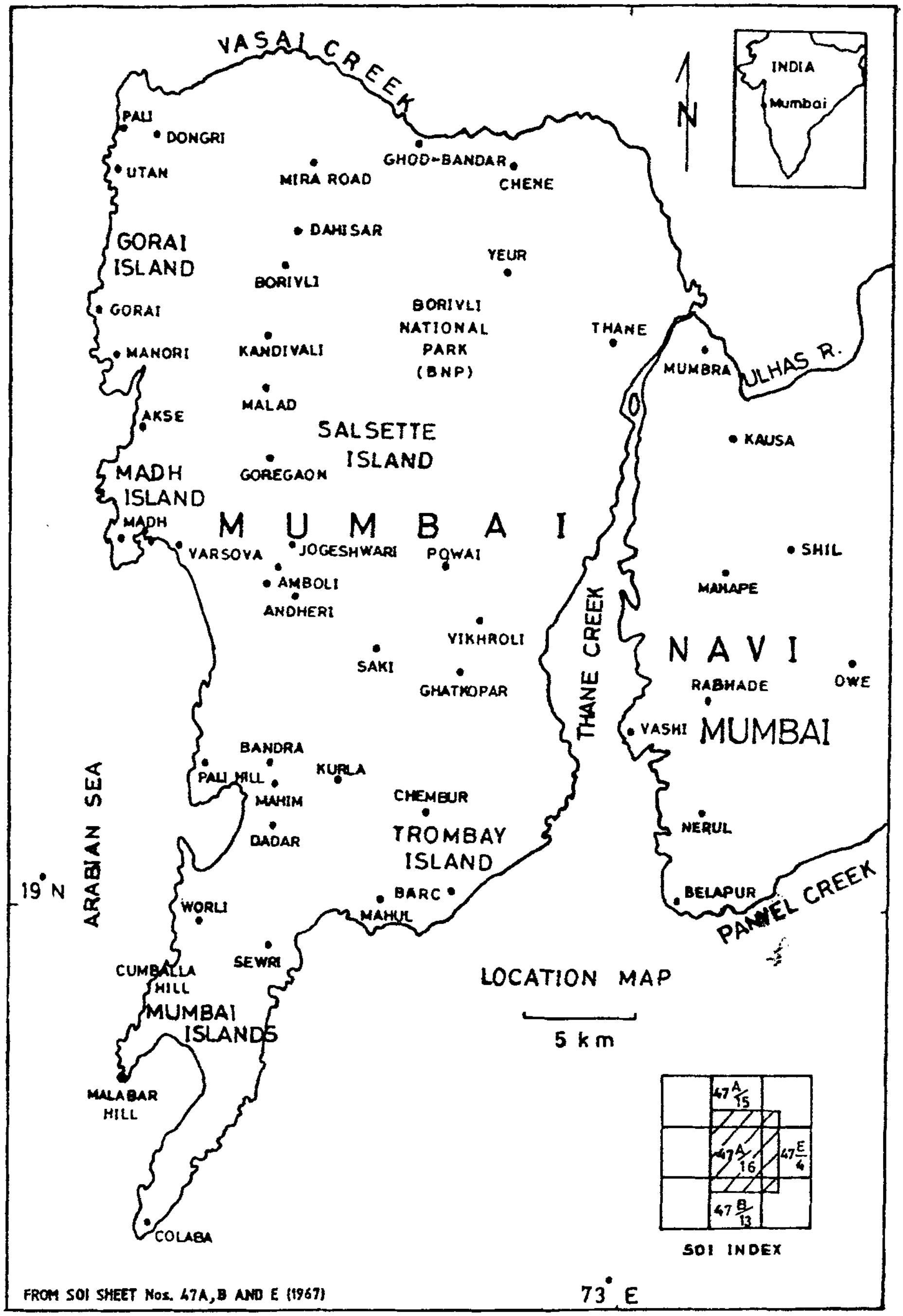
VASAI CREEK
INDIA
Mumbai
N
PALI
DONGRI
UTAN
MIRA ROAD
GHOD-BANDAR
CHENE
DAHISAR
GORAI ISLAND
YEUR
BORIVLI
GORAI
BORIVLI NATIONAL PARK (BNP)
THANE
KANDIVALI
MANORI
MUMBRA
ULHAS R.
MALAD
AKSE
SALSETTE ISLAND
KAUSA
MADH ISLAND
GOREGAON
MADH
M U M B A I
VARSOVA
JOGESHWARI
POWAI
SHIL
AMBOLI
MAHAPE
ANDHERI
VIKHROLI
THANE CREEK
N A V I
SAKI
GHATKOPAR
RABHADE
OWE
VASHI
MUMBAI
BANDRA
KURLA
PALI HILL
MAHIM
CHEMBUR
ARABIAN SEA
DADAR
TROMBAY ISLAND
NERUL
19° N
BARC
BELAPUR
WORLI
MAHUL
PANVEL CREEK
SEWRI
CUMBALLA HILL
LOCATION MAP
MUMBAI ISLANDS
5 km
MALABAR HILL
47 A/15
47 A/16
47 E/4
47 B/13
COLABA
SOI INDEX
FROM SOI SHEET Nos. 47A, B AND E (1967)
73° E

