DRMMP

City Profile, Greater Mumbai- 2010

A MCGM Initiative

DRMMP

Disaster Risk Management Master Plan

in Collaboration with Earthquakes & Megacities Initiative

City Profile

Greater Mumbai

About the Project

One of the main objectives of the *Disaster Risk Reduction in Greater Mumbai project* of the Municipal Corporation of Greater Mumbai (MCGM) or Brihan Mumbai Municipal Corporation (BMC) is to build MCGM's competency to manage disaster risks.

The Project proposes to establish a disaster risk management process that would close the institutional gap in Mumbai City's competency to manage disaster risk by equipping MCGM with a Disaster Risk Management Master Plan (DRMMP) and an Internal Competent Structure for Emergency and Crisis Management. The development of a DRMMP entails a structured participatory process by which stakeholders can understand their relationship to the various risks envisaged in Mumbai City and their role in the City's Disaster Risk Management (DRM) agenda. Further, it would establish the inter-institutional coordination processes and protocols that would align and harmonize the DRM process in MCGM with those of the relevant National, State and other public and private institutions, in particular those that provide critical services (such as but not limited to utilities, health, education and public safety), to ensure adequate communication protocols before, during and after the disaster.

The City Profile will serve as reference material for planners, investigators, researchers and policy makers doing actual work in Disaster Risk Management. The profile is a tool for understanding the geographical, environmental, institutional, social and economic setting of Greater Mumbai.

Authors

Mr. Mahesh Narvekar, Co-Project Manager, MCGM

Dr. Gita Kewalramani, Retd Professor, University of Mumbai.

Review Team

Mr. Shantaram Shinde, co-Project Director, MCGM

Prof. Ravi Sinha, Peer Reviewer, IIT-Mumbai

Dr Fouad Bendimerad, co-Project Director, EMI

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Executive Summary

Mumbai, the largest city in India, and the sixth largest metropolis in the world is a major business centre and the commercial and financial capital of the country. 33 per cent of income tax collections, 60 per cent of customs duty collection, 20 per cent of central excise tax collection, a significant quantum of the corporate tax, and 40 per cent of India's foreign trade is generated from the metropolis.

The City Profile provides a background of geographical, environmental, institutional, social and economic setting of Greater Mumbai. This background is vital to understand the characteristics, strengths and vulnerabilities of the city. It is thus invaluable in understanding the factors that promote risks in view of the need to develop proactive disaster risk reduction practices for managing disaster risk in the city.

Mumbai, formed by the amalgamation of two groups of seven islands each, is connected to the mainland across the major water bodies surrounding it via roads and railways. It is thus vulnerable to be isolated from the mainland during a disaster. Its insular character also results in an acute paucity of land in the city, resulting in high density of population and one of the highest prices of real estate in the world. Since a substantial area of the city, about half of the Island City, and one- fifth to one-fourth of the suburban area, has been reclaimed from below sea-level by infilling, there is high risk of liquefaction during an earthquake. Mumbai falls in seismic risk zone III, and can experience earthquakes measuring up to 6.5 on the Richter scale. Few buildings in the city have been built to withstand a major earthquake, much less an earthquake magnified by liquefaction. The city is thus highly vulnerable to earthquakes.

Flooding is a chronic and recurrent problem in the metropolis. Almost 60 per cent of the annual rainfall occurs during two months in a year. Occasionally 35-40 per cent of this rainfall is received in just 2-3 events. The process of urbanization too has played a major role in aggravating the problem as it has caused significant alteration to hydrology, morphology, habitat and ecology of the region.

About 60 per cent of the population of the city lives in squatter settlements. The growth rate of slum population is greater than the general urban growth rate. Slums are vulnerable primarily because of their location, density and lack of access to infrastructure. These settlements are located in areas that invariably get flooded during high tides, in coastal locations, along water mains or open drainage, on steep slopes, within industrial zones or under high tension wires. These communities suffer from inadequate access to potable water and sanitation and are more prone to health problems.

Historically, Greater Mumbai developed as a mono-centric city with port, government, banking and insurance, stock exchange, wholesale and retail activities and international trade all being concentrated in and around the Fort area. With diversification of economic growth, conversion of manufacturing sites and expansion of planned transit facilities, a clear pattern of "spatial clustering" is emerging.

One of the most vulnerable elements in Mumbai is it building stock, which contributes to increasing risk of its population. The building stock exhibits a rich mix of several different building technologies. Almost 90 per cent of the buildings located in the 'A', 'B' and 'C' wards in Island City and about 10,000 buildings in the suburbs are dilapidated - many in a state of imminent collapse. These structures act as a death trap in case of tragic accidents, like fire. The government has instituted various amendments in the Development Control Regulations to address the problem.

Though Mumbai is acknowledged as having one of the more extensive and efficient transport networks within India, its infrastructure is woefully inadequate by world-class standards. The problem is aggravated due to the physiography of the city and the large concentration of financial, commercial and administrative functions in the southern end of the city. Lack of east-west connectivity within the city is also a major constraint. The suburban rail system is the life line of the city. The fares, which are the lowest compared to any other transit system in the world, also results in super dense crush load of 14-16 standing passengers per square metre of floor space!

With one of the highest population densities in the world service providers find it difficult to supply basic amenities like health, water and sanitation. Water supply, sewerage and solid waste disposal systems need augmentation. Initiatives are being taken by MCGM to supplement water supply, adopt technology and mechanisms that ensure substantial reduction in quantity of solid waste and to increase the capacity of the storm water drainage system.

There has been an improvement in all air pollution parameters during the last two years. With the exception of SPM all other parameters are within CPCB standards. Vehicular emission load has declined despite the increase in the number of cars. The improvement is attributed to increase in the number of vehicles which run on gaseous fuels, improvement in the quality of fuel and the decrease in the average age of the vehicles. Water pollution in the creeks and coast lines is attributed to non-availability of sanitation facilities to slum dwellers which results in open defecation and waste water discharges. The treatment plants are all primary treatment plants and secondary treatment is not being done in the city.

Being a coastal megacity, Mumbai will be significantly affected by shifting weather patterns which are expected to contribute to a sea level rise as well as an increase in rainfall, both of which will significantly aggravate the problems of the city. Without timely and appropriate adaptation strategies, a large proportion of Mumbai's population will be affected by such climate change impacts.

Mumbai is faced with increasing threats from a plethora of natural and man-made hazards. This document will provide a basic input for effective disaster risk management of the city.

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Abbreviations and Acronyms

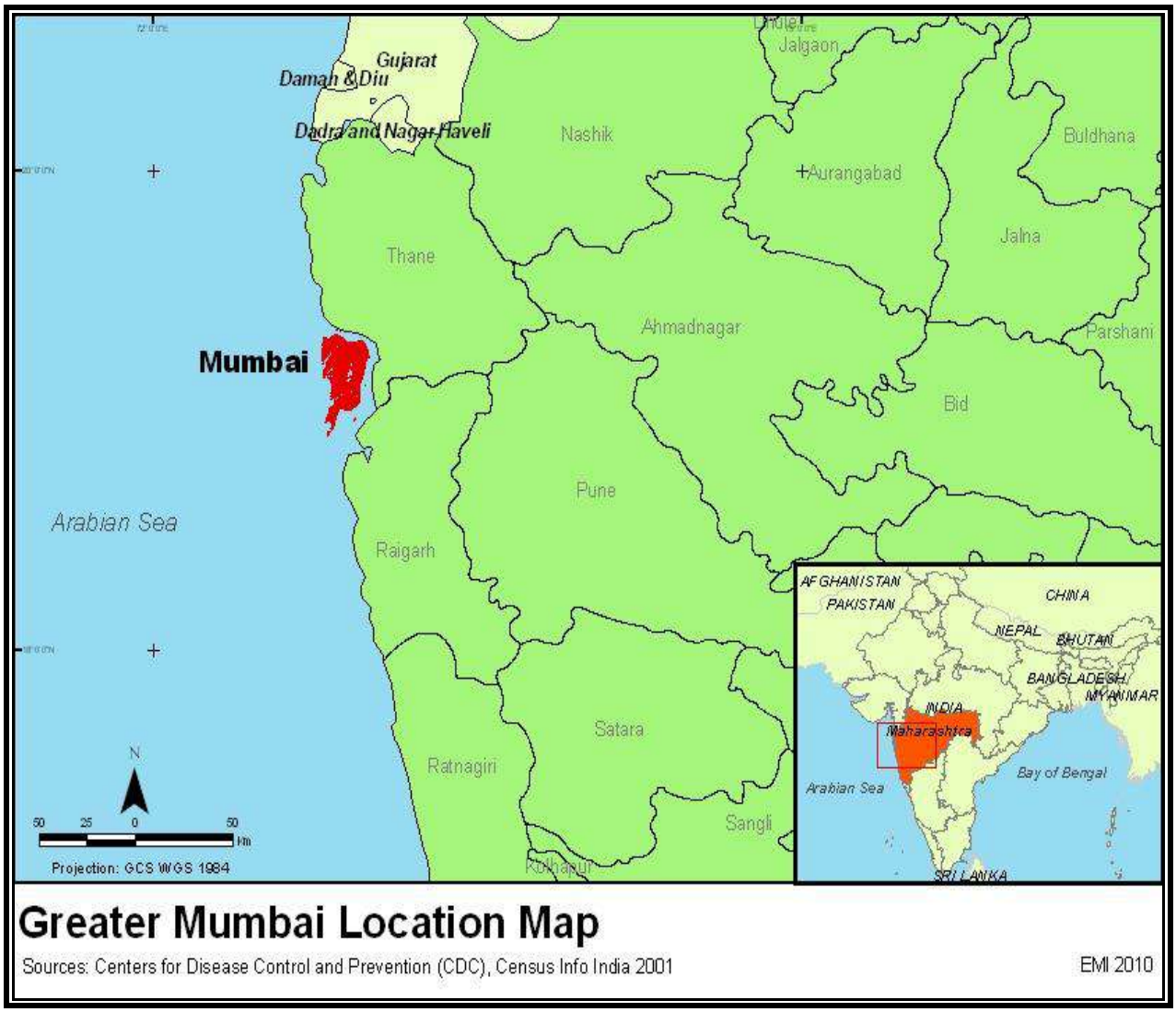
AAI	Airport Authority of India
AIILSG	All India Institute of Local Governance
ALM	Advanced Locality Management
BEST	Brihanmumbai Electricity Supply and Transport
BKC	Bandra-Kurla Complex
BMC	Brihanmumbai Municipal Corporation
BSES	Bombay Suburban Electric Supply
CBD	Central Business District
CBO	Community Based Organizations
CPCB	Central Pollution Control Board
CRZ	Coastal Zone Regulations
CST	Chhatrapati Shivaji Terminus
DCR	Development Control Regulations
DMA	Disaster Management Authority
DMP	Disaster Management Plan
DDMA	District Disaster Management Authority
DP	Development Plan
DRM	Disaster Risk Management
DRMMP	Disaster Risk Management Master Plan
DRR	Disaster Risk Reduction
EMI	Earthquakes and Megacities Initiative
GDP	Gross Domestic Product
GTS	Great Trignometric Survey
HTL	High Tide Line
IIPS	International Institute of Population Sciences
IIT	Indian Institute of Technology
IMD	India Meteorological Department
INR	Indian Rupees
IRS	Indian Remote Sensing
IT	Information Technology
JNNURM	Jawaharlal Nehru National Urban Renewal Mission
JVLR	Jogeshwari-Vikhroli Link Road
LEED	Leadership in Energy and Environmental Design
LPCD	Litres Per Capita Per Day
MBR	Master Balancing Reservoir
MBRRB	Mumbai Building Repairs and Reconstruction Board
MCGM	Municipal Corporation of Greater Mumbai
MLD	Million Litres Per Day
MMR	Mumbai Metropolitan Region
MMRDA	Mumbai Metropolitan Region Development Authority
MHADA	Maharashtra Housing and Area Development Authority

MTNL	Maharashtra Telephone Nigam Limited
MPC	Metropolitan Planning Committee
MPCB	Maharashtra Pollution Control Board
MTPA	Million tonnes per annum
MRDPA	Mithi River Development Project Authority
MSL	Mean Sea Level
MSRDC	Maharashtra State Road Development Corporation
MTPD	Metric tons per day
MUTP	Mumbai Urban Transport Project
NDMA	National Disaster Management Authority
NIDM	National Institute of Disaster Management
NEC	National Executive Committee
NGO	Non-Government Organizations
NH_3	Ammonia
NO_2	Nitrogen Dioxide
NRCUP	National Resource Centre on Urban Poverty
NRM	National Resource Management
PMGP	Prime Minister's Grant Project
POL	Petroleum, Oil and Lubricants
PPP	Purchasing Power Parity
SCLR	Santacruz-Chembur Link Road
SDMA	State Disaster Management Authority
SDRF	State Disaster Response Force
SEC	State Executive Committee
SEEPZ	Santacruz Electronics Export Processing Zone
SO_2	Sulphur Dioxide
SPARC	Society for the Promotion of Area Resource Centre
SPM	Suspended Particulate Matter
SPS	Sewage Pumping Station
SRA	Slum Rehabilitation Authority
SRD	Slum Redevelopment Scheme
SRS	Slum Rehabilitation Scheme
SSP	Slum Sanitation Programme
SUP	Slum Upgrading Program
TEC	Telecommunication Engineering Centre
TEU	Twenty-Foot Container Equivalent Unit
TDR	Transferable Development Rights
THD	Town Hall datum
USD	U.S. Dollars
YUVA	Youth for Seva

1. Introduction

Mumbai, the largest city in India, and the sixth largest metropolis in the world is a major business centre and the commercial and financial capital of the country.The city is the administrative headquarters of the state of Maharashtra. Though it constituted 0.14 per cent of the total area of the State in 2001, it accounted for 8.07 per cent of the population. In addition, it has a sizeable day-time floating population from places like Thane, Kalyan-Dombivili, Ulhasnagar, Nashik, Pune and Panvel.

Figure 1: Greater Mumbai – Location



1.1. Location

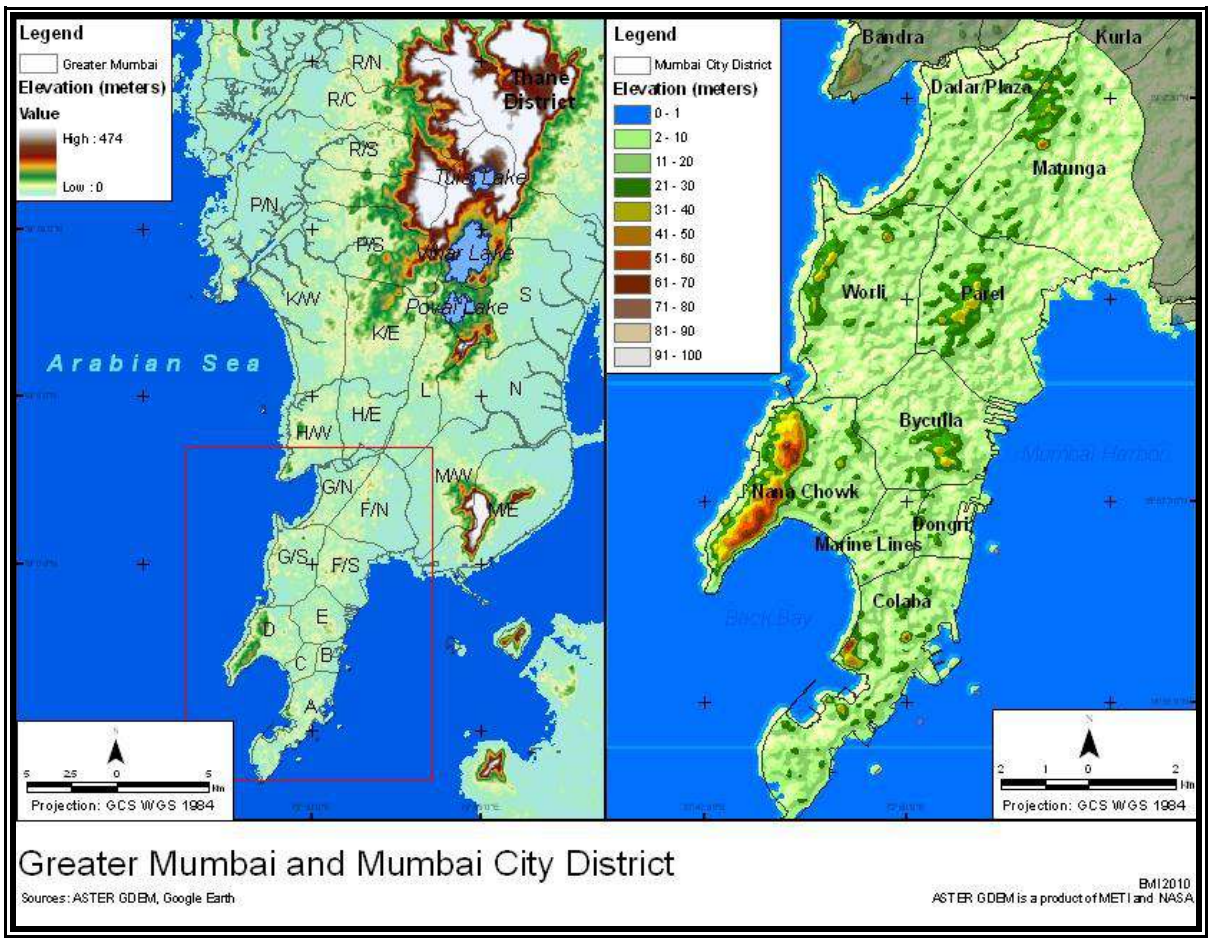
Mumbai metropolis is located on the western seaboard of India between 18° 53' and 19° 19' north latitude and between 72° 47' and 72° 59' east longitude. It has an east-west extent of about 12 km where it is broadest, and a north-south extent of about 40 km. The city includes the original island group of Mumbai, and most of the island of Salsette (a small part to the north is in Thane District). The city is surrounded on three sides by water: the Arabian Sea to the west and south and Harbour Bay and Thane Creek to the east.

1.2. Area and Divisions

Prior to 1950 Mumbai included only the Island City. On April 15, 1950, the municipal limits of Bombay were extended to incorporate Bombay Suburban District. On February 1, 1957 the municipal corporation limits were further extended by transferring a taluka (Borivali) and one village from Thane district to Bombay Suburban district. The current limits of the city have been in existence since 1957.

As per the Surveyor General of India, the geographical area of Mumbai is 603.4 km^2 (233 square miles). The city extends from Colaba in the south to Mulund, Mankhurd, and Dahisar in the north. The metropolis includes regions such as Defence lands, Mumbai Port Trust, Atomic Energy Commission and Borivali National Park which are outside the administrative jurisdiction of Municipal Corporation of Greater Mumbai (MCGM formerly Bombay Municipal Corporation or BMC). Greater Mumbai, the area under the political administration of the (MCGM), has a total area of 437.71 sq. km. (169 square miles). The city consists of two distinct regions: Mumbai City district and Mumbai Suburban district, which form two separate revenue districts of Maharashtra. The geographical area of Mumbai Island City District is 157 sq. km. while the area under MCGM is 97.56 sq km. Mumbai Suburban district has a geographical area of 446.00 sq. km. of which 374.69 sq. km. is under the jurisdiction of MCGM.

Figure 2: Greater Mumbai and Mumbai City District



Source: ASTER GDBM and Leigh Lingad

Mumbai Metropolitan Region (MMR), established under The Mumbai Metropolitan Region Development Authority Act, 1974, treats Greater Mumbai with its rapidly growing hinterland as one region for development purposes. It covers an extensive area of about 4,355 km^2 spanning four districts of Maharashtra state: Mumbai City (complete), Mumbai Suburban (complete), Thane (part) and Raigad (part). The urban agglomeration includes 7 Municipal Corporations (Navi Mumbai, Mira-Bhayandar, Thane, Kalyan-Dombivali, Bhiwandi-Nizampur and Ulhasnagar) and 13 Municipal Councils (Alibag, Ambernath, Karjat, Khopoli, Kulgaon Badlapur, Matheran, Nala Sopara, Navghar-Manikpur, Panvel, Pen, Uran, Vasai and Virar). MMR had a population of 17.81 million people in 2001.

Figure 3: Mumbai Metropolitan Region

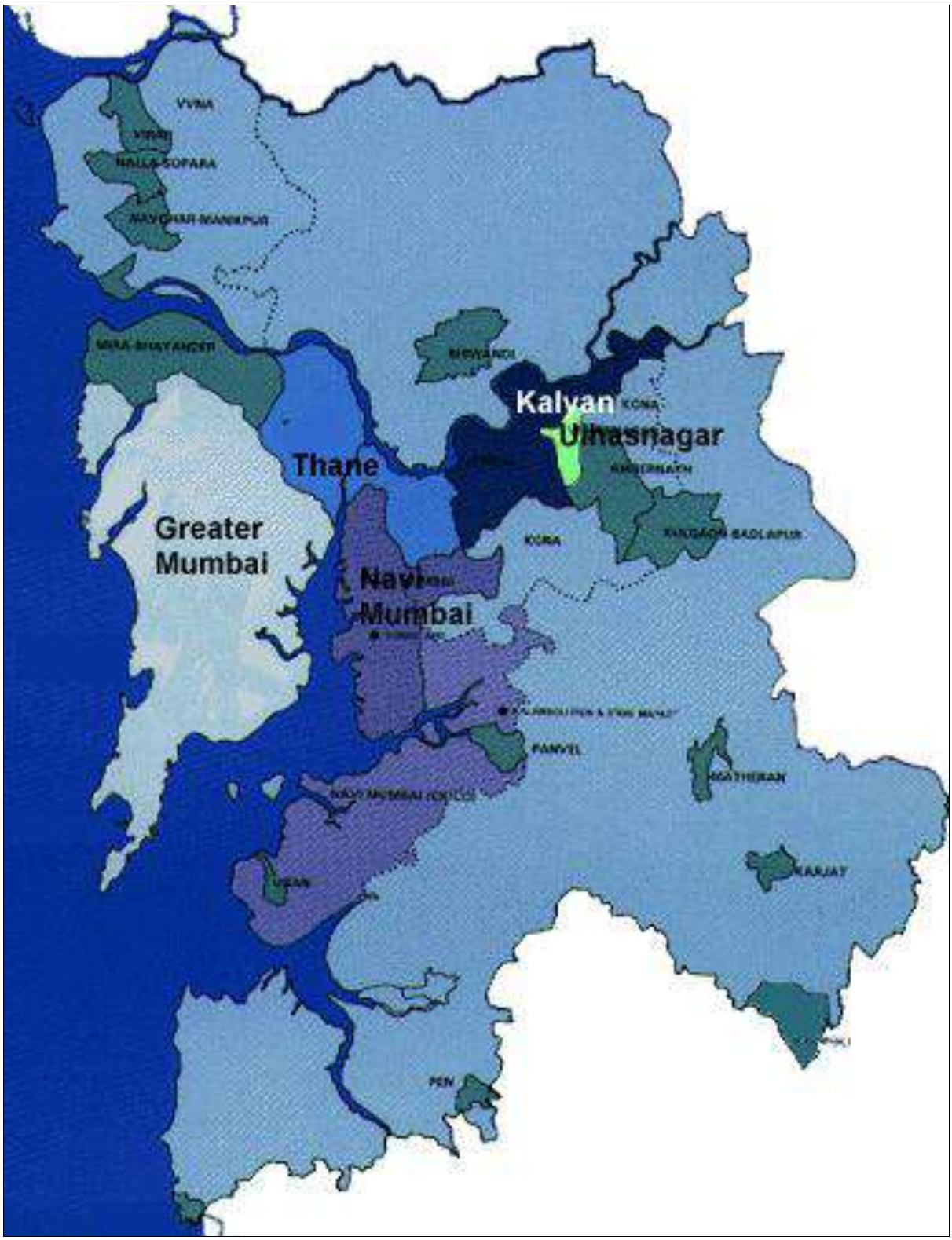


Table1: Administrative Coverage and Area of Mumbai City, Greater Mumbai and Mumbai Metropolitan Region

Units	Administrative Coverage	Land Area (Sq. Km.)	Land Area (Sq. Miles)
Mumbai City		603.40	374.69
	(1) Mumbai Island City District	157.00	97.56
	(2) Mumbai Suburban District (Mumbai Suburbs and Extended Suburbs)	446.00	277.13
Greater Mumbai (Under MCGM)		437.71	169.00
	(1) Mumbai Island City District	67.79	26
	(2) Mumbai Suburban District	369	142.47
Mumbai Metropolitan Region	Four districts of Maharashtra state: Mumbai City (complete), Mumbai suburban (complete), Thane (part) and Raigad (part). It includes 7 Municipal Corporations and 13 Municipal Councils.	4,355.00	1,681.00

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2. Administration

Mumbai is governed by fourteen different agencies. There is no single organisation or body accountable for all of Mumbai.

Table 2: Administrative Agencies in Mumbai

Sr. No.	Agency	Responsibility
1.	Government of Maharashtra	State grants, Urban planning, Industrial policy, Housing
2.	MCGM	Water supply, Sanitation, Construction and zoning, Education, Health
3.	MTNL	Local telecom services
4.	MSRDC	Major roads/sea links
5.	RTO	Vehicle registration
6.	Mumbai Port Trust	Port services, Land-lease
7.	Mumbai Police	Law and order, traffic
8.	PWD	Selected roads
9.	MPBC	Pollution reduction
10.	MIDC	Land for new industries
11.	MHADA	Housing (mainly low/middle income groups)
12.	Indian Railway/MRVC	Suburban rail, Long distance trains
13.	SRA	Slum redevelopment
14.	BEST	Road transport in Greater Mumbai , Power supply in Island City.

Source: McKinsey Report

Each agency operates independently and there is little co-ordination between the different agencies.

2.1. The Municipal Corporation of Greater Mumbai (MCGM)

MCGM is responsible for the civic and infrastructure needs of the metropolis including maintenance of roads, streets, flyovers, public municipal schools, water supply and purification, hospitals, street lighting, lighthouses, maintenance of parks and open local spaces, sewage treatment and disposal, garbage disposal, street cleanliness, cemeteries and crematoriums, registering of births and deaths in the city and prevention of epidemic outbreaks through mass production of medicines at the Haffkine Institute. The budget estimates of the civic body for 2010-11 is INR 204,173 million ($4436.61 million).

Figure 4: Municipal Corporation of Greater Mumbai Headquarters

Source: MCGM

The Municipal Corporation of Greater Mumbai (the largest local self-government in the Asian Continent) was formed in 1865 as a Corporate Body with a Municipal Commissioner and Justices of Peace. The Regular Corporation was formed with 64 members with Rate (tax) payers having right of voting. The Bombay Municipal Corporation Act of 1888, specified nine statutory collateral authorities with distinct responsibilities of city government viz:

1) The Corporation,
2) The Standing Committee,
3) The Improvements Committee,
4) The Brihanmumbai Electric Supply and Transport Committee
5) The Education Committee,
6) The Wards Committees,
7) The Mayor
8) The Municipal Commissioner and
9) The General Manager, Brihanmumbai Electric Supply and Transport Undertaking.

Each authority operates within the limitations set for it. The Mayor is the ceremonial head and chairs Corporation meetings. The Municipal Commissioner, who is appointed by the state government, is the executive head of MCGM.

Apart from the five statutory committees there are six Special Committees, viz:

1) Works Committee (City),
2) Works Committee (Suburbs),
3) Public Health Committee,
4) Markets and Gardens Committee,
5) Law, Revenue and General Purposes Committee,
6) Women and Child Welfare Committee, which deal with specified subjects.

In addition, the Grants-in-Aid Committee has also been constituted for submitting proposals to the Corporation for awarding grants to certain institutions.

There is a separation of powers between the deliberative and executive functions of the Corporation. The Deliberative wing comprises the Deputy Mayor, 227 Councillors directly elected at Ward elections and 5 nominated Councillors having special knowledge or experience in municipal administration to be nominated by the Corporation. The Councillors exercise general authority over civic affairs through budgetary and financial controls by determining taxes and allocating expenditure, approving contracts and other financial proposals and approving appointments to senior posts. They are responsible for overseeing that their constituencies have the basic civic infrastructure in place.

The Executive Wing is headed by the Municipal Commissioner. There are four Additional Municipal Commissioners, two Joint Municipal Commissioners, Director (Engineering Service & Projects) and Director (Medical Education and Public Health) who assist the Commissioner in the overall management and supervision of the administration of the Corporation.

In 1964, a decentralised administrative system was introduced to speed disposal, improve efficiency and effect economy. The city is divided into seven administrative zones each consisting of three to five wards named alphabetically from A to T. There are a total of 24 wards. Mumbai City District has two zones. Zone 1 contains wards A-E, while Zone 2 contains wards F/South, F/North, G/South and G/North. Mumbai Suburban District is divided into 5 zones. Zone 3 contains H West, H East and K East wards, Zone 4 contains K West, P South and P North wards, Zone 5 contains L, M East and M West wards, Zone 6 comprises N, S, T wards and Zone 7 comprises R South, R North and R Central wards. Each zone is the charge of a Deputy Municipal Commissioner while the administrative head of each ward is an Assistant Commissioner. In addition, there are 15 Deputy Municipal Commissioners who supervise the work of the major departments pertaining to the civic administration.

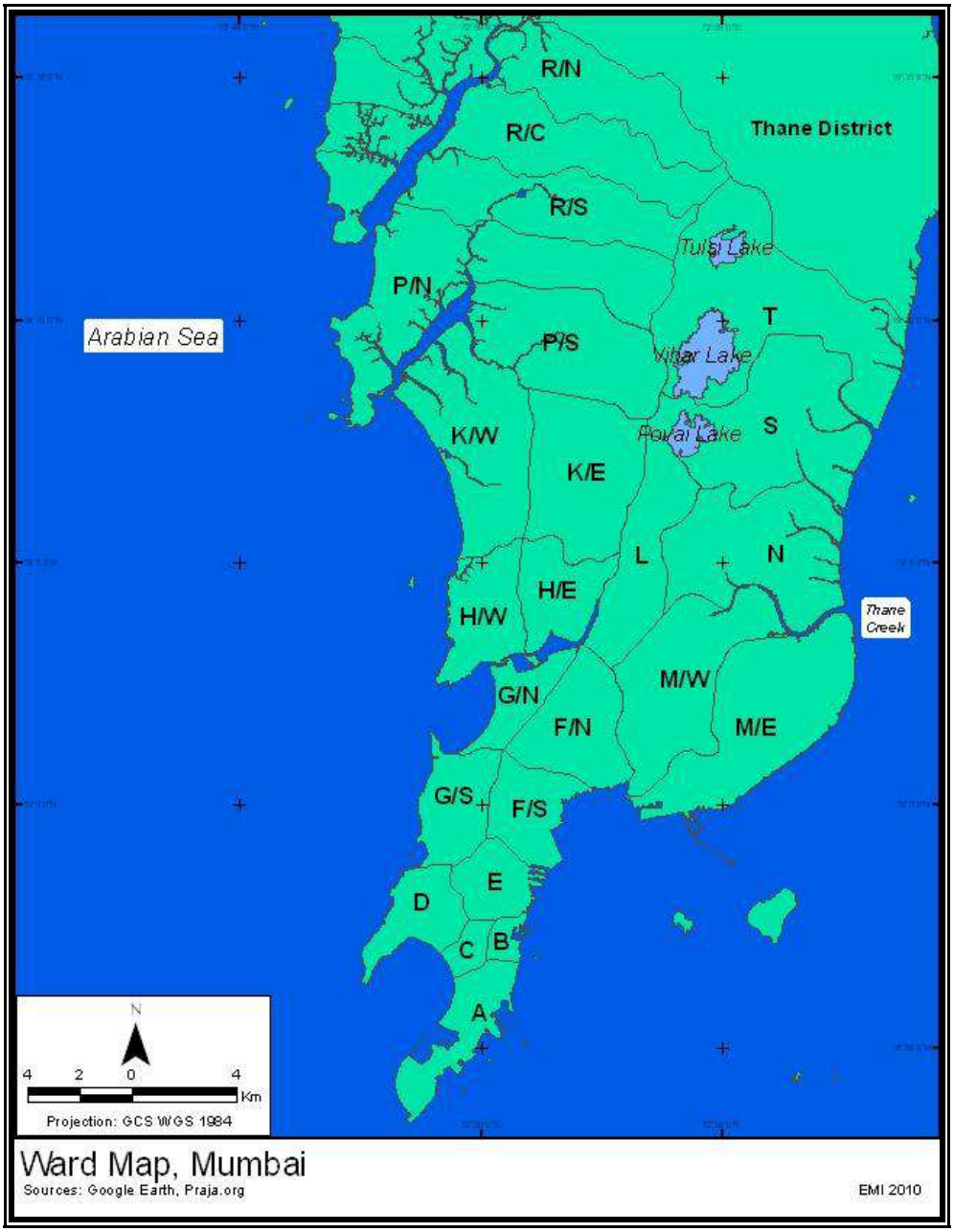
MCGM has 42 departments which provide various services to the citizens. The main departments are:

- Public Relations Department
- General Administration Department
- Information and Technology Department
- Planning & Urban Poverty Eradication Department
- Assessment & Collection Department
- Election Branch
- Estate and Land Department
- Education Department
- Engineering Unit, which comprises the following departments
  - Development Plan
  - Civic Training Institute and Research Centre
  - Roads, Traffic& Bridges
  - Mechanical & Electrical Engineering
  - Storm Water Drains
  - Water Supply Projects
  - Sewerage Operations
  - Sewerage Projects
  - Mumbai Sewerage Disposal Project
  - Building Proposals
  - Solid Waste Management
- Public Health Department which includes the following Municipal Hospitals & Medical Colleges
  - K.E.M. Hospital and G.S. Medical College
  - B.Y.L. Nair Charitable Hospital & T.N. Medical College
  - Nair Hospital Dental College
  - Lokmanya Tilak Municipal General Hospital & Medical College
  - Kasturba Hospital
  - Group of T.B. Hospitals

- Acworth Hospital for Leprosy
- Eye Hospital
- E.N.T. Hospital
- Municipal General Hospitals (18)

- Municipal Printing Press
- Gardens & Zoo Department
- Mumbai Fire Brigade
- Deonar Abattoir
- Security Department
- Legal Department
- Licences Department
- Markets Department
- Shops and Establishments
- Environment Department
- Vigilance
- Disaster Management
- Heritage Conservation
- B.E.S.T.

Figure 5: Wards of Greater Mumbai



Source: Praja.org

2.2. District Collector

In October 1990, the metropolis was divided into two revenue districts - Mumbai City District and Mumbai Suburban District. Each district is under the jurisdiction of a District Collector. The Collectors are in charge of property records and revenue collection for the Central Government, and to oversee the national elections held in the city.

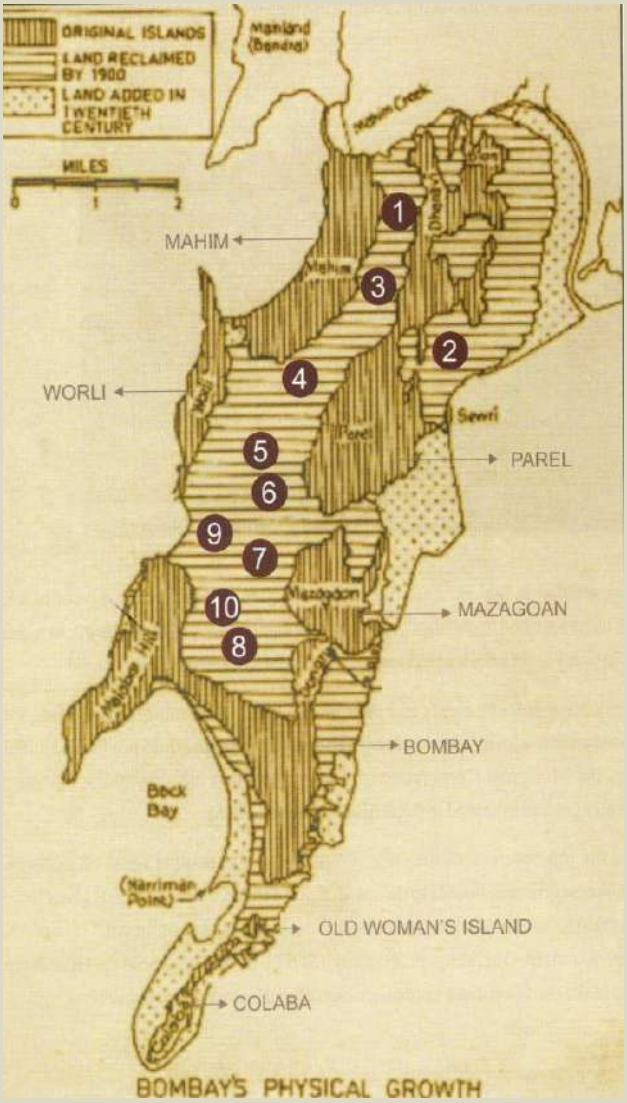
3. Physical Environment

3.1. Relief

Mumbai city lies on what were formerly two groups of islands, stretching southward of the Ulhas estuary. The southern group currently referred to as Mumbai Island City originally consisted of seven separate islands (Fig.6). Since the 17th century, these islets have been joined through drainage and reclamation projects, as well as through the construction of causeways and breakwaters to form one landmass, currently known as Island City.

The northern island group - known as the Salsette group, on which the present Mumbai Suburban District is situated, also consisted of a similar group of seven islands. The district is named after the main and the largest island of the group. These islands remained separate till the beginning of the nineteenth century. Today, Mumbai City comprises the merged seven islands of the Island City and four islands of Mumbai Suburban District. Mumbai continues to develop essentially on reclaimed lands. The city has a low level coastal tract; the average height at some points is just one meter above mean sea level – i.e. 1.5 m below high tide level.

Figure 6: The Original Seven Islands of Mumbai City and Subsequent Physical Growth



1. Sion
2.Wadala
3. King's Circle
4. Dadar
5. Parel
6. Lalbaug
7. Byculla
8. Grant Road
9. Mahalaxmi Station
10. Mumbai Central

Source: Greater Bombay District Gazetteer Vol I, 1985

Figure 7: The Original Seven Islands of Mumbai Suburban District, 1893

Source: Wikipedia

The city is confined to a 35^0 wedge resulting in an acute paucity of land in the city. Sea and water bodies occupy 66% of the total area of the circle drawn with a radius of 25 km from the city center, as compared to 22% for Jakarta and 5% for Seoul. The land area accessible within 25 km from the Central Business District (CBD) is only 230 km^2, as compared to 1523 km^2 for Jakarta and 1864 km^2 for Seoul.

Since a substantial area of the city – about half of the Island City, and one- fifth to one-fourth of the suburban area has been reclaimed from below sea-level by infilling and pushing the sea outward through dyke-walls (Back Bay reclamation) human interference has played a major role in shaping its topography and configuration. The present day Island City is not only a single land mass, but it is not even an island due to filling in of the breach of Mahim Bay between Sion and Kurla and the construction of the Mahim Causeway.

With the exception of Mahim (Baradbet), hill cores dominated the topography of the islands comprising the original cluster of the Island City. With the silting of lagoons, filling of breaches between the islands and gradual reclamation of the tidal flats, salt marshes and salt pan areas, the Island City today consists of a low-lying plain with elevations ranging from 10 meters to 15 meters. It is about 40 km long north to south, and 5 to 7 km broad east to west, flanked by two parallel ridges of low hills running along the two shores. The eastern ridge, more discontinuous, and levelled in many parts continues below the high-water level beyond Colaba, forming the dangerous reef marked by the Prongs Lighthouse. The Colaba headland protects the harbor (10 km in width), lying on its eastern side from the force of the open sea. The western ridge is of higher elevation and terminates in Malabar Hill. Between the two ridges lies the shallow expanse of Back Bay. This false harbour is one of the several beautiful bays, accessible only to fishing boats, which indent the western shore for a distance of 13 km from Colaba to Mahim.

The eastern water-front facing the protected waters of the bay is the harbour area, with numerous docks, quays and berths. Many navigable channels are maintained through the Bay. The western water-front, on the other hand, is a series of alternating headlands and bays, the largest of them being in the southern and north,ern extremes, namely the Back Bay and the Mahim Bay. It is in these bays that limited stretches of sandy beaches have been formed. Dadar, beach lies behind the Worli headlands in Worli Bay.

Suburban Mumbai is located on Salsette. As late as 1808, Salsette included seven islands, namely Salsette proper, the main and largest of the islands, Trombay in the south-east, also large with a central hilly core, Juhu, Varsova, and Marve, that are sand bars pushed inland by the sea, and resting on knolls, Dharavi and Rai Murdhe. Today they form a single land mass, off the Ulhas mouth.

In the north centre of Salsette island lies a hill complex that rises to elevations of 467 m. in the conical peak of Kanheri, 463 m. in Shendur, and 417 m. in Avagadh. Two spurs of ridges shoot off southwards from this hill complex from near Kanheri

and Avagadh peaks, enclosing in between a horse shoe shaped valley, which opens out southward and slopes in the same direction. The western ridge, of a higher elevation, runs over a distance of about 10 km and ends near Marol. The eastern spur, though lower, is longer, and gradually descends to the level of the plains around Ghatkopar-Kurla. Most of the low hills around Kurla-Ghatkopar, Andheri-Jogeshwari and Marol have been reduced to ground level.

The Kanheri hill complex merges into tidal swamps towards the east; while towards the west these hills pass into wide plains with a few isolated hillocks. Alternating rocky headlands and pocket beaches are thus observed along the western seafront, which are breached by Malad and Manori creeks. The creeks are fringed by intertidal areas, as are the stretches to the south along Mahim creek. The intertidal areas are characterized by a gentle gradient and a wide tidal range (spring tide: 3.6m, neap tide: 1.5m). Mangroves, mudflats and salt-pans are observed here.
Traversing these low tidal flats, and occasionally rising to higher elevations are protrusions and outcrops of acidic and basic lava flows that in places form low hills, while in others form low dyke ridges like ribs. The low hill ridge of Kalina, the knolls of Marol, the vertically well jointed columnar basalts of Andheri, Ambivli and others further north, are of this category. Gilbert hill in Andheri, a remnant of a ridge of basaltic rock estimated to be 65 million years old, has been chipped away to a single column. It was declared a Grade 2 heritage site in 2007. Along the western coast the there is a chain of low hills, broken and discontinuous, and a continuation of the western hill ridge of the Island City peninsula that runs from Malabar Hill through Worli northwards. This ridge forms headlands at a number of places like Bandra, Danda, Madh, Manori Uttan,and Dongri. Where they have been breached by tidal extensive tidal marshes have been formed. It is on this residual hill remnant that sand bars and spits of wave deposition like Juhu and Versova have been transfixed.

Figure 8: Remnants of Gilbert Hill, Andheri

Source: The Times of India

Small depressions, forming ponds of fresh water used to dot the low flats especially to the west of the main hill range in the past: as for example, the Padam Talao to the north of the Military Camp Hill, which existed within the present airport area. These depressions have been mostly filled up for hygienic reasons and have become built up in most cases.