Fig. 1

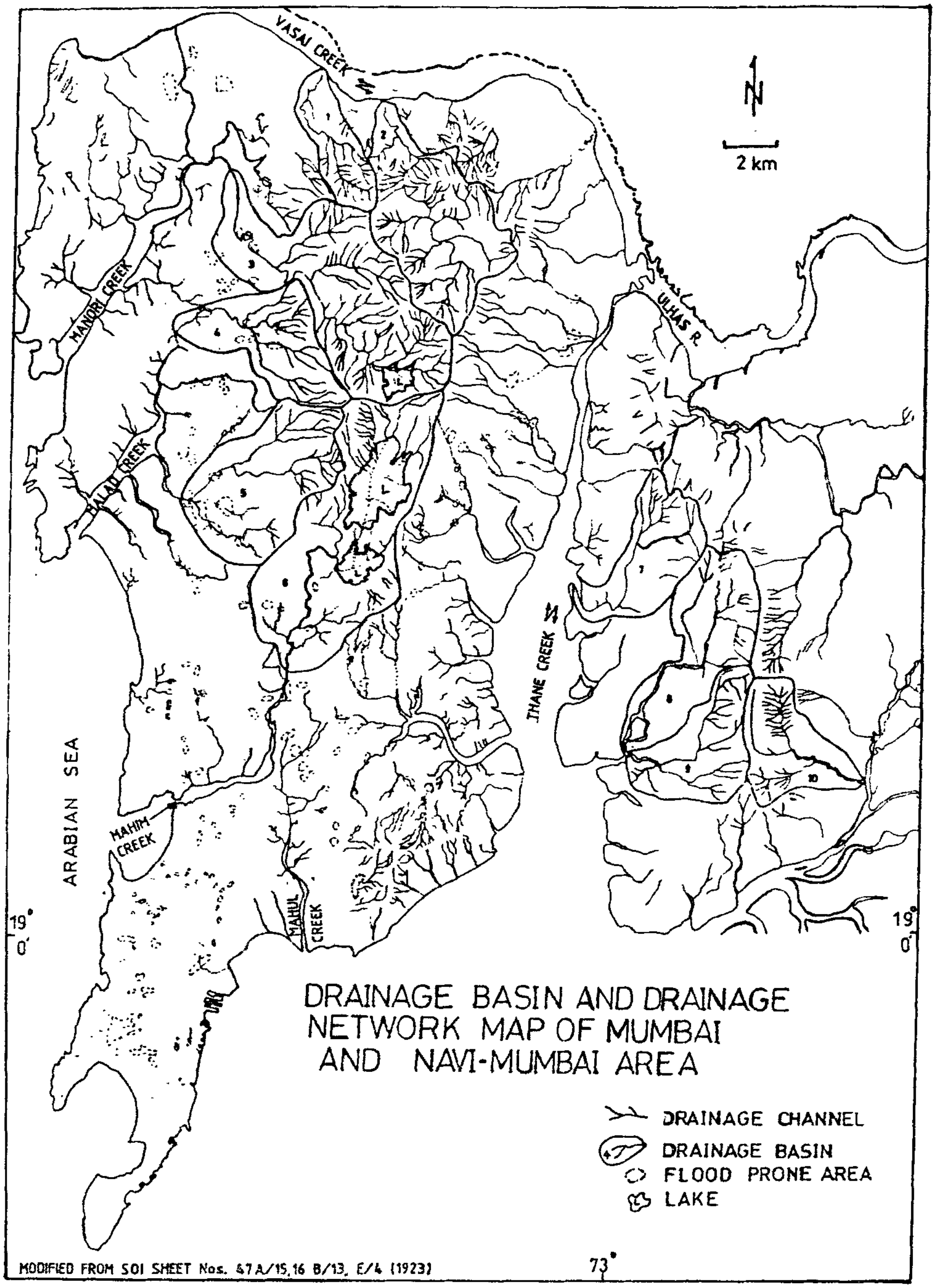
VASAI CREEK
2 km
ULHAS R.
MANORI CREEK
MALAD CREEK
THANE CREEK
ARABIAN SEA
MAHIM CREEK
MAHUL CREEK
19°
0'
19°
0'
DRAINAGE BASIN AND DRAINAGE NETWORK MAP OF MUMBAI AND NAVI-MUMBAI AREA
DRAINAGE CHANNEL
DRAINAGE BASIN
FLOOD PRONE AREA
LAKE
MODIFIED FROM SOI SHEET Nos. 47A/15,16 B/13, E/4 (1923)
73°