To the east of Salsette lies the Thane creek which opens into the northern part of the Harbour Bay. It runs for 16 km. north to south from near Thane to Trombay. It is very narrow, barely 200 m. wide, at the northern Thane end, and gradually opens out to over 2 km at its southern end, where it is bridged to carry over it a road and rail line from Mumbai to Navi Mumbai. The Panvel creek debouches into it at its southern end, immediately north of the Hog island.

The Harbour Bay is studded from south to north with many islands. The Kansa or Gull islet, lies at the entrance of the Dharamtar creek to its east. Karanja island, Cross or Gibbet island, Butcher island, Elephanta island and Hog island are the other islands in the harbour end. The northern end of the harbour bay is Trombay with the small mosque of Pir Pav on its southern extremity, from which the land rises into a hill 300 m. in height. Outside the harbour, but within port limits, lie the islands of Henery and Kenery.

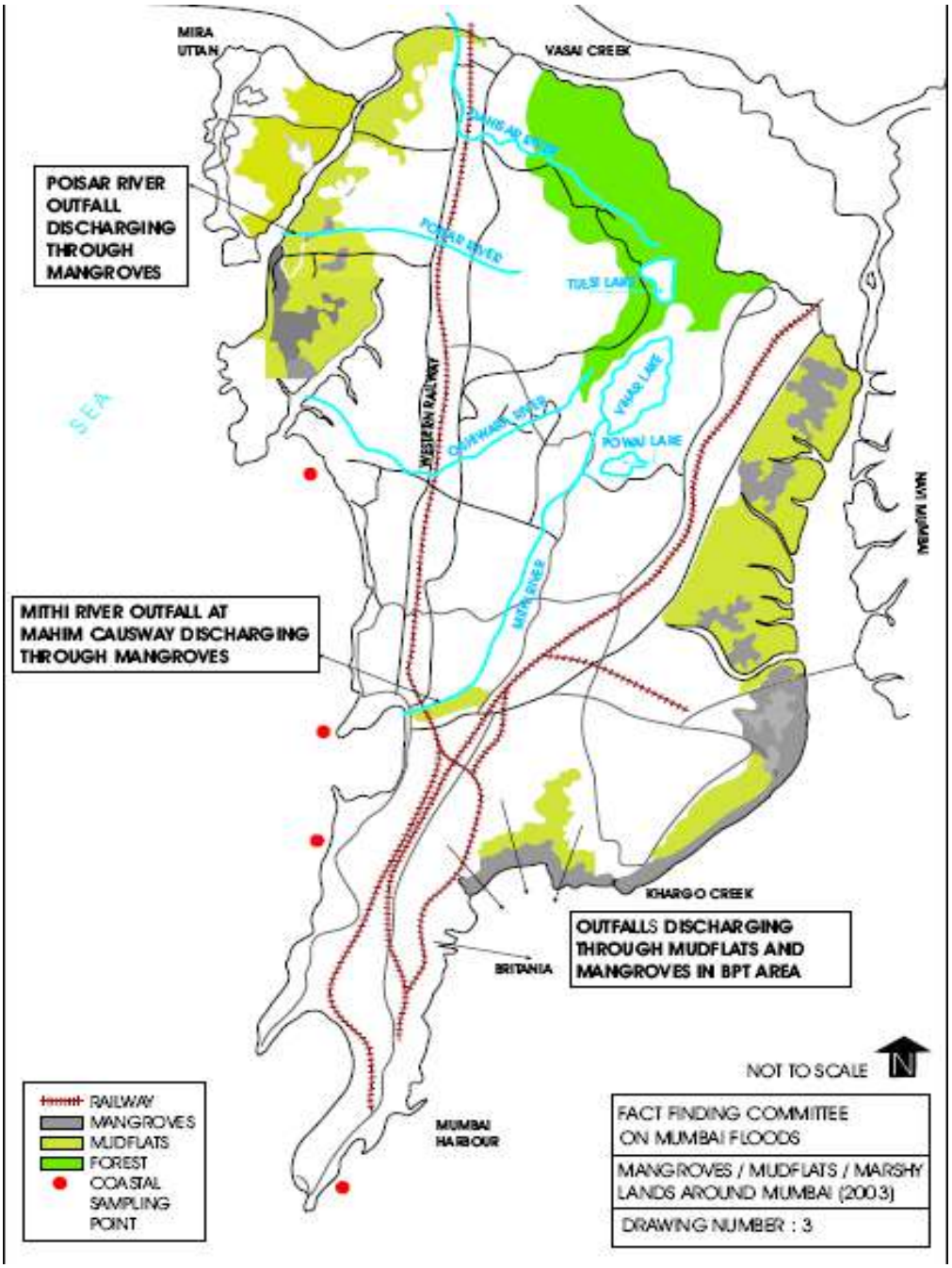
3.2. Drainage

The city area has no natural drainage outlet. The central area forms a depression, flanked by hills, and being on reclaimed grounds is barely two to three metres above sea level. This region is liable to flood during the monsoons.

There are four main streams in the suburbs. They rise in the central hill complex of Salsette Island. The Mithi River drains southwards while the Dahisar, Poisar and Oshiwara Rivers drain westward. The hydrological setting has been influenced by man in a variety of ways. Damming of upper reaches of the rivers, infilling and leveling of the first and second order streams, constriction of the mouth of Mithi River and Mahim Bay and reclamation of riverine wetlands has taken place. Siltation and clogging of drainage arteries have resulted in reduction of river widths and depths which compounds the problem of flooding. Encroachments inside the riverbed as well as on the banks and holding ponds have choked and constricted the water courses and aggravated flooding risks.

The Mithi River has the largest catchment (7265 hectares) and is the natural drainage system in the heart of the suburbs. Flooding of the river therefore can disrupt life totally as was witnessed on July 26, 2005. The river originates at Sanjay Gandhi National Park from the overflow of Vihar and Powai dams and enters the Arabian Sea via Mahim Creek. It has an approximate length of 17.9 km, of which the first 11.8 km, i.e. from Vihar Lake to CST road, Kurla, falls under MCGM jurisdiction. The section on the downstream side of CST road is under the jurisdiction of MMRDA.

Figure 9: Rivers in Mumbai



Source: Fact Finding Committee on Mumbai Floods, 2006

Major causes of flood/overflow of Mithi River are narrowing of the banks for housing and slums as well as for the runway extension of Santa Cruz airport, reclamation of the river bed by industrial units, diversion of the course of the river for construction of Santa Cruz runway and taxi bay extensions, construction of walls around Air India and Indian Airlines colonies, Bandra-Kurla Complex reclamation, and reclamation of natural ponds. In addition, the main river besides being forced to

turn 90^0 four times in rapid succession, has been made to pass through a culvert, and in some sections is bunded with walls and embankments on both sides. (Development of Action Plan for Environmental Improvement of Mithi River and along its Banks, 2005)

Following the July 26, 2005 deluge, major steps have been initiated to enhance the carrying capacity of Mithi by widening and deepening its course. The work was carried out in two phases. Phase I commenced on April 8, 2006 and was completed on June 31, 2006. The 11.8 km stretch of the river between Vihar Lake and CST Road was de-silted and widened as per the Chitale Committee report. About 3800 structures were demolished at an expenditure of INR 328.8 million (US$ 7.14 million). Phase II of the project started in April 2007. Widening of the river course has been completed except for the portion between CST Road and Kurla-Kalina Road where the width of the river is yet to be finalized by Mithi River Development Project Authority (MRDPA). 2,92,000 cubic meters of silt and 4,02,000 cubic meters of hard rock had been excavated from the river bed till December 2009. A RCC retaining wall, 7.4 km long, has been completed and 1050 structures have been demolished for widening the river. 735 structures remain to be demolished. A flow meter has been installed at Powai and a measuring scale has been marked on the existing pier of Krantinagar Bridge to monitor the level of water in the Mithi river to provide early warning of rising level of water in low-lying areas to officials as well as citizens. In addition, to contain flooding a 25 meter long and 4.5 meter high weir has been constructed downstream of the Jogeshwari-Vikhroli Link Road with openings at the bed level which will help to discharge water slowly from the river during periods of heavy rainfall. Upstream of Jogeshwari-Vikhroli Link Road, in Aarey Colony, a holding pond has been created at the side of the river for flood protection in its micro-catchment.

The Dahisar River originates at Tulsi Lake and has an approximate length of 12 km. The mouth of the river is at Manori Creek and the total catchment area is 3,488 hectares. Land use/land cover estimates from Indian Remote Sensing (IRS) data (February-April, 2005) indicate that dense vegetation/forest cover account for 20 per cent of the Dahisar river catchment area and sparse vegetation 32 per cent. These are assets of the catchment area and need to be preserved. Only 24 per cent of the catchment area is built up, with slums accounting for 9 per cent. The Dahisar River has an ancient pedestrian arch bridge which forms a bottleneck in the downstream area. Despite this, water does not head up much because it can spread out in the low-level marshy land as a surface sheet flow and not as a channel flow. Detailed studies need to be undertaken to develop ponding facilities in areas of sparse vegetation to enhance long-term sustainability of the basin.

The major cause of flooding of the Dahisar River is narrowing of the banks due to structures which include the bridge along Dahisar River between Western Express Highway and SV Road, marble shops near the Western Express Highway, Leprosy Colony located between Dahisar and Borivali, slum pockets between Bhagwati Hospital and Rustamji Park, and Ranchhoddas Marg and tabelas (cattle-sheds).

MCGM has undertaken training of the river under the BRIMSTOWAD project. 1800 meters of the river have been trained to date at a cost of INR 278.9 million (US$ 6.06 million).

The Poisar river originates at Sanjay Gandhi National Park near Appapada and Kranti Nagar, Kandivali (East). It has an approximate length of 7 km and enters the sea at Malad Creek. Land use/land cover estimated from IRS data (February-April, 2005) indicates that dense vegetation/forest cover account for 3 per cent of the catchment area and sparse vegetation 27 per cent. Built up area accounts for 53 per cent of the catchment, of which slums comprise 18 per cent.

Major causes for flooding of the Poisar River are narrowing of the banks for housing and by slum colonies, reclamation of the riverbed by small industrial units and reclamation of secondary channels of the river. MCGM has undertaken widening and training of the river under the BRIMSTOWAD project in two parts. 3550 meters of the river in both sections has been trained to date at a cost of INR 670million (US$ 14.56 million). The project has been delayed due to encroachments at several places. In addition, a 'no objection certificate' from military authorities is awaited.

Oshiwara River originates at Aarey Colony, Goregaon (East) and has an approximate length of seven km. The river discharges into Malad Creek and has a total catchment area of 2,938 hectares. Land use/land cover estimated from IRS data in February-April, 2005 indicates that 53 per cent of the catchment area is built up, with slums accounting for 23 per cent. Of the three rivers flowing westward, Oshiwara catchment has the least area under tree cover. Dense vegetation/forest cover accounts for 3 per cent of the area and sparse vegetation 16 per cent. The zones under grass/rough pasture (20 per cent) and sparse vegetation which together account for 46 per cent of the basin could provide potential areas and open spaces for rehabilitation of residential, commercial and industrial units located in flood-risk zones.

Major causes for flooding of the Oshiwara River are narrowing of the banks for housing, encroachments by industrial units and loss of extensive mangrove stands in the downstream region of the river in Goregaon (West). Widening and training of three nullahs has been undertaken by MCGM under the BRIMSTOWAD project. INR 275 million (US$ 5.98 million) has been expended to date. Encroachments of Fairdeal nullah and Indian Oil nullah have hampered the progress of the work.

3.3. Geology

The entire Greater Mumbai area is occupied by Deccan basalt flows and their acid and basic variants, poured out between the late Cretaceous and early Eocene times. The basaltic flows are horizontally bedded and are more or less uniform in character over wide areas.

Table 3: Stratigraphic succession of rocks in Mumbai City

Time Period	Type of rock
Recent	Alluvium, Sand and recent Conglomerate
Cretaceous to Eocene	Laterite Trap dykes Volcanic agglomerate and breccia Basalt flows with interbedded ash beds and fossiliferous fresh water shakes.

Source: Greater Bombay District Gazetteer

Besides the common dolerite and basalt, felsitic differentiates of the Deccan traps such as andesite, rhyolite, rhyodacite and pitchstone as well as mafic types such as oceanite, ankaramite and monchiquite also occur in the city area.

The western ridge of the Island City comprises stratified ash beds overlain by hard, massive andesitic lava flows, both formations showing gentle tilt towards the west. The stratified ashes which display variegated colours and variable textures attain a total thickness of about 45 m. The varieties are from bottom to top: (i) coarse grained acid tuffs of variegated colours noticed to the east of Worli fort, (ii) yellowish brown ash exposed near Chowpatty beach along the embankment of Walkeshwar road, Malabar-Cumballa ridge, Haji Ali tomb and the Worli and Worli fort hills. The exposures at Worli contain fossil tortoise and frogs and (iii) coarse grained carbonaceous ash covered by yellowish brown tuffaceous ash devoid of fossils.
The ash beds are capped by massive lava flows which attain a thickness of about 16 m. The rocks are aphanitic, have a conchoidal fracture and exhibit conspicuous hexagonal columnar jointing. They are exposed on the Malabar, Cumballa, Worli hills and extend on to the Salsette island. Dark coloured fossiliferous shales attaining a thickness of about 2 m. are exposed at the foot of the Worli hills. Being deposited during a period of quiescence and overlain by a later flow, these beds are known as ' intertrappean beds'.

The eastern ridge represents a different suite of rocks.
They are, from bottom to top :
(i) basalt, greenish amygdaloidal basalt exposed at Bhoiwada, Mazagaon and Koliwada hills,
(ii) red ash breccia noticed in the exposures at Sion,
(iii) highly chilled basic lavas of Sewri fort and Antop hills, described as Melaphyre in the older literature,
(iv) stratified ashes of Sewri and Cotton Green.
The geology of the intervening low lands is more or less obscured by the development of the city of Bombay, but some of the recent excavations near Flora Fountain, Old Custom House and Dadar have revealed the presence of either the greenish-grey basalt or the yellowish brown ash.

Basalt is the major rock unit in Salsette Island constituting the main ridge extending from Ghatkopar, Vikhroli, east of Jogeshwari, Aarey Milk Colony to Kanheri and beyond. At places, there are ash beds intervening between successive flows; these are observed in the cuttings of the Western Express Highway passing through Jogeshwari. The isolated hills near Andheri, Jogeshwari railway station, Chincholi and Mandapeshwar are also largely composed of basaltic types. Acid to sub-acid types are associated with the basalts at Dongri, Manori, Madh, Karodiwadi, Malad and Kurla. The basalts in the quarries at Gilbert hill, Andheri, exhibit perfect columnar jointing with spectacular pentagonal columns, over 40 m. in height.

Another interesting geological feature is the occurrence of a vast thickness of volcanic agglomerate near Tulsi Lake and Kanheri caves, indicating a possible volcanic focus from which much of the pyroclastic rocks in the Bombay and Salsette islands may have extruded. These agglomerates are largely made up of elongated sub-angular vesicular bombs, blocks of brown chert, trachyte, volcanic ejectment and small pieces of yellow to reddish brown limonitic matter, varying in size from a few centimetres to as much as one metre, set in a matrix of dense, dull light grey amorphous material. At places this matrix resembles bauxite. Some of these agglomerates show fine banding and layers with alternate siliceous and tuffaceous matter, at places with beautiful and intricate plications and contortions. Some of the horizons of the agglomerates and breccias, particularly those which are bauxitised, are quite soft. Differential weathering has resulted in the siliceous bands which stand out as fine minute ribs in some places, simulating fossil wood. This feature may be observed in caves No. 84, 85, 86 and 87 at Kanheri. Small plateaus east of Kanheri caves and south-west of Tulsi lake are covered by laterite with bauxite pockets at 500 m. elevation above sea level.

The basalts are intersected by sills and dykes of olivine dolerite, tachylyte, etc. The dykes have a general north-south trend and appear to be limited to the eastern margin of the main ridge from west of Mulund, and the eastern banks of the Vihar lake to Vikhroli. Some of these dykes extend further south towards Mankhurd, Chembur and Nanole in the Trombay Island.

Volcanic breccias and ashes interbedded with basalts are noticed at several places near Ghod Bundar, around Tulsi and Vihar lakes, Santacruz, Kurla and Sion. The plains to the west of the main ridge extending from north of Bandra to Borivli and beyond are clothed by marine alluvium represented by saline marine muds, recent shell-limestones, calcareous sand stones, etc. A fair stretch of shore sands with occasional dunes extends from Juhu in the south to Versova, Marve and Manori in the north. Trombay Island is separated from Mumbai and Salsette by extensive tidal flats with a series of low hills extending north-south in the centre. Faces of amygdaloidal olivine basalt dipping gently towards west, with ramified layers and dykes of rock types described variously as oceanite, ankaramite and monchiquite etc., are prevalent in this area.

Faults: Mumbai city is on a seismically active zone. A well-marked fault is seen near Antop hill. Sukheswala (1958) has given evidence for two north-south running faults in Bombay island, one to the east of western ridge and other running along the western ridge. The faults extend into Salsette island and have maximum throw of 75' and 40', respectively. Three major earthquake fault lines lie under the Thane, Panvel and Dharamtar creeks. Mumbai falls in seismic risk zone III, which represents "moderate risk". Mumbai can experience earthquakes measuring up to 6.5 on the Richter scale.

No minerals of economic importance are found in the Mumbai area except pockets of bauxite in the laterite plateau, east of Kanheri caves. However, large quantities of building stones required for construction work in Mumbai city are mainly supplied from the quarries in the vicinity. The main rock types quarried are basalt, andesite and granophyric trachyte, basalt being the most abundant of all. The Gateway of India is built out of granophyric trachyte.

3.4. Groundwater Conditions

The area coming under Greater Mumbai limits is covered by Deccan lava flows, with intertrappean beds occurring at a few places. The yield of wells in basaltic terrain depends on the thickness of the weathered zone of the basaltic flows, and the presence of joints and fissures, whereas the yield for wells in intertrappean beds is dependent on their lithologic character. The sandy and calcareous intertrappean beds yield a copious supply of water, whereas the beach sands and clayey sands which overlie the basaltic flows along the coast carry lenses of fresh water supported by a zone of brackish water which has hydraulic contact with the sea. Heavy withdrawal of water here upsets the equilibrium between the fresh and brackish water interface. The groundwater available to the wells in Mumbai city is mostly from these formations.

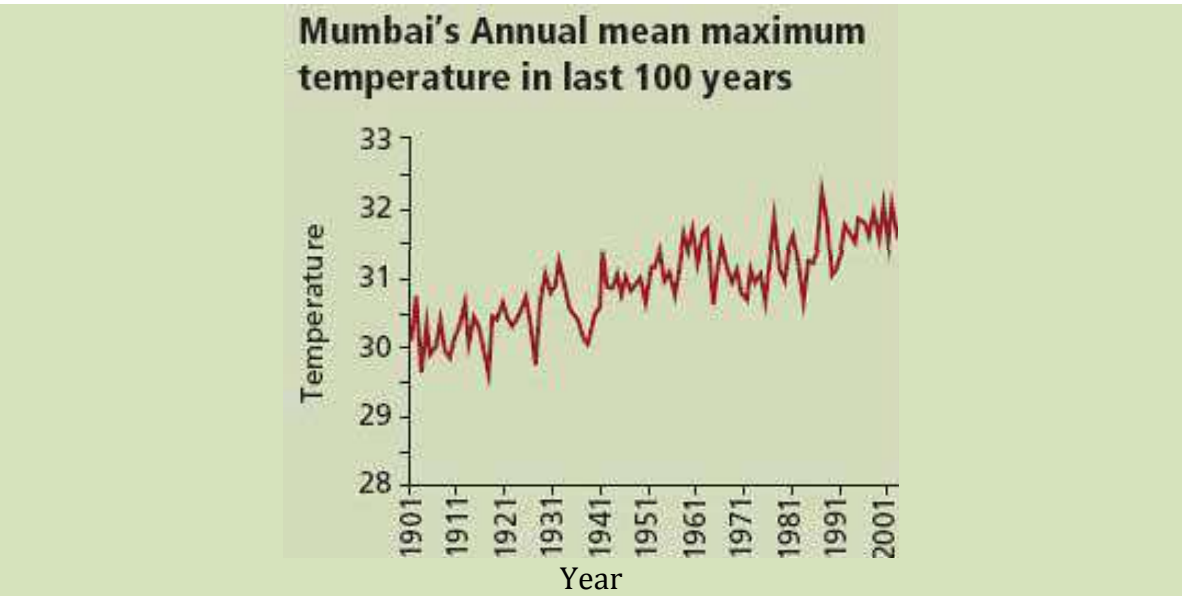
3.5. Soil Profile

The soil cover in the city region is predominantly sandy due to its proximity to the sea. In the suburbs, the soil cover is largely alluvial and loamy.

3.6. Climate

Mumbai has a tropical humid climate. The city does not experience distinct seasons, but the climate can broadly be classified into three seasons. The cold season from December to February is followed by the summer season from March to June. The period from June to about the end of September constitutes the south-west monsoon season, and October and November form the post-monsoon season.