Fig. 2

a b c

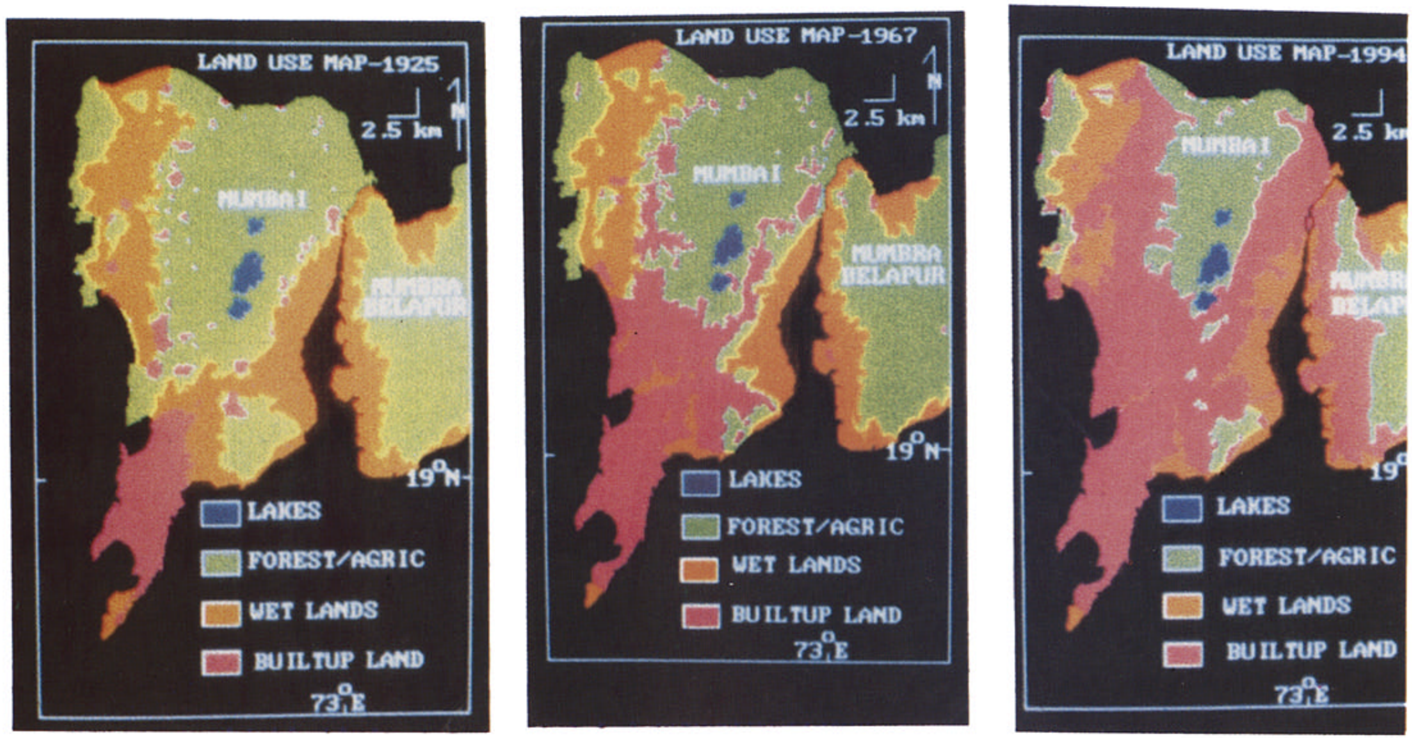

Fig. 3. Landuse maps for the year 1925 (a); 1967 (b); and 1994 (c) of the Mumbai and Navi Mumbai areas.

agricultural land has taken place while a 300 per cent increase in built-up land is seen. The wetlands too show a reduction by 23 per cent. The results are given in Table 1.