Figure 10: Mumbai – Annual Mean Maximum Temperature



Source: Regional Metrological Centre, IMD, 2009

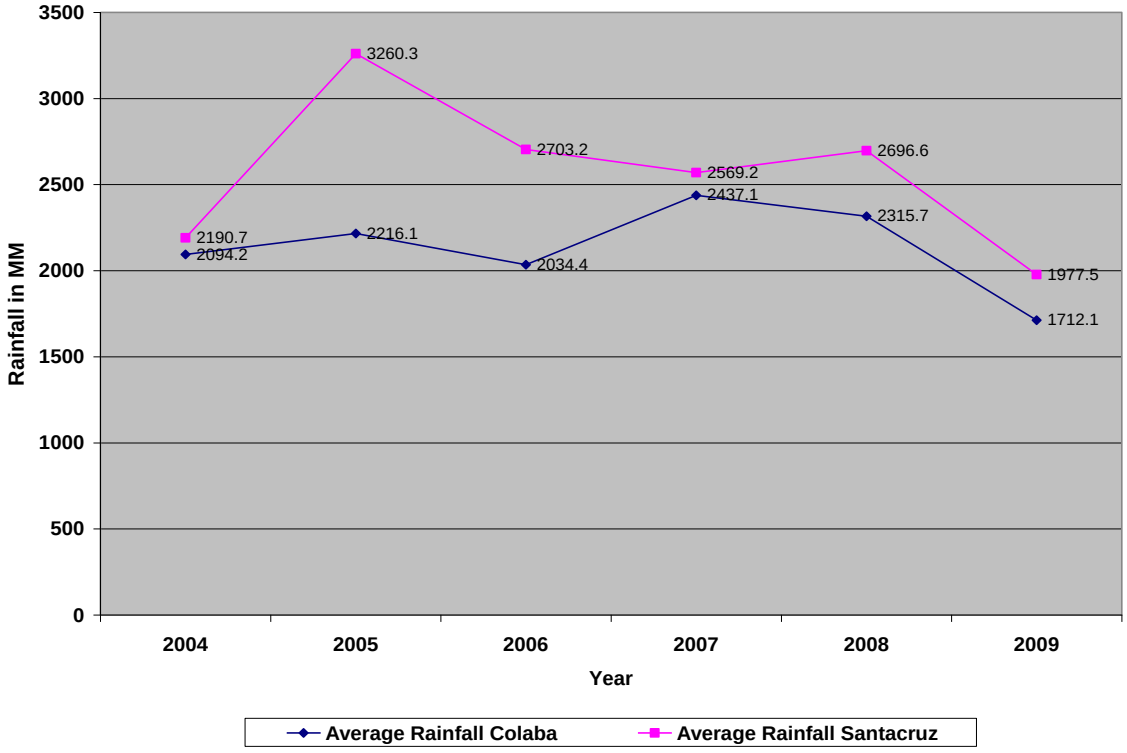
The average annual temperature is 27.2 °C. In the Island City, the average maximum temperature is 31.2 °C, while the average minimum temperature is 23.7 °C. In the suburbs, the daily mean maximum temperature range from 29.1 °C (84.4 °F) to 33.3 °C while the daily mean minimum temperature ranges from 16.3 °C to 26.2 °C. The record high is 40.2 °C on 28 March 1982, and the record low is 7.4 °C on 27 January 1962. The average maximum temperature has increased by 1.62 °C from 1901-2001(Figure 8). On February 07, 2008 the city recorded a temperature of 8.5 °C – the lowest in 46 years.

Table 4: Mumbai –Annual Rainfall (mm), June – September, 2004-2009

Month	June		July		August		September		Total		Annual Average
Year	C	S	C	S	C	S	C	S	C	S	
2004	310.1	253.6	805.9	837.8	785	932.9	193.2	166.4	2094.2	2190.7	2142
2005	578.1	519.7	805.1	1663.3	215	309.1	601.3	749.9	2199.5	3242	2721
2006	411.6	353.9	871.2	1023.2	568.5	938.6	182.2	387.5	2033.5	2703.2	2368
2007	847.6	1007.2	499.7	523.6	677.5	606	95.2	121.3	2120	2258.1	2189
2008	932.8	936.1	675.3	807.3	368.2	628.6	342.3	326.2	2318.6	2698.2	2508
2009	263.8	281.2	741.8	1119.8	204.4	292.5	518.7	313.5	1728.7	1944	1386
Average	557	548	733	996	470	618	322	344	2082	2506	2294

C: Colaba S: Santa Cruz

Figure 11: Mumbai – Annual Rainfall (mm), June – September, 2004-2009



The average annual rainfall in Mumbai during 2004-2009 was 2294 mm. The variation in rainfall from year to year is quite appreciable. During 2004-2009, the annual rainfall varied from a minimum 1712.1 mm at Colaba in 2009 to a maximum 3260.3 mm at Santa Cruz in 2005 (Table 4). The rainfall is usually higher in the suburbs than in the city.

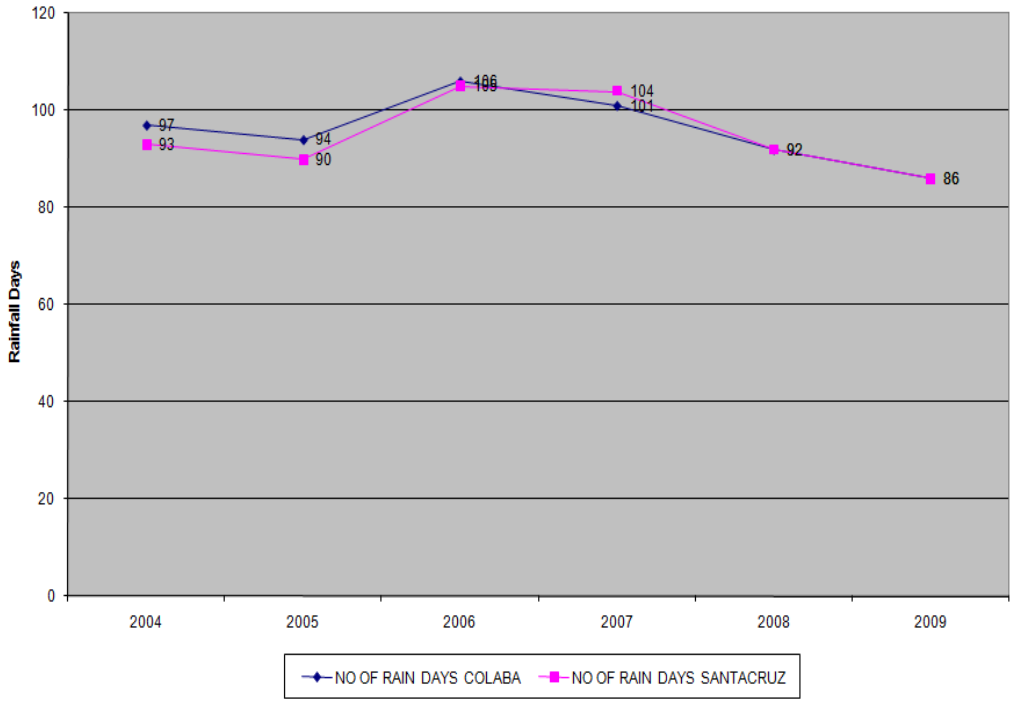
Table 5: Mumbai - Number of Rainy Days, June-September 2004-09

Month	June		July		August		September		Total		Average
Year	C	S	C	S	C	S	C	S	C	S	
2004	20	17	29	29	27	26	21	21	97	93	95
2005	18	15	25	25	27	25	24	25	94	90	92
2006	23	18	31	31	30	31	22	25	106	105	105.50
2007	23	21	28	27	27	30	23	26	101	104	102.50
2008	19	23	31	27	26	25	16	17	92	92	92
2009	12	11	31	31	27	27	16	17	86	86	86

C: Colaba S: Santa Cruz

On an average from 2004 to 2009 there were 96 rain days.

Figure12: MUMBAI - Number of Rainy Days, June-September 2004-09



Almost 60 per cent of the average rainfall occurs in July and August, though figures vary considerably from year to year (Table 6). In 2007, 46 per cent of the rainfall was received in July and August whereas in 2004 these two months accounted for 78 per cent of the rainfall. July is the rainiest month, usually receiving more than one-third of the annual rainfall. In 2006, 51 per cent of the annual rainfall in the suburbs occurred during this month. The average monthly rainfall for July alone during 2004-2008 was 851.2 mm – higher than London's average annual rainfall of 611 mm. In addition, 50 per cent of this rainfall is sometimes received in just 2-3 events. The highest annual rainfall ever recorded was 3,452 mm in 1954. The highest rainfall recorded in a single day was 944 mm at Santa Cruz (1200 mm is the average annual rainfall for India) on July 26, 2005. An analysis of the probability of such extreme events and their expected return period based on data going back to 1886 for Colaba and 1957 for Santa Cruz reveals that in any year, the probability of 24-hour rainfall exceeding 200 mm is 50% for Santa Cruz and 33% for Colaba.

Table 6: Mumbai - Percentage of Annual rainfall, June-September 2004-09

Year	June % rainfall			July % rainfall			August % rainfall			September % rainfall		
	C	S	Mean	C	S	Mean	C	S	Mean	C	S	Mean
2004	14.8	11.6	13.2	38.5	38.2	38.4	37.5	42.6	40.0	9.2	7.6	8.4
2005	26.1	15.9	21.0	36.3	51.0	43.7	10.5	10.0	10.2	27.1	23.0	25.1
2006	20.2	13.1	16.7	42.8	37.9	40.3	27.9	34.7	31.3	9.0	14.3	11.7
2007	34.8	39.2	37.0	20.5	20.4	20.4	27.8	23.6	25.7	16.9	16.8	16.9
2008	40.3	34.7	37.5	29.2	29.9	29.5	15.8	23.3	19.5	14.8	12.1	13.4
2009	15.4	14.2	14.8	42.4	55.1	48.7	11.9	14.8	13.4	30.3	15.9	23.1
Avg.	25.3	21.5	23.4	34.9	38.8	36.9	21.9	24.8	23.4	17.9	15.0	16.4

C: Colaba S: Santa Cruz

Figure 13: Mumbai–Percentage of Annual Rainfall, June-September, 2004-09

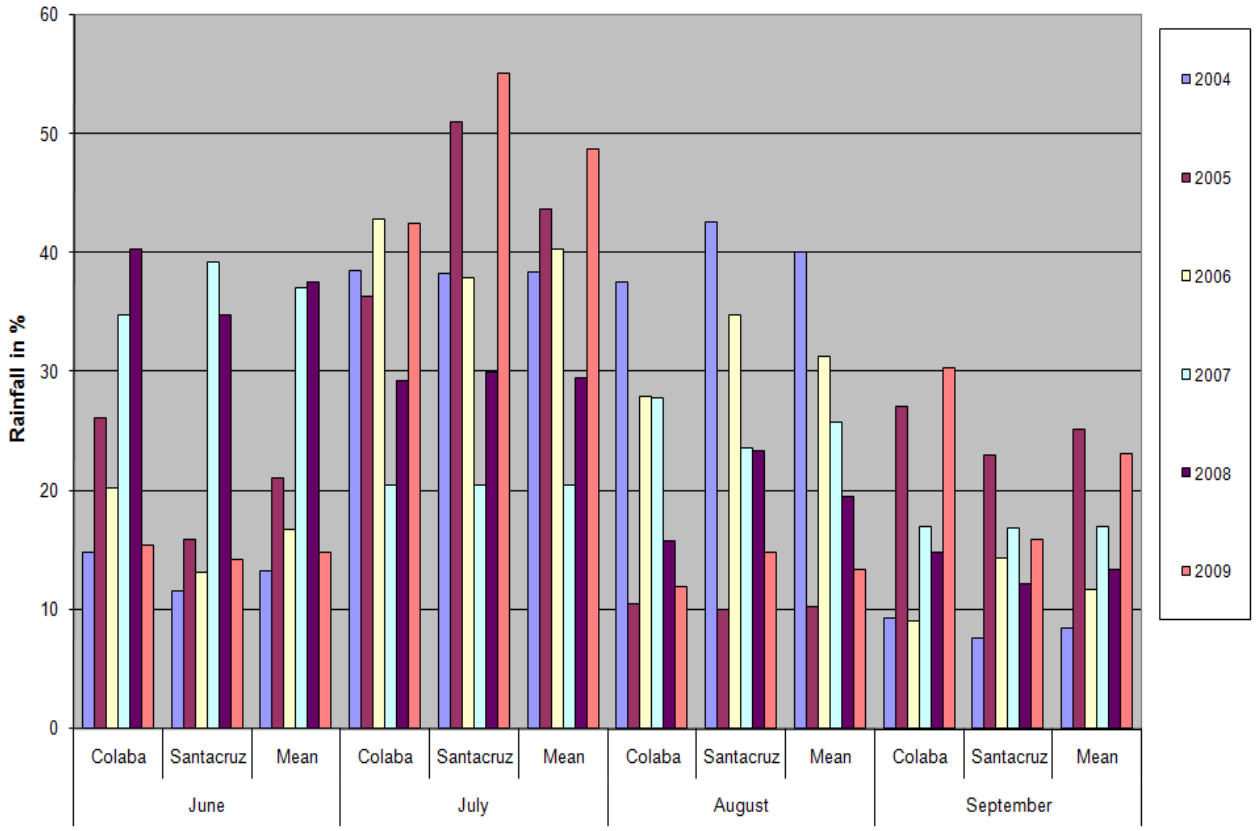
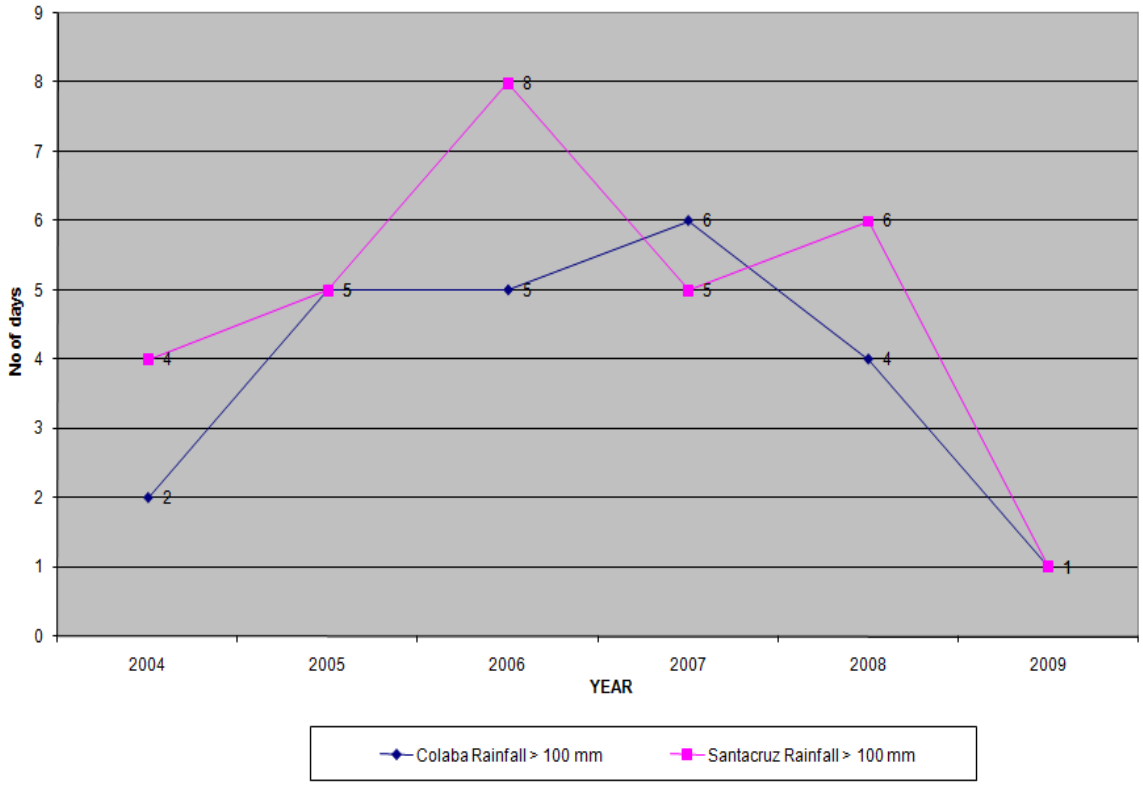


Table 7: Mumbai - Number of Days when Rainfall > 100 mm

Month	June		July		August		September		Total		Average
Year	C	S	C	S	C	S	C	S	C	S	
2004	0	0	1	2	1	2	0	0	2	4	3
2005	2	0	2	3	0	1	1	1	5	5	5
2006	0	0	4	3	1	5	0	0	5	8	7
2007	3	3	1	1	2	1	0	0	6	5	6
2008	1	3	2	2	0	0	1	1	4	6	5
2009	0	0	0	0	0	0	1	1	1	1	1

C: Colaba S: Santa Cruz

Figure 14: Mumbai - Number of Days when Rainfall > 100 m



Probability of flooding is high when rainfall exceeds 100 mm on a given day. From Table 7 it is observed that this occurs between 1-7 times a season.

The problem of flooding becomes acute when heavy rainfall coincides with high tide of more than 4.5 meters. Though high tide exceeding 4.5 meters is common (Table 8), the probability of heavy rainfall coinciding with high tide more than 4.5 meters is not frequent, as Table 9 would indicate.

Table 8: Mumbai - Number of days when tide height > 4.5 meters

Year	June	July	August	September	Total
2004	6	7	7	2	22
2005	6	5	6	6	23
2006	3	5	5	5	18
2007	5	5	6	5	21
2008	6	6	6	1	19
2009	6	6	5	5	22

Figure15: Mumbai - Number of days when tide height > 4.50 meters

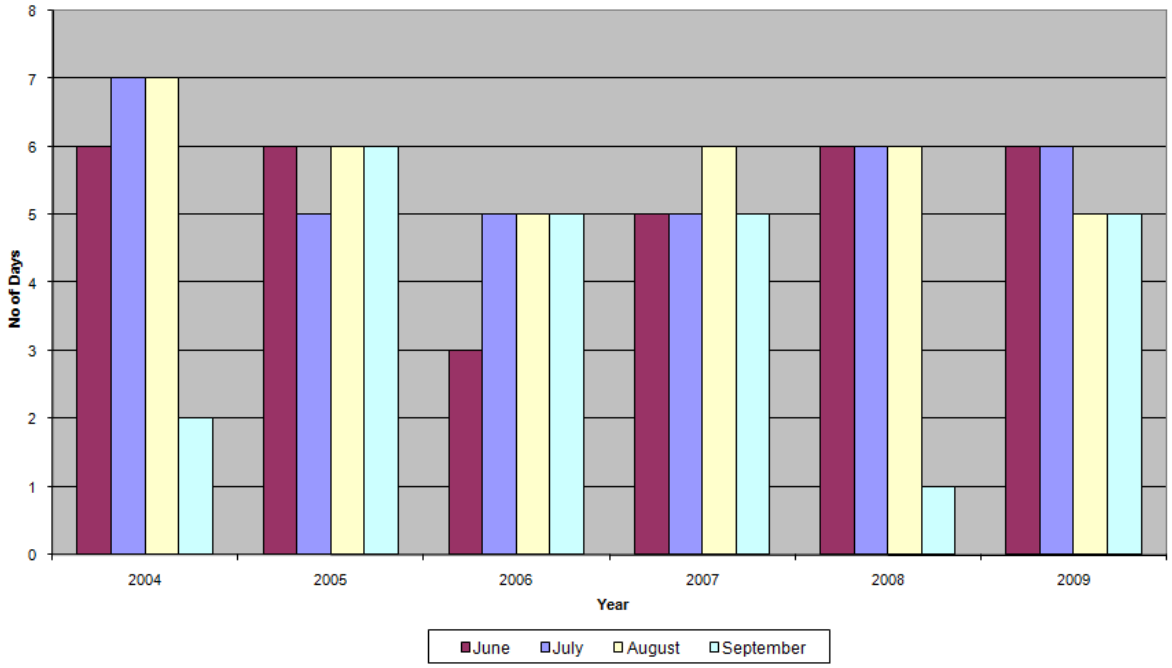
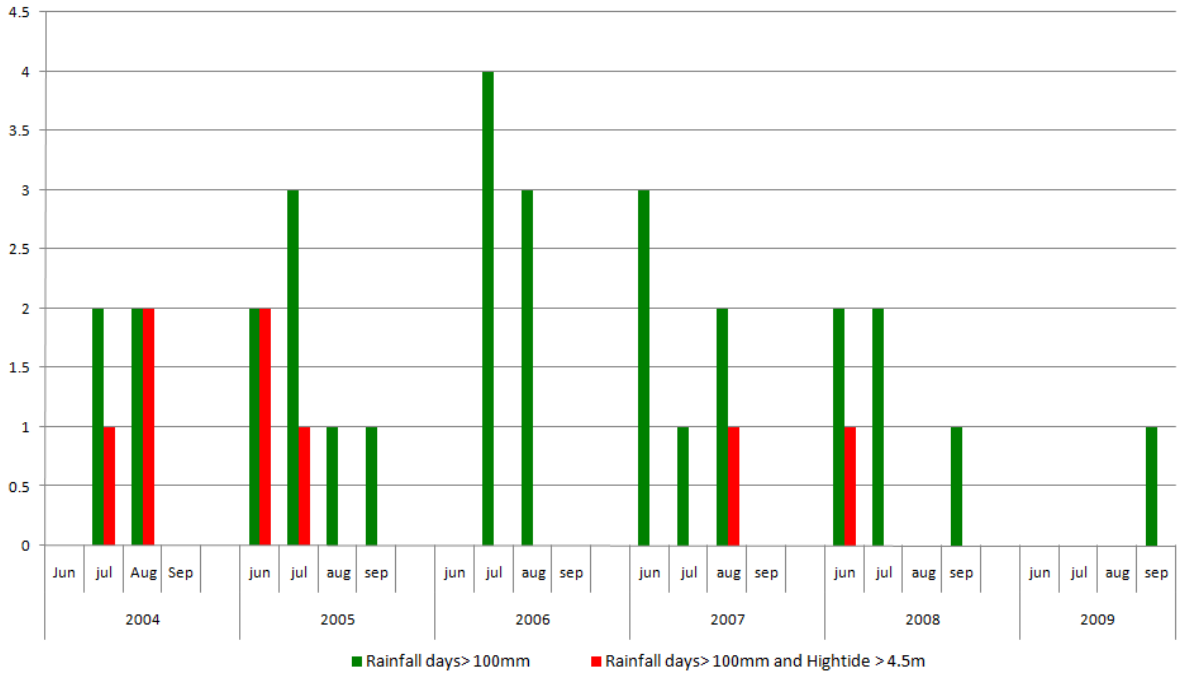


Table 9: Number of days with rainfall >100 mm and high tide > 4.5 meters

Month	June		July		August		September		Total	
Year	C	S	C	S	C	S	C	S	C	S
2004	0	0	1	1	1	2	0	0	2	3
2005	1	2	1	1	0	0	0	0	2	3
2006	0	0	0	0	0	0	0	0	0	0
2007	0	0	0	0	2	0	0	0	2	0
2008	1	1	0	0	0	0	0	0	1	1
2009	0	0	0	0	0	0	1	1	1	1

Figure 16: Number of days with rainfall >100 mm and high tide > 4.5 meters



Prior to the monsoon (May/June) and during the post-monsoon months (October/November) storms and depressions from the Arabian Sea may cause widespread heavy rain and gusty winds. The last two severe cyclones off the coast of Mumbai were in 1992 and 1996. On 11th November, 2009, Indian Meteorological Department (IMD) issued a warning that a deep depression over southeast and adjoining east central Arabian Sea was likely to develop into a cyclonic storm and hit

the west coast including Mumbai. Fortunately the cyclonic storm, 'Phyan', crossed the Maharashtra coast south of Mumbai.

Relative humidity ranges from 61 per cent to 87 per cent being the highest in the monsoon period. During the winter months (November-January) relative humidity ranges from 61 per cent to 72 per cent.

3.7. Tides

Being a coastal city tides are of great significance, particularly during the monsoons. The dominant tide in the Mumbai Harbour is the semi-diurnal tide with a period of 12 hours and 40 minutes.

The tides generate currents in the harbour. The tidal flow is unsteady and the magnitude and direction of the current varies with respect to location, time and depth.

Table10: Mumbai: tidal levels related to Chart Datum.

Tide	Above(+) or Below(-) Chart Datum
Highest High Water recorded	+ 5.39 m
Mean High Water Spring Tides.	+ 4.42 m
Mean High Water Neap Tides.	+ 3.30 m
Mean Sea Level.	+ 2.51 m
Mean Low Water Neap Tides.	+ 1.86 m
Mean Low Water Spring Tides.	+ 0.76 m
Lowest Low Water recorded.	- 0.46 m
Highest Low Water	+ 2.74 m

3.8. Vegetation

Old accounts indicate that there was considerable vegetation in many parts of the city. Today, urbanisation and industrialization have rendered extensive areas barren. The Island City is almost devoid of natural vegetation, with trees mainly confined to the road-sides. In the suburbs the luxuriant groves and gardens have almost disappeared due to human encroachment. However, Mumbai contains the largest national park in the world, the Sanjay Gandhi National Park, within the city limits. The park, which dates back to 4th century BC, was known as Krishnagiri National Park in the pre-independence era. At that time the area of the park was just 20.26 sq km. In 1969, the park was expanded to 104 sq km. (of which 80 sq km are located within the city limits) by acquiring various properties adjoining the park. It was notified in 1974. An independent unit of the Forest Department, 'Borivali National Park Sub-division' was created and it was renamed as 'Borivali National Park'. In 1981 it was re-christened as 'Sanjay Gandhi National Park'.

The park is one of Asia's most visited National Parks with 2 million annual visitors. It is known for its dense forests and contains over 1,000 species of plants, 59 species of mammals (including a small population of tigers), 52 varieties of reptiles, 13 species of amphibians, 250 varieties of birds and 115 varieties of butterflies. The variety of butterflies is more than in the entire United Kingdom. (Krishna Tiwari, city forest project head with the Bombay Natural History Society). The park also encompasses the famous ancient (between 1st century BC and 9th century AD) Kanheri Cave complex.

Figure 17: Sanjay Gandhi National Park

Source:www.sanjaygandhinationalpark.net

The major portion of the forest area forms the catchment areas of the Tulsi and the Vihar lakes that provide water to Mumbai city. To the north is the Tulsi catchment area with pure ever-green vegetation on hill tops blending into mixed deciduous trees. Teak, aim, hed, kalamb, humband climbers are present in the moist areas, and deciduous trees like sowar and pangarain in the drier parts. Marsh is observed at the fringe of the lake. In the centre of the park is the catchment area of Vihar lake. This region has a higher percentage of Khair species. Towards the lake, the proportion of tad trees increases progressively.

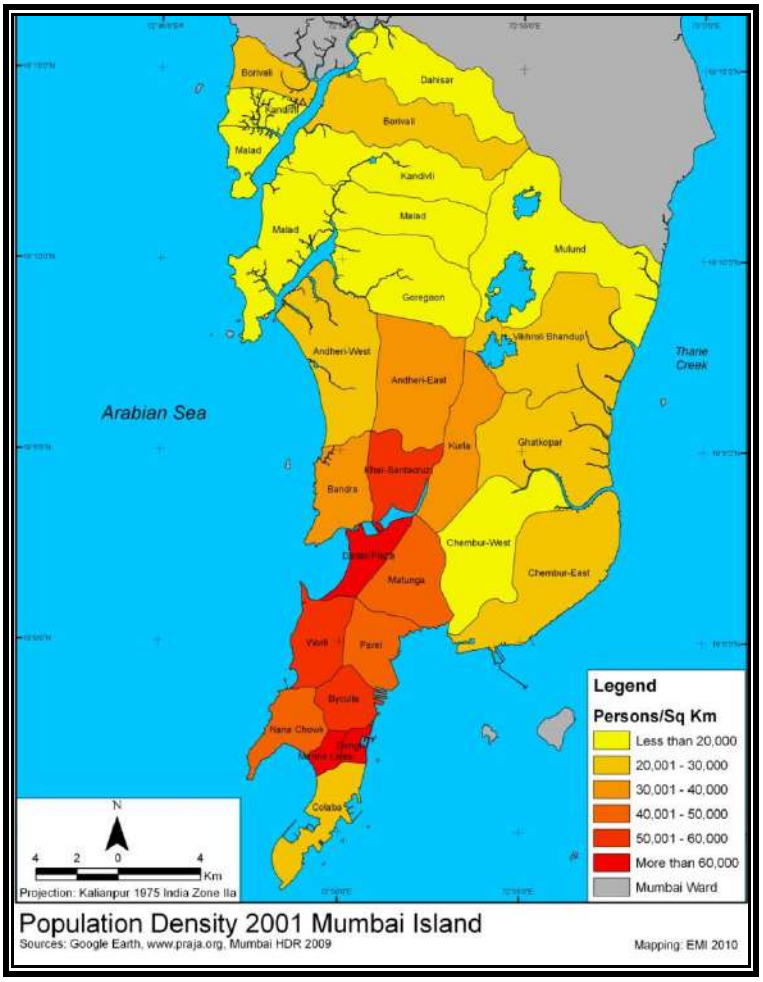
4. Demographic Characteristics

4.1. Population Size, Distribution, Density and Growth Rate

According to the 2001 census, the population of Mumbai was 11,914,398, a twelve fold increase since 1901, when the population was just 92,000. Extrapolations by the World Gazetteer in 2008, estimated a population of 13,662,885 for Mumbai City and 21,347,412 for Mumbai Metropolitan Region (MMR). The current population of the city is estimated between 14 to 15 million. By 2015, Mumbai is expected to be not only the world's second largest city containing 22.6 million people but also to have one of the highest population densities (UN Population Division, 2006).

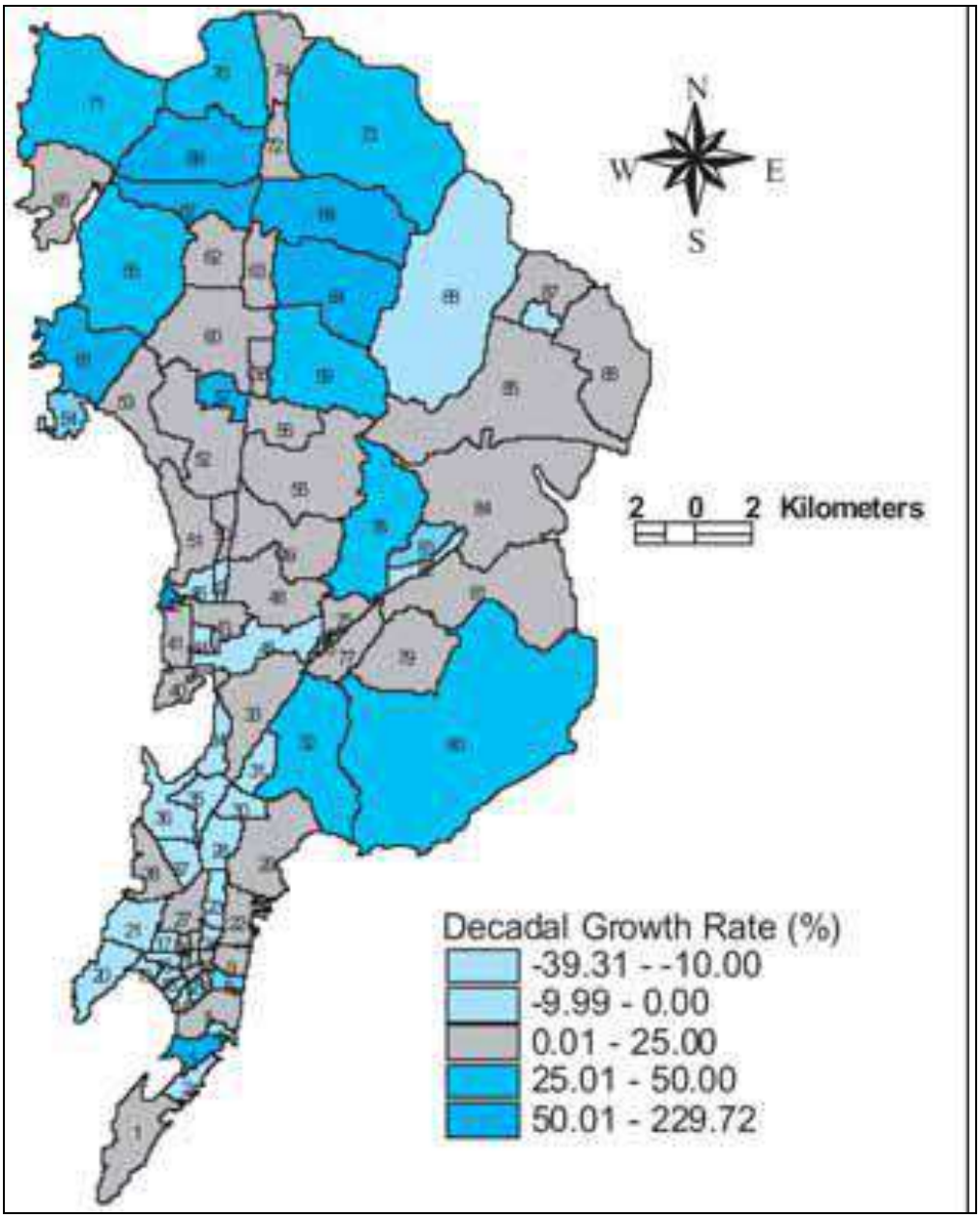
In 1661 there were only 20,000 inhabitants in Mumbai. The population grew rapidly to 92,000 in 1901 and to nearly three million in 1951. During the decade 1941–1951 the city experienced an unprecedented growth rate of 75 per cent because of the influx of refugees due to the partition of India.

Figure 18: Greater Mumbai – Population Density, 2001



The availability of physical space is a key factor determining the quality of life of the city's residents. In 2001, the average population density for Mumbai city was 27,000 persons per km^2, one of the highest in the world. Ward C, the most densely populated area, had a density of 114,001 persons per km^2. Due to high densities, service providers find it difficult to supply basic amenities like health, water and sanitation.

Figure 19: Mumbai: Decadal Growth Rate of Population (Sections), 1991-2001



Source: AIILSG, 2009

In 1961 the island and suburbs had more or less an equal share of the population. From 1961-2001, though Mumbai experienced vibrant growth of 187 per cent, the

nucleus of the city, represented by the Mumbai City District, virtually stagnated with a growth of just 20.02 per cent. This was in stark contrast to the dynamism exhibited by Mumbai Suburb District, which recorded a growth of 522.2 per cent. In fact, the Island City registered a negative growth rate (-3.4 per cent) from 1981-91 but marginally recovered with 12.7 per cent growth from 1991-2001. Effective planned development of suburbs, however, has not taken place due to lack of supporting infrastructure and a sound policy environment for development of residential and commercial nodes. In recent years, there has been a spurt in the growth rate of the Island City due to the schemes adopted by the government such as Redevelopment of Mill areas, Cluster Development Scheme etc., which will get reflected in the 2011 census.

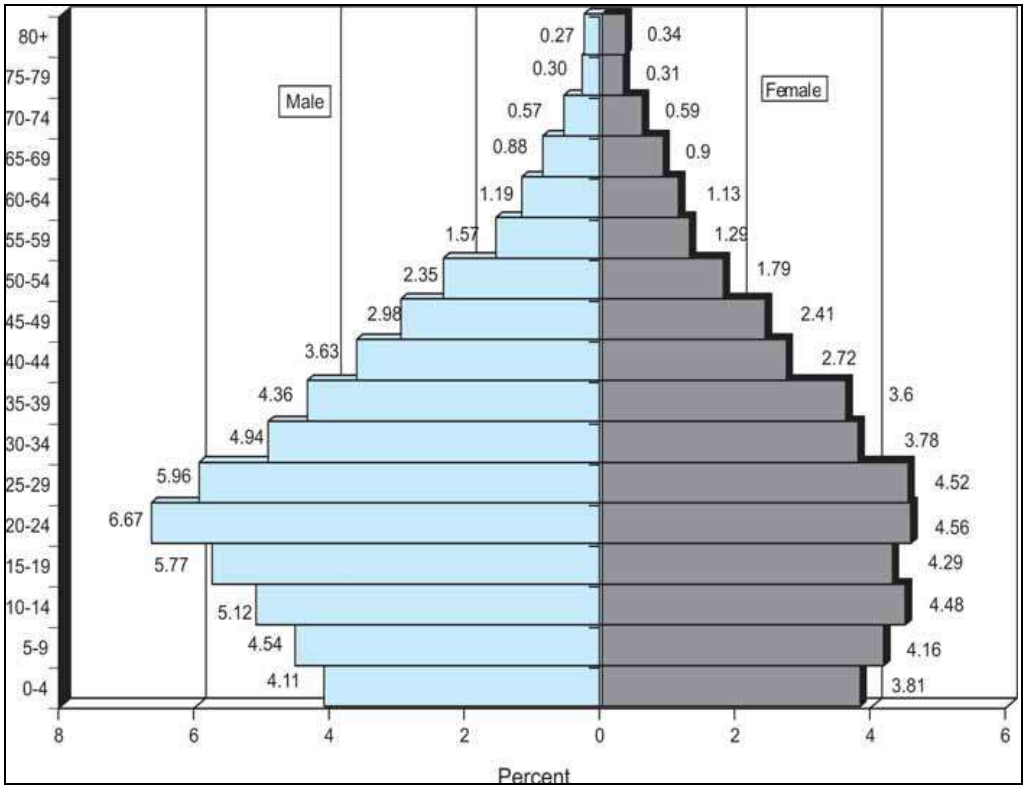
4.2. Age Structure and Sex Ratio

With 68 per cent of the population under 34 years of age (2001), the age structure of Mumbai is relatively young. Only 6.5 percent of the total population is above 60 years. The sex ratio is 809 females to 1,000 males, significantly lower than the female-male ratio of India (933-1,000). Most males are concentrated in the age bracket 20-29 years. With the exception of those in the 'above 70' age bracket, there are more males than females. This is mainly due to the fact that many males migrate to the city for work, leaving their families in rural areas.

The sex ratio for the 0-6 years age group provides an indicator of the survival of the girl child as it is influenced by sex ratio at birth as well as child mortality rates. Sex ratio at birth indicates if there has been any untoward intervention against a particular sex before birth. Mortality rates reflect the social factors which influence the survival odds of boys and girls. An average of 952 to 943 girls per 1,000 boys is taken as the natural sex ratio at birth by the government. Anything drastically beyond signifies human intervention. According to Faujdar Ram, Professor, International Institute of Population Sciences (IIPS), Mumbai, the sex ratio for Mumbai in the 0-6 years age group was 898 girls per 1,000 boys for Mumbai City Island and919 girls for every 1,000 boys in Mumbai Suburban district. In this aspect Mumbai compares poorly with the other districts in the country - Mumbai City Island ranks 473 and Mumbai Suburban district 420 in India's 593 districts list.

A rapid household survey conducted with a sample size of 1,000 households for 1996-1998 by IIPS shows that 763 girls were born per 1,000 boys in Greater Mumbai. This raises serious concerns about misuse of pre-natal diagnostic techniques for sex selective abortions in preference of a male child. It is believed that the proliferation of diagnostic clinics has made it easier, and increasingly cheaper to access such services. (karamyog)

Figure 20: Greater Mumbai, Age-Sex Pyramid, 2001



Source: AIILSG, 2009

4.3. Literacy

In 2001, Mumbai had a modest literacy rate of 76.87 per cent. However, it is much higher than the national average literacy rate of 64.8 per cent. Male literacy rates are slightly higher (81.4 per cent) than female literacy rates (71.28 per cent). This is due to a higher school dropout rate among girls. Higher education levels are poor – only 14 per cent of people in Mumbai hold a college or university degree.

4.4. Ethnicity

68 per cent of the city's residents are Hindus, 17 per cent are Muslim, 4 per cent Christian and 4 per cent Buddhist. The remaining 6 per cent are Parsees, Jains, Sikhs, Jews or have an atheist ideology.

Mumbai is one of the most cosmopolitan cities in India with over 50 per cent of its population of non-Maharashtrian ethnicity. Large ethnic groups that migrated during an earlier point of time often reside in segregated enclaves. Gujaratis are dominant in Ghatkopar, Mulund, Borivali, and Kandivali, South Indians (Tamils and Malayalis) in Chembur, Marol etc., Parsees & Sindhis in South Bombay. Other communities, such as those from UP, Bihar and Punjab are scattered in different parts of the city.

5.Slums

Census of India 2001 defined a slum as a compact area of at least 300 residents or about 60-70 households of poorly built congested tenements, in unhygienic environment usually with inadequate infrastructure and lacking in proper sanitary and drinking water facilities. If at least 20 households live in an area it is considered as "non-notified slum". Areas notified by municipalities, corporations, local bodies or developmental authorities are classified as "notified slum". In general terms, slums are informal housing of disparate families which has developed into community settlements. They are built without legal sanction and do not receive services and amenities as per minimal legal standards leave alone modest human requirements. Most slum dwellers participate in the informal economy.

5.1. Causes of Growth of Slums

The growth of slums in Mumbai is related to physical constraints of space in the city coupled with rapid in-migration and growth of population. Property values in the city were extremely high in the nineties due to the sharp rise of business interests associated with the economic liberalization of the country as well as due to immense property speculation. Restrictive laws like Urban Land Ceiling and Regulation Act (1976), Rent Control Act (1942), the regulatory restriction on Floor Space Index (FSI), Coastal Zone Regulations (CRZ) and restrictions on sale of industrial properties also contributed to high property prices. By the mid-nineties, real estate prices peaked and were among the highest in the world (*Economist*, 1995). This resulted in a rapid increase of slum population in the city. The growth rate of slum population exceeded the general urban growth rate. In 2001 slum dwellers constituted 54.06 per cent of the population of the city, today it is estimated that they account for about 60 per cent of Mumbai's population. The slums occupy a mere 8 per cent of the land area of the city.