Table 1. Landuse (Area in sq. kms)

Landuse class	*Year*		
	1925	*1967*	*1994*
Forest/Agriculture	521.86	464.35	263.28
Wetlands	235.23	191.12	160.00
Built-up land	102.90	204.51	436.71

Effects on drainage basins and drainage channels

To study the extent of land use changes, the drainage basin and drainage network map-images were superimposed on the landuse map image for the year 1994 separately. Table 2 gives the values obtained from this study. It can be seen that the area under built-up land in some basins is as high as 50 per cent while the stream length effect of built-up land on stream length is as high as 40 per cent. It is also evident that higher order streams were affected the most.

The drastic changes within a drainage basin affects the channel parameters. The large percentage of impervious cover due to urban landuse in the form of buildings and roads reduces the infiltration capacity in a basin causing proportional increase in the amount of surface runoff (Anderson, 1970; Morisawa, 1985). Since the man-made changes are much faster than the capacity of the drainage channels to modify, to accommodate the larger volume of water they now have to carry, it results in channel overflow and flooding in the vicinity of the drainage channels as seen in Figure 2. The data about the flooding sites has been collected from the Brihana Mumbai Mahanagar Palika (BMC, 1993).

A very different phenomenon was observed where the channels affected were the first order streams. These streams being the youngest are the first to react and adopt to any change. An example of the above kind is seen at the base of Hostel 1 hill in IIT Powai, Mumbai campus where new construction of residential buildings and reclaiming a valley by dumping construction debris has resulted in a fresh deepening of the stream channel by about 30 cm within the last two years. This removal of soil from the upper reaches of the drainage is also compounded by deforestation. The soil removed is redeposited in the lower reaches of the basin, and in the present study these localities fall within highly populated and built-up area of the Mumbai city and suburbs. According to the city municipal corporation estimates, about 200,000 cubic metres of silt will have to be removed from the city drainage channels this year (1996) before the monsoon sets in (TOI, 1996). This causes a decrease in the water carrying capacity of the channels and results in flooding of adjoining area.

Conclusions

The urbanisation of any area brings with it its own set of advantages and problems. Environmental changes resulting from human activity like land reclamation, deforestation and quarrying in a metropolitan city like Mumbai and the neighbouring Navi Mumbai (Mumbra-Belapur) area have led to problems like monsoonal flooding.

The results bring out the quantum of damage already done to the forest cover and the drainage network of the area. The city planners and developers should consider these aspects in future land development schemes.

Table 2. Effect of built-up land on drainage channels.

Basin No.	*Total Area sq. km*	*Area under BUL* sq. km*	*% area under BUL*	*Length under BUL*				*Total length under BUL*	*Total stream length*	*% length under BUL*
				1st order	*2nd order*	*3rd order*	*4th order*			
1	8.98	3.93	43	2.74	0.9	1.26	4.23	9.13	23.58	39
2	27.2	2.86	10	2.13	1.23	0.8	2.39	6.55	81.2	8
3	37.44	6.8	18	–	–	–	4.67	4.67	95.69	5
4	16.56	8.13	49	3.12	3.27	3.73	3.57	13.69	35.4	38
5	•24.21	12.09	50	3.26	0.51	8.5	2.7	14.97	40.49	37
6	42.07	22.73	54	8.49	2.71	1.86	4.5	17.56	86.81	20
7	14.81	6.36	43	4.75	2.43	3.28	–	10.46	28.33	37
8	20.24	9.25	46	0.65	1.66	3.4	–	5.71	31.89	18
9	14.59	7.4	42	2.3	4.5	4.67	–	11.47	28.25	40
10	12.75	4.87	38	1.71	0.86	2.39	2.2	7.16	31.70	22.5

*Built-up land

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