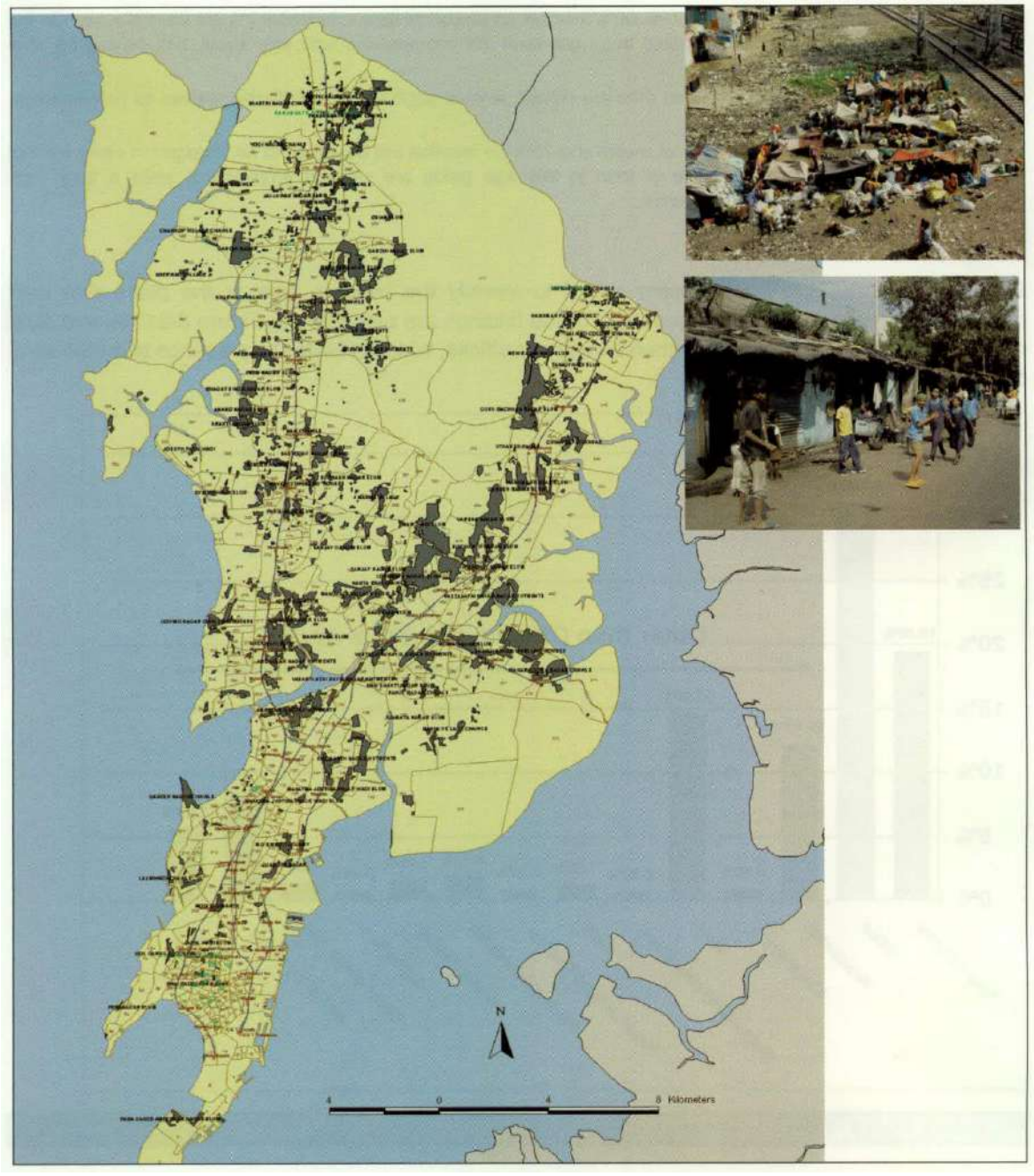
5.2. Distribution of Slum Population

Slums of varying sizes, population, and densities are found across Mumbai, except in C Ward. These slums are located on lands owned by a variety of entities – about 50 per cent are located on private land, 25 per cent on State Government land, 20 per cent on MCGM property and 5 per cent on land belonging to the Central Government and Housing Board.

According to survey conducted by YUVA, a nongovernmental organisation, and Montgomery Watson Consultants in 2001, there were 1,959 slums holding 5.72 million people, comprising 92 per cent of all slum population. The Environmental Status Report for 2002-03 of MCGM reported about "2,245 slum pockets", while according to the Slum Rehabilitation Authority the figure is over 2500.

As per census figures, 2001, the largest proportion of slum households (44.3 per cent) is in the western suburbs extending from Bandra to Dahisar, 28.7 per cent in the eastern suburbs from Sion and Mankhurd to Mulund. The smallest proportion, 26.9 per cent, is in the city extending from Colaba to Mahim, Sion and Mankhurd.

Figure 21: Greater Mumbai – Location of Slums



Source: MMRDA, 2008

Table 11: Greater Mumbai: Number of Households and Total Population of Slums, 2001

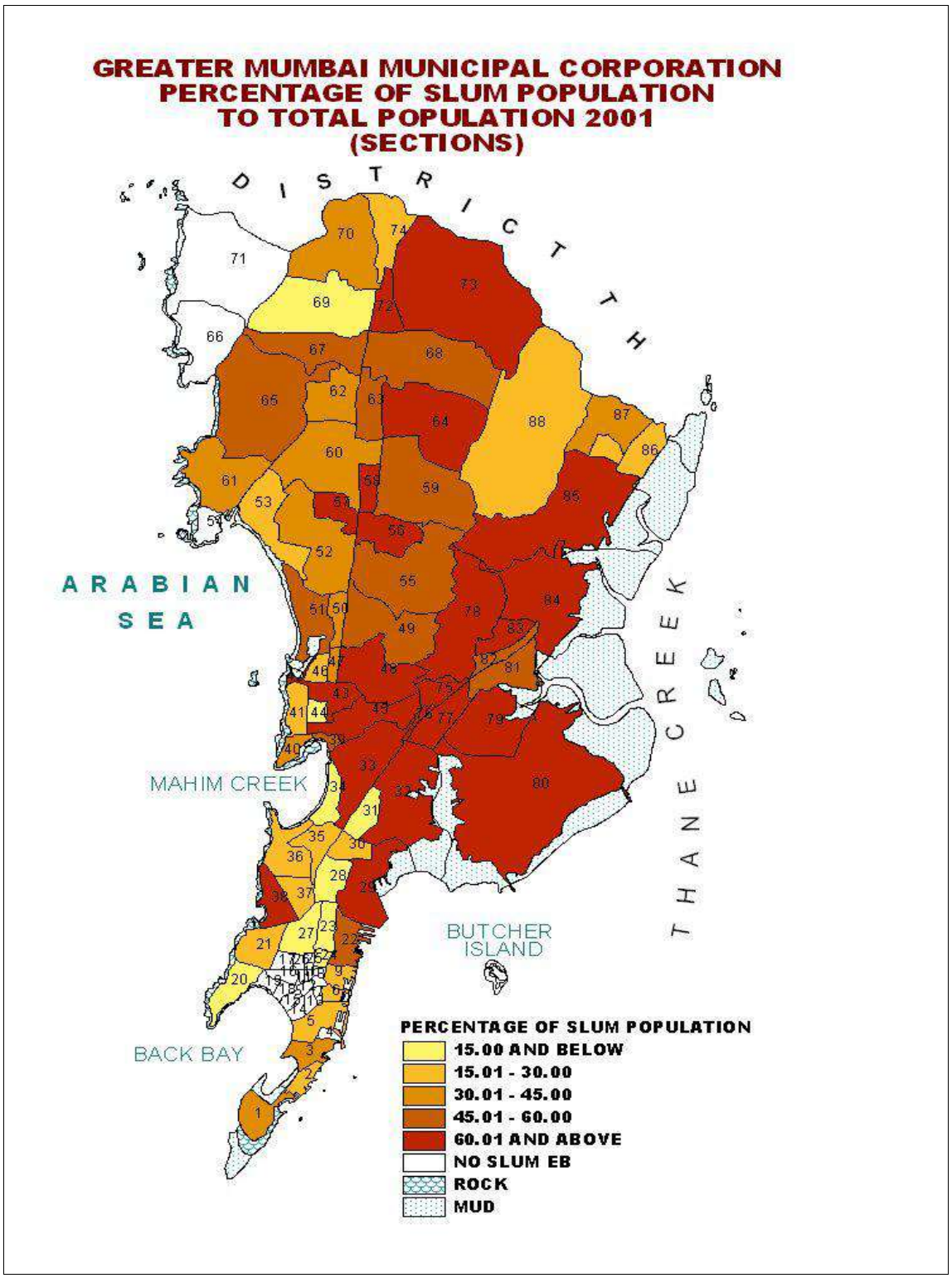
District	Number of Households		Total
	Slum	Non-Slum	
1. Mumbai District	224115 (16.8%)	453048 (38.7%)	677163 (26.9%)
2. Mumbai Western Suburbs in Mumbai Suburban District	580911 (43.6%)	533725 (45.0%)	1114636 (44.3%)
3. Mumbai Eastern Suburbs in Mumbai Suburban District	526958 (39.5%)	196832 (16.6%)	723790 (28.7%)
4. Total	1331984	1183605	2515589

(Source: Census of India, 2001)

The map depicting slum population to total population (Figure 22) indicates that in the Eastern suburbs the slum population accounts for about 75 per cent of the population of the area. This is an area of low-lying terrain and a high concentration of industries. The Western Suburbs have relatively lower concentration of slum population. The City Island has the least concentration with most areas having slum population accounting for less than 30 per cent of the total population. Only four sections have slum population accounting for more than 60 per cent of the total population

The conditions in slums leave a lot to be desired. Sanitation is poor and water supply scarce. Only 14 per cent of toilets get some water supply while 18.5 per cent of the population has access to piped water supply. With this scenario, residents are vulnerable to diseases, not to speak of natural calamities.

Figure 22: Greater Mumbai – Percentage of Slum Population to Total Population (Section wise), 2001



Source: Census of India, 2001

5.3. Slum Redevelopment Initiatives

Like many cities of the developing world, numerous strategies to deal with slums have been implemented in Mumbai. Till the early 1970s slum dwellers were considered as illegal squatters and policy of the state government was focused on their demolition. The slum clearance programmes were unsuccessful as the squatters simply moved to another place nearby or, in most cases, rebuilt the hutments in the same place. In 1971, Maharashtra Slum Area Improvement, Clearance and Redevelopment Act, was passed. A census of hutments was carried out in 1976 and identity cards were issued to slum families. The slum improvement work still continues in declared slums through local bodies.

Subsequently, in the 1980s, the state government, with the World Bank's support, introduced two important housing initiatives: A Sites and Services Program and a Slum Upgrading Program (SUP) based on a policy of in-situ upgrading through tenure legalization. Slum land was given on lease of 30 yrs to a co-operative society formed of slum dwellers at a nominal lease rent. Soft loans for renovation of individual structures on as-is-where-is basis were provided. However, up gradation on as-is-where-is basis was difficult because of high density of settlements,. Moreover, the schemes could only be implemented on slums situated on State Government, Municipal Corporation and Housing Board lands which did not have non-conforming reservations like playground, school, hospital, etc.

Since the mid-eighties the state government has supported the redevelopment strategy and has implemented three successive programs. The redevelopment programs undertaken include:

5.3.1. Prime Minister's Grant Project (PMGP)

In 1985, the central government made a grant of INR one billion (US$ 21,706,065,266.31) to the Government of Maharashtra to improve housing conditions in Mumbai. One of the main proposals of the PMGP was the redevelopment of Dharavi with an appropriate density and infrastructure. According to the state government records, in 1985, Dharavi had a population of 300,000, within an area of 172 hectares (Warning, 1995). A Slum Reconstruction program was proposed in which it was recommended that only 30-35,000 families be accommodated in Dharavi in four to five storied buildings. 20,000 families were to be relocated outside Dharavi. According to a census conducted by a well-respected NGO, the Society for the Promotion of Area Resource Centre (SPARC), Dharavi had a population of 500,000 residents or 100,000 families. Thus, if the PMGP's proposal for Dharavi was implemented, over 65,000 families would be displaced. Not only was relocation on such a scale politically difficult, the required land or financial resources would not be sufficient. Consequently, it was decided to limit slum reconstruction to a pilot effort of 3,800 houses which were to be organized as cooperatives. The cooperatives were to be provided thirty-year,

renewable leases to the redeveloped land. In addition, in a bid to serve more beneficiaries it was also decided to upgrade 25,000 houses. PMGP supported residents who opted for Slum Reconstruction with a direct subsidy of ten percent and an interest-free loan for twenty percent of the construction cost. Inaccurate cost estimates, cost inflation, the inability of beneficiaries to keep up with required payments, and the complexities involved in implementing the redevelopment strategy resulted in a slowdown of the construction work. To bridge the gap between the actual cost of the project and PMGP's initial estimates, it was decided that commercial property owners would pay one and a half times the cost of housing, thereby cross-subsidizing the residential members. However, financial problems persisted and the agency found its institutional capacity stretched in implementing such a complex strategy.

5.3.2. Slum Redevelopment Scheme (SRD)

In 1991, the State Government instituted a program of "free-housing" through slum redevelopment in which old PMGP projects could also be altered to meet the new stipulations. The government invited private developers to be the promoters in redeveloping the slums. Slum dwellers were to be resettled on the original site in houses of 17-21 square meter (180-225 square feet) carpet area, with the beneficiaries paying only INR 15,000 (US$324.75) which was approximately 23 percent of the estimated cost of construction per house. To make the scheme feasible, the SRD allowed project promoters to develop additional floor space on the slum land by increasing the FSI to 2.5. The profit of developers was capped at 25 per cent of their investment. The anticipated profit from the projects was to be the key variable determining the allowed FSI for redevelopment.

There was little progress in the implementation of the scheme and only 185 proposals of redevelopment were submitted (Afzulpurkar, 1995). This was attributed to the profit cap of 25 percent being impractical as well as due to the non-factoring of interest rates and the developer's cost of finance in the calculation of a developer's profit, and thereby, the maximum allowed FSI. In addition, approval procedures were too slow and complicated.

5.3.3. Slum Rehabilitation Scheme (SRS)

In 1995 the State Government replaced SRD with SRS, as the former was unsuccessful and unattractive to developers and slum dwellers. New implementation guidelines were instituted based on the Afzulpurkar committee report (Afzulpurkar, 1995).An autonomous body, the Slum Rehabilitation Authority was instituted under the chairmanship of the Chief Minister as a centralized, single-window agency to approve projects and institute regulatory changes to improve project implementation. The land occupied by slums was the resource for the scheme and the cost of construction of the rehabilitation of tenements was to be

cross-subsidized from the free sale of tenements in the open market. There was no financial involvement of the government.

From the perspective of the slum dwellers some of the key features of the new program were

- all slum dwellers resident in Mumbai prior to January 1, 1995 were eligible for redevelopment benefits
- a standard area of 21 m^2 (225 square feet) was to be provided to all beneficiaries
- an abatement in municipal property taxes for the first ten years, followed by a progressive increase over the next ten years
- a corpus fund of INR 20,000 (US$ 432.99) per slum dwellers house (approximately, thirteen percent of the estimated cost of construction) would be established by developers for future maintenance expenditure.

From the perspective of the developers the SRS the modifications incorporated were

- the profit ceiling was deregulated
- The entity developing the slum rehabilitation scheme is entitled to free sale component in proportion to the rehabilitation component.
- F.S.I. upto 3 can be consumed for tenement density of 500 to 650 per hectare in situ, as against 1.33/1.00 FSI available for general sites and F.S.I. upto 4 can be consumed for tenement density of more than 650 per hectare in situ with prior Government approval.

There are three types of schemes as per the provisions of different sections of Development Control Regulations (DCR) under which they are approved. Under provisions of DCR 33(10), the slums are rehabilitated at the same site. If the maximum built up-area exceeds the maximum FSI permissible in-situ the balance is allowed as Transfer of Development Rights (TDR). Where rehabilitation of slum dwellers is not possible in-situ due to physical constraints like vital projects, footpaths, hillocks, etc., the project is implemented under D.C.R 33(10) clause 3(11), Project Affected Persons Tenement Scheme. In the third scheme, rehabilitation is done under provisions of DCR 33(14), Permanent Transit Tenement Scheme. The land owner is allowed to consume existing FSI potential of the land owned by him. Additional potential of 1.5 for suburbs, 1.66 for difficult area (Dharavi or as declared by SRA) and 1.00 for city is granted under this scheme. The developer constructs transit tenements out of a prescribed part of this additional potential. The balance of the additional potential is allowed as free sale component.

Slum redevelopment is attractive to Mumbai's slum dwellers because it recognizes their dislike of displacement and provides them with more valuable housing.

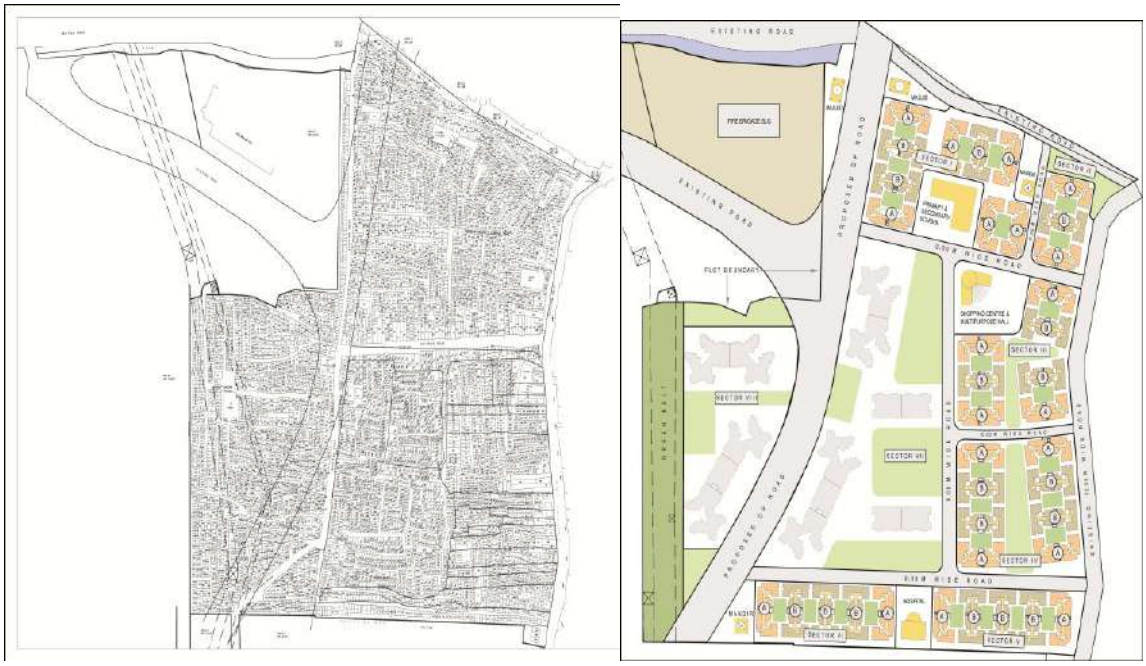
Table12: Greater Mumbai: Status of Slum Rehabilitation projects (30/12/2008)

Particular	33(10)	3(11)	33(14)	Total
Number of S.R.A projects sanctioned	1116	26	59	1201
No of tenements approved in the scheme	206716	63684	12941	283341
No of tenements allotted	46041	49894	456	96391

Source: Presentation by Suhas K. Karvande, Deputy Municipal Commissioner, MCGM

Figure 23: Slum Rehabilitation Project Existing slum

Existing layout of Slum Proposed layout plan



Source: Presentation by Suhas K. Karvande, Deputy Municipal Commissioner, MCGM

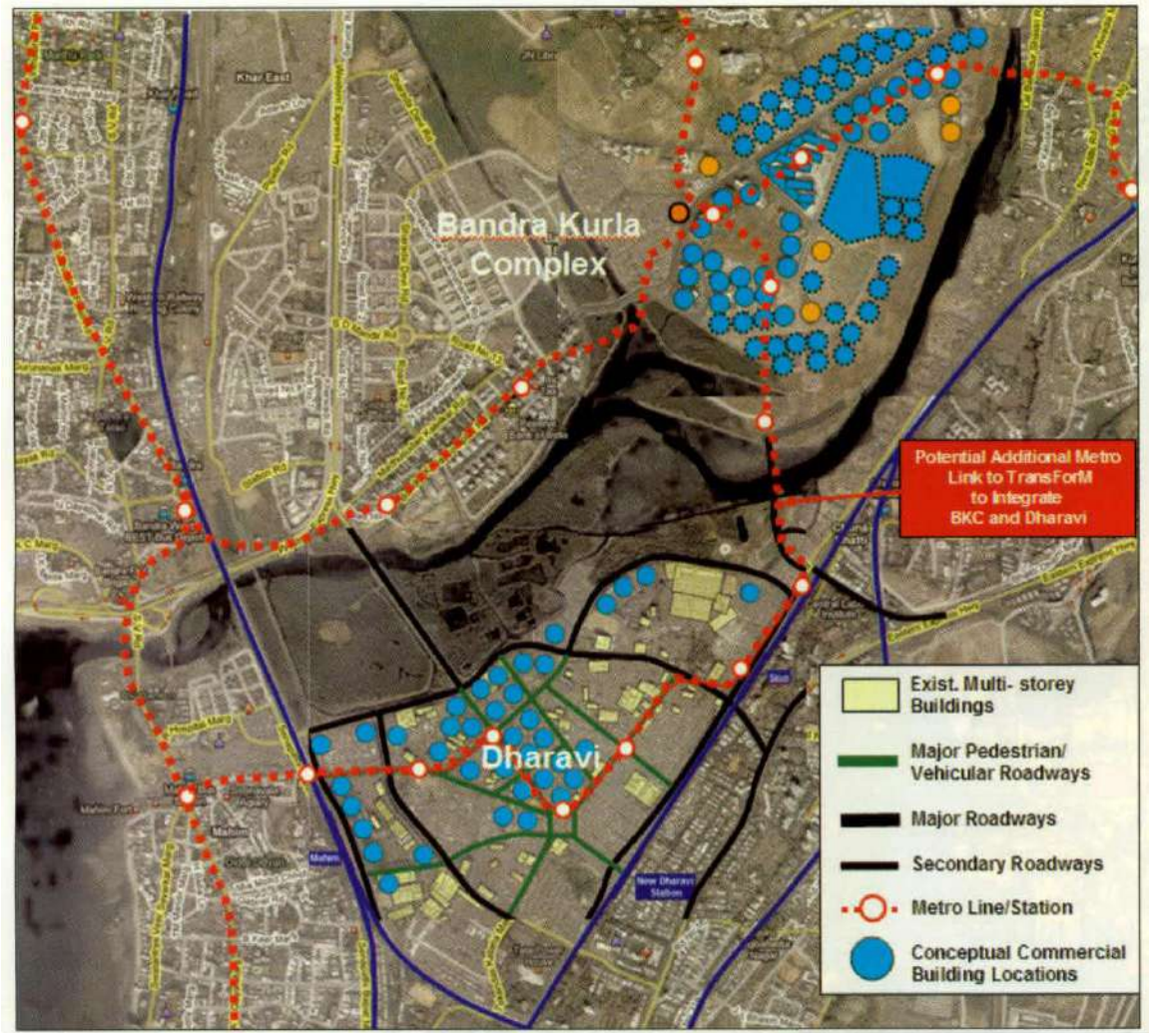
Figure 24: Photograph of a Slum Rehabilitation Building

Source: Presentation by Suhas K. Karvande, Deputy Municipal Commissioner, MCGM

5.3.4. Dharavi Redevelopment Project

The Government of Maharashtra has initiated the process of redevelopment of Dharavi, India's largest slum having an estimated area of 2.25 sq km and population density of approximately 39,600 persons per km^2(based on a recent survey by the Kamla Raheja Vidyanidhi Institute of Architecture which established that this was the density of Chamra Bazaar in Dharavi).The project is to be implemented through the Slum Rehabilitation Authority (SRA), according to the norms of S. R. Act of 1971.Of the 2.25 sq km, the actual redevelopment will span 1.46 sq km. The slum has been divided into 10 sectors, each of which will be allotted to different developers. It is proposed that Dharavi will be redeveloped as an integrated township with modern amenities such as wide roads, electricity, ample water supply, playgrounds, schools, colleges, medical centers, socio-cultural centers etc. Non-polluting industries / businesses are to be retained, and all the established businesses and manufacturing units will be provided with modern technical and economic strategies for sustainable development. The total duration of the project is expected to be of five to seven years. It is expected that this will eventually become a working model for the rest of the slums in the city.

Figure25 : Dharavi: Potential Concept Development Plan



Source: MMRDA, 2008

6. Urban Morphology and Land Use

Prior to the arrival of the Europeans the islands comprising Mumbai city today were inhabited by *kolis*, the fishermen community, that even today lives in scattered coastal enclaves hardly distinguishable from a slum.

6.1. Island City

6.1.1. Central Business District

The city centre located in the Fort area is essentially a zone of administration, business, finance and wholesale trade. Recreation, higher education and hotels also find a strong localisation in this zone. The Fort houses most of the State and Central Government offices, offices of the railways, banks and business houses as well as those of airways, inland and overseas communications. The streets are relatively broad and straight and reveal a grid pattern within the old Fort areas. A small residential core of retail shopkeepers still persists as a pocket within this region, to the south of the railway terminal at Victoria Terminus. The eastern sections of the Fort, adjoining the water front has a cluster of business houses and offices handling port functions, and is skirted by streets dominated by banking. To the south of the Fort, a retail shopping-cum-residential ribbon extends south along the Colaba causeway and ends rather abruptly in the low density residential zone, occupied by the Defence services in South Colaba.

At the southern tip of Marine Drive is Nariman Point, also referred to as the country's first central business district. Banks, financial institutions, private equity firms, airline offices, most of the consulates and high commission offices of various countries, Maharashtra Legislative Assembly and Vidhan Sabha are located here. The area is the fifth most expensive office location in the world with an average annual rental of $107 per sq ft, according to a survey conducted in 123 key locations in 63 countries across the world by realty services firm Cushman & Wakefield.(Economic Times, 24 Feb 2010). The report also stated that rental rates had dipped by around 20% in 2009, compared with the year-ago period owing to the economic meltdown and that companies and financial institutions were shifting to Mumbai suburbs such as BKC, Andheri and others. The exodus of finance companies such as UBS, AG and JPMorgan Chase & Co was attributed to sky-high rentals and an acute shortage of Grade A properties. As a result several iconic buildings were refurbished and in recent times and the supply of A Grade office space has increased to 2.5 million sq ft against 1.75 million at BKC.

6.1.2. Residential

The old pre-British, pre-industrial core area of the city stretches across Girgaum, Khetwadi, Bhuleshwar, Thakurdwar, Umarkhadi, Mandvi and Mazagaon. Morphologically, these areas are characterised by narrow main streets, widened to an extent in the recent past, crooked gullies and lanes, intertwining, old buildings with wooden balustrades overlooking the streets, high ceilings, and groupings into *wadis* or localities enclosed within a compound of high wall and a single entrance. The *wadis* are socially homogenous. The built-up areas practically consume the entire wadi, and there is little space devoted to open grounds, parks and recreation centres.

The elevations of Malabar, Walkeshwar and Cumballa hills with an airy, western aspect and abundant sea breeze, proximity to the city centre and yet an aloofness from the congested old core, have attracted the upper echelon of society like businessmen, financiers and top level administrators to the area. A significant amount of urban renewal has taken place with skyscrapers replacing the villas of earlier times. Along the Back Bay, this upper class residential zone descends to a promenade of multi-storeyed Art Deco apartment structures—the Marine Drive, occupied by the upper middle sections of society. To the south of Nariman Point, in Cuffe Parade, and further beyond along the foreshore road adjoining the newer reclamations of Back Bay is a high income residential zone. The upper class residential area of Cumballa Hill descends in the north to the Hornby Vellard and extends beyond along the Worli seaface in a residential zone very similar to the Marine Drive.

Urban renewal is fast transforming the erstwhile mill areas of Lalbaug, Parel and Byculla, extending as far north as Dadar and Naigaum into an upper class residential area.

The northern sections of the Island City comprising Prabhadevi, Dadar, Mahim, Wadala and Sion are middle class residential areas, developed during the forties and later. The roads are better aligned and wider and the houses are generally three-storied. Unlike the older residential zones of South Bombay these areas boast of more open space, parks and gardens.

Recently Sewri has witnessed a consistent rise in capital values due its central location and future infrastructure developments. Old residential stock, such as Sewri Koliwada, BDD chawls, Shivaji Nagar, Gulmohar Society, Labour Camp and Bhatwadi, is giving way to mid-ranged residential development. Several developers view the area as a strategic destination and it is estimated that 1.5 million sq ft of high-end residential development is in the pipeline (Sinha Archana, 2010)

6.1.2. 1. Redevelopment of the old residential core

Almost 90% of the old residential buildings located in 'A', 'B' and 'C' wards in the old pre-industrial core of the Island City are dilapidated - many in a state of imminent collapse. This has been caused by the negative effect of rent control legislation. In 1971 the Bombay Building Repairs and Reconstruction Board was created to take over the maintenance of decrepit buildings and to redevelop buildings which had reached a point of near collapse. 19,642 buildings were identified and a separate tax levied on these buildings apart from other taxes, called "cess", for their repair. However, the pace of reconstruction of cess buildings was very slow due to paucity of funds.

Table 13: Cessed Buildings in Mumbai

Period of Construction	Category	No. of buildings (1969)	No. of buildings (2009)
Up to 1st September,1940	A	16,502	13,480
Between1st September,1940 & 31.12.1950	B	1,489	1,502
Between 1st January,1951 & 30th September,1969	C	1651	1,273
Total		19,642	16,255

Source: MHADA

In 1991 Development Control Regulations (DCR) were framed for the city. Provisions for Redevelopment of cess buildings in the Island City were incorporated in Rule no. 33(7). The law was introduced to increase involvement of tenants/landlords/private developers.FSI of 2, or consumed, whichever was higher, was introduced for their redevelopment. Many cessed buildings had already consumed FSI 3 - 6 (FSI regulations were imposed in Mumbai for the first time in 1964) so there was no scope for free sale construction. Redevelopment was uneconomical and relocation in situ was impossible, so the scheme failed to give the desired results.

In October 1992 a separate board, Mumbai Building Repairs and Reconstruction Board (MBRRB), was constituted under the apex body of Maharashtra Housing and Area Development Authority (MHADA) for repairs and reconstruction of cess buildings. These buildings were structurally repaired up to the ceiling limit of INR 2000 (US$ 43.21) per m^2. If cost of structural repairs exceeded this, the building was declared as 'Beyond Economical Repairs' and taken up for reconstruction after acquisition. Only 937 buildings have been reconstructed by MHADA to date, while

there have been 2774 building collapses resulting 730 casualties and 1702 injuries. Moreover, repair of cessed buildings does not ensure their permanent structural stability. Currently there are 16,218 cess buildings housing 400,000 families and a population of about 2 million.

Figure 26: Collapse of a 110 year old, MHADA cessed, 5 Storey bldg with 90 flats, January 09, 2010

Reay Chambers, Dockyard Road

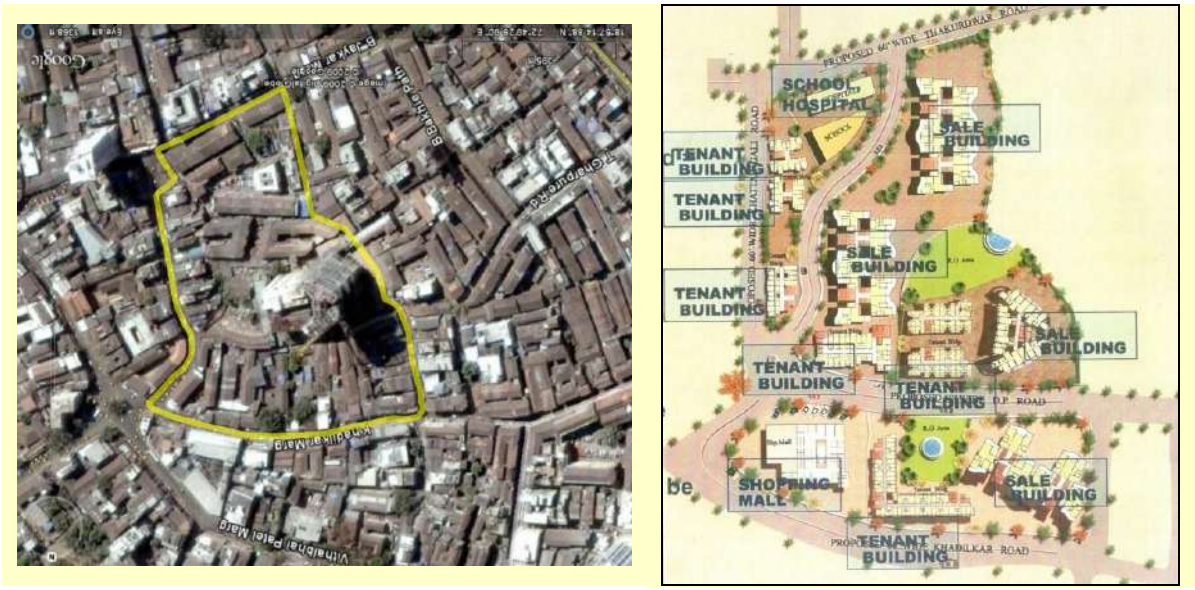
Source: The Times of India

In a bid to provide incentives for urban renewal of the city core the Government of Maharashtra modified Development Control Rules 33(7) and 33(9). DCR provision 33 (7), amended in 1999, is applicable for buildings constructed before 1950 and those declared as dangerous, prior to monsoon of 1997. It allows FSI of 2.5 or FSI required to accommodate all the tenants in the building plus an incentive FSI, whichever is more, for the reconstruction of a building. Incentive FSI is given to encourage composite redevelopment by clubbing old properties together instead of developing each property separately, in a bid to reduce congestion and develop better infrastructure such as internal roads, open spaces, etc. If incentive FSI cannot be fully utilized on the same plot TDR can be availed. 2487 buildings are taken up for redevelopment under DCR 33(7) to date.

On February 25, 2009, DCR 33(9) rules were amended for repairs and reconstruction of cessed buildings with a view to redevelop and renew inner city areas and dilapidated buildings through options of land assembly, conserving heritage structures and places of archeological importance. Notification for use of Cluster Approach is for redevelopment of cessed buildings, buildings belonging to Government, Semi Government and MCGM, buildings that are declared dangerous or injurious to health and slum areas. The area under slums and the area under buildings constructed after 30.09.1969 cannot exceed 25 per cent of the total plot area. Cess buildings are to be developed through a joint venture between private developers and MHADA, provided it is feasible and acceptable to both parties. FSI was raised to 4 or FSI required for rehabilitation of existing tenants/occupiers plus incentive FSI whichever is more. Each cluster for development must enclose a minimum of 4,000 m^2 and a maximum of 20,000 m^2. Developers have to provide basic amenities including parks, roads & playgrounds and a corpus fund for rehabilitation buildings which will ensure their maintenance for 10 years. There is also a provision for Development Charges of INR 5,000/- (US$ 108.25) per m^2 for areas exceeding the zonal FSI. This will create funds for augmentation of offsite infrastructure.

The prime objectives of the cluster redevelopment scheme are to protect people living in dilapidated buildings, leverage land use to improve quality of life, create infrastructure and bring in global standards of planning.

Figure 27: Proposed Cluster Development in Girgaon



Area of Cluster is 34104.25 Sq.mts. and there are 2000 tenants
Source: MHADA

6.1.3. Commercial

The zone of contact that lies between the Fort, Girgaum, and Mandvi, namely Dhobi Talao and Princess Street market areas, has retained its historical tradition of being the main area of wholesale and retail commerce. The shopping function extends in ribbon like extensions into the old core along the main roads. Street and road-wise differentiation and specialisation in shopping patterns is discernible e.g. hardware in Lohar Chawl, stationery in Abdul Rehman street, jewellery in Zaveri Bazar, leather work around the Phule Market, etc.

Though initially the wholesale markets provided the impetus for the growth and development of the city, they also aggravated problems of unruly traffic, congested streets and overcrowding. With a view to reducing congestion in South Mumbai, the State Government and the MMRDA decided to shift the wholesale markets located therein. In pursuance of this policy decision, the onion and potato wholesale market, wholesale markets of sugar, spices condiments, dry fruits as well as the iron and steel markets have been shifted to Navi Mumbai. The wholesale markets of ground nuts, pulses and edible oil etc are also proposed to be relocated in Navi Mumbai.

6.1.4. Industrial

The areas of Lalbaug, Parel and Byculla, extending as far north as Dadar and Naigaum, covering an area of about 25 sq km, comprised the textile industry zone. The first mill was established in 1856 and by 1931 it is estimated that half of the population of the city was dependent on the textile industry. By 1975 the industry was at its peak, employing almost 250,000 workers in more than 52 mills (Adarkar & Phatak, 2005). Thereafter the industry declined for a number of reasons. The 18 month-long strike in 1982-83 saw the loss of over 100,000 jobs and was the proverbial nail in its coffin (D D'Monte, 1998). In March 1991 Regulation 58 of the new DCR came into force, providing for development of sick and/or closed cotton textile mills on condition that one third of the land is given to the MCGM for public amenities and 27-37 per cent (depending on the area of the mill) is given to the MHADA and Public Sector Units for housing. The remaining lands could be developed by the owner for residential and commercial uses as may be permissible under the DCR in force. The regulation intended to regulate the development of cotton textile mills so as to generate open spaces and public houses for the city, in a manner, which would create a coherent urban form. However, the redevelopment that occurred has been in a piece meal haphazard manner on a total commercial basis, with little land becoming available either for low income housing or for public amenities. The textile mills in the area have been replaced by malls, upscale commercial complexes, IT offices, hospitality and upper class residential housing. This area is the new growth centre in the Island City.

Besides the mill lands, a number of multinational corporations with industrial facilities such as Glaxo, Siemens and Cadbury were located in Worli and Lower Parel

area. Many of these companies are relocating their production facilities to cheaper locations and most of these former industrial sites are being converted for commercial use.

To the east, industrial estates, factories, warehouses and port related activities were the hallmark of Sewri in the past. Currently the area is emerging as a residential belt due to its central location within the island city and the movement of industry outside city limits due to economic reasons. The area is in close proximity to Worli, Prabhadevi and Lower Parel and has easy connectivity to Nariman Point and BKC business districts, as well as retail and shopping establishments being planned the area. Potential infrastructure projects such as the proposed Sewri-Nhava trans-harbour link, proposed new international airport, and the monorail has escalated the demand for residential property in the area.

6.1.5. Port Functions

Docks, wharves, warehouses, godowns and associated auxiliary functions characterise the eastern, water-front extending from the Fort, northwards right upto Sewri-Wadala. The roads are congested with heavy truck traffic.

6.1.6. Open Spaces

Mumbai has one of the lowest proportion of open spaces both in terms of area and population. On the western side of the Fort, on reclaimed ground, are the only vast open grounds of South Bombay, the Azad, Cross and Oval maidans, lined on their edges by administrative offices. MCGM has put up a proposal to club the three maidans measuring 14.87 hectares, via a tunnel or pathway and grow a forest in the area.

To the north of the old residential core is a bowl shaped depression, on ground reclaimed during the early phases of development of Mumbai. The lowest level of this depression has been converted into the Race-course.

One of the oldest zoos in the country, Veermata Jijabai Bhosale Udyan and Zoo, is located in the heart of the Island City. It covers an area of 21.45 hectares, of which one third houses the zoo and the remaining two third comprising a botanical garden, lawns and pathways.

In addition to the above 233 gardens, a number of playgrounds and recreational grounds are scattered across the Island City.

6.2. Mumbai Suburban District

The main transport arteries of the metropolis have contributed considerably to urban sprawl in the suburbs. Initial developments were somewhat planned followed

by unrelated, unplanned extensions. Retail shopping and hawkers cluster around the entry points of the railway stations. Industrial extensions were peripheral, in open sites, but with the expansion of the suburbs got engulfed. Slums and hutments occupy the low-lying tracts. By and large, the suburban development is lop-sided, lacking in social and civic amenities.

6.2. 1. Residential

Beyond Mahim Creek, along the Western Railway and the Swami Vivekanand Road are middle income residential suburbs, while the upper income residential suburbs are located on higher elevations like Bandra, Pali Hill and Khar. These areas are undergoing urban renewal and fast changing skylines. Middle and lower income housing colonies are strung all along the railways and on newly reclaimed grounds. Depressions, low-lying areas and creek sides house hutment dwellers. To the east of Kurla are the fast growing residential suburbs of Chembur, Govandi and Deonar. The building of the rail and road bridges across Thane creek to the mainland along this section resulted in a ribbon-like residential development extending eastwards upto Mankhurd. Though principally residential, industrial units are observed at several places like the CST Road, Kalina, outskirts of Parle etc.

6.2. 2. Commercial

The commercial centre in the suburbs is the Bandra-Kurla Complex (BKC) which in 1977 was planned and developed by MMRDA as the first of a series of "growth centres" to arrest further concentration of offices and commercial activities in South Mumbai. The complex spans an area of 3.7 km. m^2 of low-lying land, located between the Mithi river, Vakola nalla and Mahim Creek. With the National Stock Exchange, Securities and Exchanges Board of India and many other financial institutions and banks having established their headquarters, BKC has emerged as a financial district. It is fast emerging as a multifaceted CBD with the establishment of star hotels, convention centres, as well as the offices of the American Consulate and British High Commission within the complex.

Kurla in its vicinity, which till recently was characterized by narrow, dingy bylanes lined with small industrial units and lower income housing is witnessing a rapid transformation. The suburb is set to add over 6 million sq ft of upscale office space and around 3 million sq ft of mall space shortly. This upcoming office space is three times the 2 million sq ft office space at Nariman Point, the city's main office hub, and half that of BKC (Raghavendra Kamath, 2009).

In recent years Andheri has emerged as an important commercial hub. It has witnessed substantial leasing of space by media, information technology (IT), and dotcom firms as well as traditional businesses. A large number of back-end operations and corporations, internet start-ups, IT companies and call centres have relocated here.

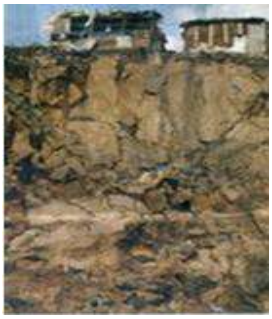
6.2. 3. Industrial

Industries have developed along the main arteries and link roads of the suburban zone. Ready access to the rail yards, uncongested main roads, cheaper availability of land and nearness to the water and power mains aided the rapid expansion of industries in the suburbs. These industrial areas show a greater degree of differentiation according to types and their associations of auxiliary industries than those located in the Island City. North of the old textile core of Kurla, and adjoining the Kurla rail yard, automobile engineering and electrical engineering industries are located. A zone of light engineering extends further along the Central Railway and Agra road upto Vikhroli, while beyond Vikhroli, right upto the municipal limits in Mulund is an area of light chemicals, drugs and pharmaceuticals and associated industries like cosmetics. A large number of the engineering, chemical and pharmaceutical industries are relocating outside the city. Large power and water absorbing industries, mostly medium sized engineering units like machine tools, have developed along the Andheri-Kurla link road and Powai lake area, particularly in Marol, Saki and Powai. Many of the small and medium scale industries are housed in State aided and private industrial estates. Auxiliary and associated industries develop together under the same roof in such estates. Andheri has some of the most important industrial associations like Laxmi Industrial Estate, Shah Industrial Estate, CEPZ Marol Naka, MIDC (Maharashtra Industrial Development Corporation), Saki Naka and Santa Cruz Electronic Export Processing Zone. The Film industry is located along the fringe of this zone.

The western suburbs which are essentially residential, have so far withstood the penetration of industries in them barring a limited development of food processing industries, such as soft drinks and confectionery. Some industrial expansion, of engineering industries, took place along the Western Express Highway, to the east of residential zone of the western outer suburbs. Trombay is a 'restricted' industrial area with a cluster of two oil refineries, a petro-chemical complex, a fertiliser plant, a thermal power unit, and the Bhabha Atomic Research Centre.

6.2. 4. Open Spaces

Figure 28: Encroached hill marred by landslides at Andheri



Source: Times of India

In addition to 199 gardens and a number of playgrounds, and recreational grounds there is a large green belt in the north centre of the Suburban District, clothing the hills of the central area. A substantial part of it is devoted to the National Park, to the south of which is the government owned Aarey Milk Colony. In areas which are not protected the hillsides are being systematically demolished by the quarrying industry. The quarry sides have extensive development of hutments. Quarrying in the hills have made them prone to landslides as uprooting of trees and digging of the soil has a cascading effect throughout the range.

7. Economy

Greater Mumbai contributes about US$ 10 billion of Maharashtra's economy of about US$ 37 billion — about 26 per cent of the total size of the state's economy. 33 per cent of income tax collections, 60 per cent of customs duty collection, 20 per cent of central excise tax collection, a significant quantum to the corporate tax, and 40 per cent of India's foreign trade is from Mumbai (Mumbai City Development Plan, 2006). The city which contributes about a third of the nation's tax collections was ranked 49 in the Global Financial Centre Index, according to a survey by consultants Z/Yen Group Ltd. and published by the City of London. The index uses external sources to determine property and occupancy costs to judge competitiveness, and an online questionnaire from 1,455 respondents. Dubai is ranked 23rd and Shanghai 35th. (Pooja Thakur, 2010)

Figure 29: Bombay Stock Exchange

Source: ceoworld.biz

The Bombay Stock Exchange, the largest stock exchange in India and third largest exchange in the world, as well as the National Stock Exchange and Multi Commodity Stock Exchange are located in the city.

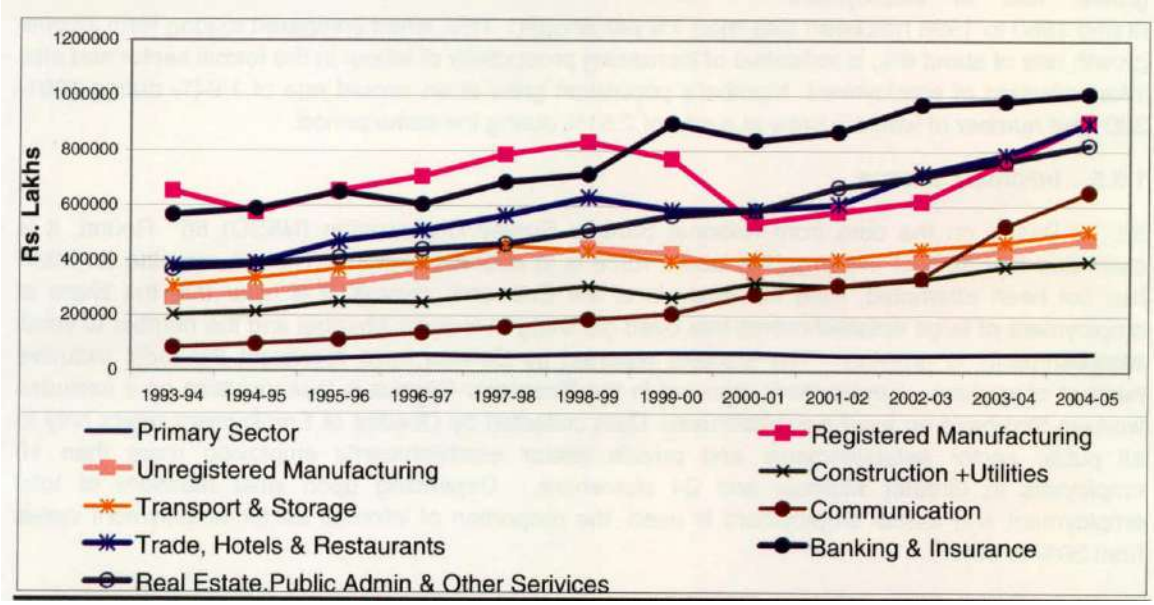
Mumbai is the capital of India's pharmaceutical industry and the world's most prolific film production centre. Consequent to the country's economic liberalization reforms in the nineties, Mumbai became the South Asian regional head-office of many multinational corporations.

7.1. Occupational Structure

The major economic activity in Mumbai in the 17th century was fishing and agriculture. Under British rule the port was not only a major employer, but also was the force behind the emergence of wide range of services and financial activities. These, in turn, created the business agglomeration economies and manual labour pools making Mumbai very attractive as a location for public and private sector offices.

The first textile mill was established in 1854 and the city was a textile manufacturing hub till the 1980s when most of the mills shut down. Subsequently, there was also a large-scale relocation of engineering, chemicals and pharmaceutical industries from Mumbai to locations elsewhere and the city's economic structure witnessed a paradigm shift from 'manufacturing activities' to 'services'. The service-based businesses are mainly in sectors like Finance, IT, Telecom, Tourism, Entertainment, Advertising and Communication, etc. The replacement of manufacturing jobs by the service sector has been a gradual process. In 1981, the industrial sector accounted for 44 per cent of the jobs, while the services sector accounted for 54 per cent. By 1991, the share of the industrial sector in employment declined to 39 per cent, while that of the services sector increased to 60 per cent Currently the service sector accounts for three-fourths of the employment.

Figure 30: Greater Mumbai – GDP Growth Rates of Different Sectors



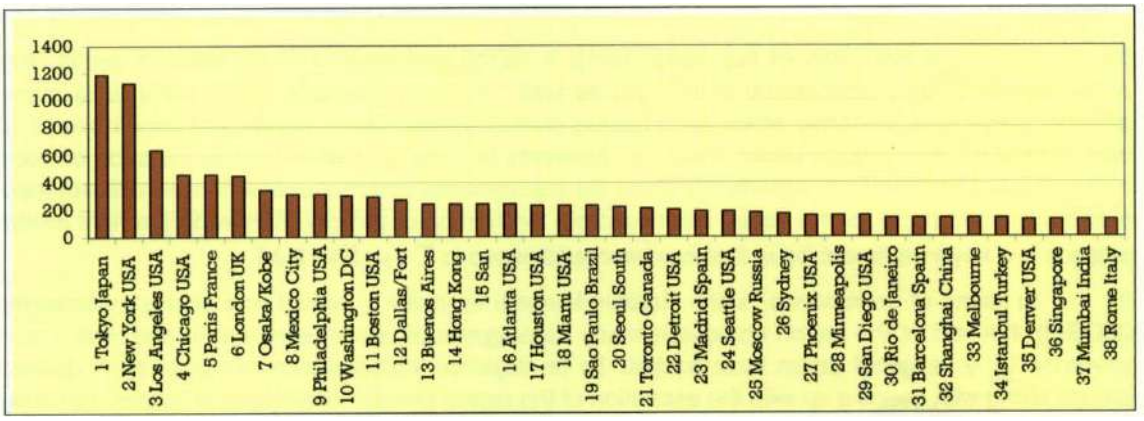
Source: MMRDA, 2008

In 2000, the service sector, both formal and informal, contributed 74 per cent of Mumbai's Gross Domestic Product (an increase of 11 per cent from 1993-94) while the secondary sector increased from 63 per cent to 74 per cent during the same period. Despite being an urban area, the primary sector, notably fisheries has consistently contributed about 1 per cent.

A cause for concern is that employment in the informal sector has grown at a faster rate than that in the formal sector, resulting in its share of total employment increasing over time. The growth of formal-sector employment in the services sector has not been adequate to fill the gap and thus former mill and other manufacturing workers have been absorbed by the informal sector.

The long term (1993/94 to 2004/5) Compound Annual Growth Rate of income of Greater Mumbai, Maharashtra and India is 6.5%, 5.7% and 6.3% respectively. It is estimated that the per capita income of the city is higher than any other country in the SAARC region. Estimates of a study by M/S PriceWaterCoopers in 2005, ranks Greater Mumbai as the 37th richest city in the world with a total income of US $126 billion (in PPP terms). The same study observes that by the year 2020 the city would improve its position to 24th richest city in the world with an estimated income of US $300 billion.

Figure 31: Estimated Total GDP in 2005of Top38 Cities(billion US$ in PPP terms)



Source: UK Economic Outlook, March 2007, PriceWaterCoopers

7.2. Income Distribution

The per capita net income for Mumbai (2006 to 2007) based on 2009 prices was INR 65,361 (US$1414.13). A baseline survey conducted by MMRDA of 16,000 slum households using average monthly household income of INR 2,978 (US$ 64.64) as an indicator found that 40 per cent of the households were below the poverty line provides evidence of Income-based polarization. However, despite the coexistence of both extreme wealth and absolute poverty, per capita income for Mumbai is higher than that of the average per capita of both the State of Maharashtra (i.e. INR 41,331 or US$ 894.22) and the entire country (INR 29,382 or US$635.70). (AIILSG, 2009)

7.3. Spatial Clustering of Economic Activities

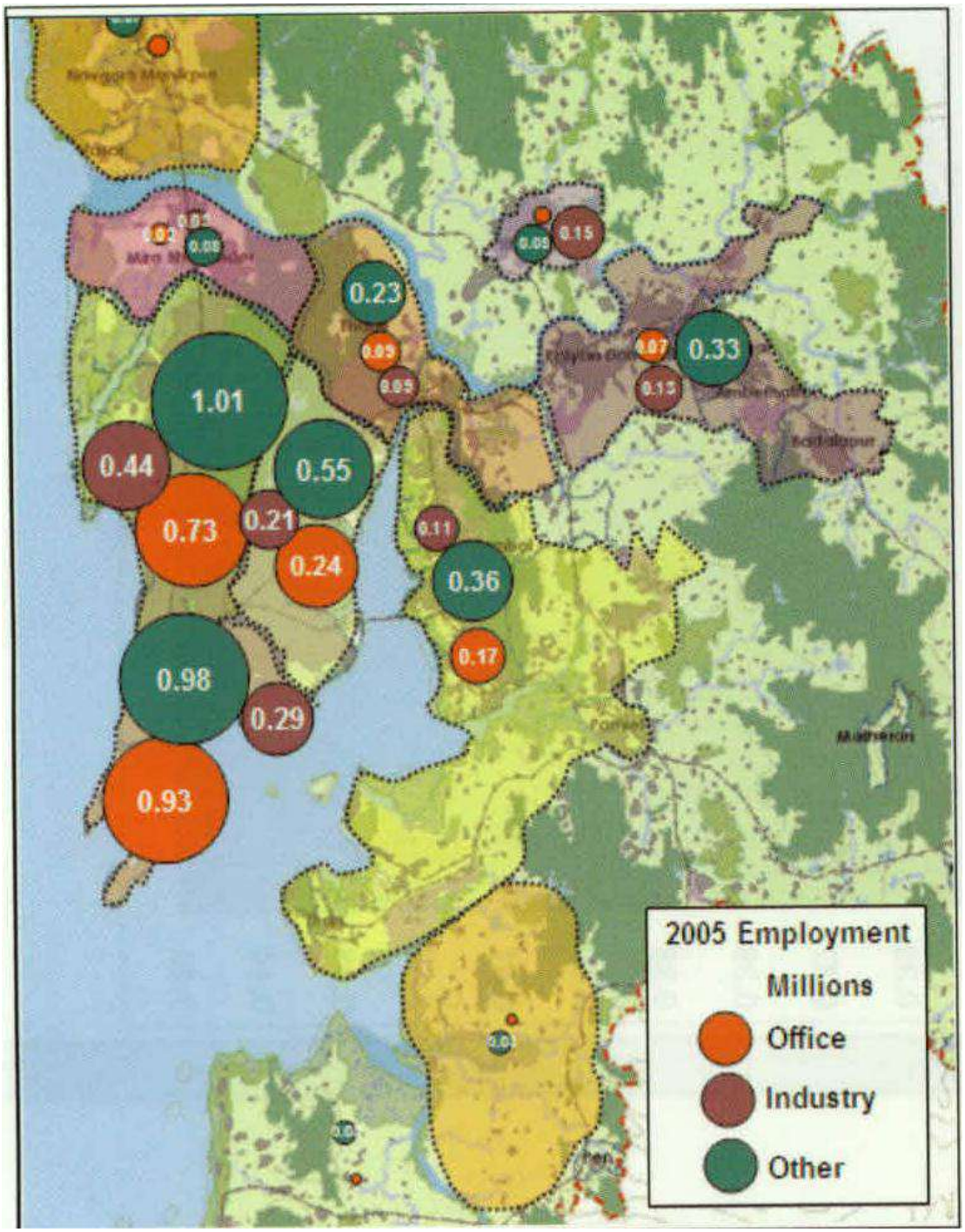
Greater Mumbai historically developed as a mono-centric city with port, government, banking and insurance, stock exchange, wholesale and international trade all being concentrated in and around the Fort area. With diversification of economic growth, conversion of manufacturing sites and expansion of planned transit facilities, a clear pattern of "spatial clustering" is emerging.

Table 14: Spatial Clustering of Economic Activities in Greater Mumbai

Sr. No.	Economic Activity	Location
1	Financial services including banking and insurance	Fort, Nariman Point, Bandra Kurla Complex
2	IT and ITES	Andheri-Kurla Road, Malad
3	Media and entertainment	Malad – Link Road, Goregaon
4	Retail	Mill district, Malad, Mulund
5	High end export oriented manufacturing	SEZs in Andheri, Goreaon, Powai, Gorai-Manori

Source: Comprehensive Transportation Study for Mumbai Metropolitan Region, 2008

Figure 32: Distribution of Office, Industry & Other Employment (2005)



Source: Comprehensive Transportation Study for Mumbai Metropolitan Region, 2008

8. Transportation

Though Mumbai is acknowledged as having one of the more extensive and efficient transport networks within India, its infrastructure is woefully inadequate by world-class standards. The problem is aggravated due to the physiography of the city and the large concentration of financial, commercial and administrative functions in the southern end of the city. Three key issues constitute the crux of the problem: a) severe north-south congestion on the western and central railway lines and the key arterial roads b) lack of east-west connectivity within the city and c) poor connectivity between the city and the hinterland.

Unlike the other metropolitan cities of India, Mumbai was lucky in inheriting a well-developed suburban rail system and an efficiently operated bus system under BEST management. Despite a sharp deterioration in the quality of Mumbai's public transport, nearly 80 per cent of the total journeys made in the city, i. e. 11.2 million out of 14 million journeys per day are by public transport, mainly by suburban trains and buses. The modal split is divided between trains and buses in the ratio of 58 per cent for trains (6.5 million journeys) and 38 per cent for buses (4.7 million journeys), with the average lead of travel of 25 km for rail and 7 km for buses. Of the remaining 2.8 million journeys, about 1.4 million journeys, or 10 per cent of the total, are made by intermediate public transport (taxis and rickshaws). The rickshaws are used mainly for short trips to and from rail stations in suburban areas. Car users approximately account for 5 per cent journeys, and the remaining 5 per cent journeys are walk trips, particularly in south Mumbai and suburbs. According to a survey conducted by MMRDA (MMRDA, 2008) about 50 per cent of the workforce either walks to work or is gainfully employed at home. People living in slums are disproportionately represented in this sector. People working in offices and industry have a higher disposition to travel by mechanized modes. Therefore, as people move into more formal jobs motorized travel will increase.

8.1. Road Transport

The road length in Mumbai is 1941.424 km, comprising of about 1,950 km of MCGM-maintained roads and about 50 km of State Highways (23.5 km of Eastern Expressway and 25.33 km of Western Expressway from Bandra to Dahisar). All the roads in the city are either concretised or black-topped. To date 488 km of roads have been concretised of which 30 km were concretised in 2009-10. Mumbai's streets cover only about 11 per cent of its surface, compared to 21 per cent in Delhi and 22 per cent in New York City. Three North-South arterial roads (Western Express Highway, Eastern Express Highway and Sion-Panvel Highway) are the backbone of the road transport system. Cross road links are less developed. The streets in most part of Mumbai City are old and narrow, and their capacity is seriously reduced by lack of appropriate management of traffic and parking.

Table 15: Greater Mumbai –Road Network Inventory

Parameter	Description	Greater Mumbai
Categorisation of Roads by No. of Lanes	Single and Intermediate Lane	1.7
	Two Lane Undivided	26.7
	Three Lane and above Undvided	21.8
	Two Lane Divided	7.9
	Four Lane Divided	12.2
	Six Lane Divided	19.1
	Eight Lane Divided and above	10.7
	Total	100.0
Categorisation of Roads by ROW Range	ROW (0 - 15m)	25.0
	ROW (15 - 30m)	54.0
	ROW (> 30)	21.0
	Total	100
Categorisation of Roads by Pavement Condition	Good	47.0
	Satisfactory	37.0
	Poor	16.0
	Total	100
Categorisation of Roads by Divided or Undivided	Divided	50.0
	Undivided	50.0
	Total	100

Source: Comprehensive Transportation Study for Mumbai Metropolitan Region, 2008

While the number of vehicles multiplied 37 times over the last 50 years, the length of the Mumbai's road network only doubled (Philipp Rode, 2006). According to the Maharashtra government, the number of vehicles in Mumbai has shot up by 13 times in the past 26 years. Between 2005-06 and 2008-09, the number of motorised vehicles increased from 1.39 to 1.72 million. Mumbai roads have more cars/km than any other city in the world. In addition, they are used by vehicles registered in Thane, Panvel etc. Though the growth in the number of vehicles has declined since 2007, it is considerably higher than the 2.5 per cent growth in population and the less than 0.5 per cent increase in road space. This inevitably has led to severe congestion on the roads - traffic density during peak hours in some areas of the city is so high that the average speed drops down to as low as 6-8 kmph, especially in areas of Sion, Bandra and Dadar.

Table 16: Increase in Vehicles in Greater Mumbai, 2005-06 to 2008-09

	2005-06	20006-07	2007-08	20008-09
Total no of vehicles	13,93,637	15,33,816	16,31,837	17,15,044
% increase in vehicles	8.05%	9.13%	6.39%	5.10%

Source: MCGM

As the existing western corridor stretching from Bandra to Cuffe Parade was highly congested and the traffic volumes had reached saturation levels, it was proposed to

construct a north – south sea link, the West Island Freeway Project. The first phase of the project the Rajiv Gandhi Sea Link is a cable-stayed bridge with pre-stressed concrete viaduct approaches, which links Bandra and the western suburbs of Mumbai with Worli and central Mumbai. The sea link reduced travel time between Bandra and Worli from 45–60 minutes to 7 minutes. The link has an average daily traffic of around 37,500 vehicles per day, about half the pre-opening estimate of 70,000. The second phase, the Western Free Way Sea Link project, which will connect the Worli end of Rajiv Gandhi Sea Link to Nariman Point and further to Cuffe Parade, will have as estimated length of 12.75 km. The project is proposed to be executed in two phases: Phase A comprising the Worli-Haji Ali section and Phase B the Haji Ali-Nariman Point section. It is to be executed under build-operate-transfer with or without grants.

Figure 33: Rajiv Gandhi Sea Link

Source: tejwebworld.com

8.1.1. BEST

The major public bus service provider in the city is BEST. The total fleet as on April 30, 2010 was 4404 and turn out of buses was 96 per cent or 4208 buses. While the fleet has almost doubled in the last 18 years, its operational performance has remained stagnant over the last several years. From the table given below it is observed that from 2000 the average km per bus per day has declined marginally as has the average number of passengers per bus per day, despite a marginal increase in the number of passengers carried per day

Table 17: Operational Performance of BEST Bus System, 1990-91 to 2008-09

Sr. No.	Description	1990-91	2000-01	2005-06	2006-07	2007-08	2008-09
1.	Total fleet owned	2712	3430	3391	3404	3570	4037
2.	Average total vehicles on road per day	2143	3155	3075	3081	3090	3434
3.	Average capacity/buses	77	75	72	71	70	69
4.	Total Vehicle kms ((in hundred thousands)) p.a.	1634	2441	2401	2368	2264.29	2375.99
5.	Average kms per bus/day	209	212	214	211	200.2	189.6
6.	Occupancy ratio or load factor	73	55	58	61	67	74
7.	Number of passengers in a year ((in hundred thousands))	15037	15116	15102	15030	15530.22	15986.27
8.	Number of passengers carried per day ((in hundred thousands)	41.20	41.41	41.38	41.18	42.43	43.79
9.	Average No.of Passengers per bus/day	1922	1313	1346	1337	1373	1275
10.	Passenger earnings/year (in hundred thousands)	16560	64273	79458	79492	79536.47	82751.64
11.	Average earning per bus/ day (INR)	2117	5581	7079	7069	7052	6602

Source: BEST

Table 18: BEST- One Way Passenger Trips Originated Daily

Sr. no.	Year	One Way Passenger Trips (in hundred thousands)
1.	1970-71	23.48
2.	1980-81	42.95
3.	1990-91	41.20
4.	2000-01	41.41
5.	2005-06	41.38
6.	2006-07	41.18

Source : MMRDA Transport & Communications Division-August 08, Basic Transport & communication statistics for Mumbai Metropolitan Region

BEST has introduced four fast track corridors (Mantralaya to Mahim, Colaba to Sion, Sion to Thane and Mahim to Mira Road) to provide cheaper and faster public transport. The fast track service is a pre-cursor to Bus Rapid Transit System which the government wants to introduce in the near future. There are plans to create dedicated bus lanes on the Eastern and Western Express Highways.

The biggest problem cited by BEST is lack of sufficient buses. In 2008, BEST placed orders for 1000 buses under JNNURM, 36 of which had been received till November 2009. In 2010 1000 new buses will be added, with a capacity of 45,000 passengers which represents a 30 per cent addition to the BEST fleet. In addition, Navi Mumbai and Thane buses will also be plying between Mumbai and these cities. The question is whether these additional buses will be able to increase the number of bus trips/day (stagnant at 4,300,000 for last 25 years) to 5,500,000 per day. London with a population half of Mumbai and with three times more cars, achieved an increase of 40 per cent in bus trips with an addition of 1000 buses in a period of 5 years, thus visibly reducing traffic congestion. In Mumbai traffic congestion would decline if a significant part of the new fleet is deployed to cater to marginal car users, first class train users and multi trip commuters. However, the air-conditioned services as well the fast track bus services which cater to these groups, carry fewer passengers per day and earn less revenue than regular buses, in spite of higher ticket price, compared to regular buses (Table 19). This is because these services operate over fewer miles and have poor occupancy especially in the off peak direction. According to Mumbai Environmental Social Network, the solution is to permit the buses to use flyovers, the Rajiv Gandhi sea link and to offer high frequency (few stops) reliable services from residential areas to commercial areas in direct corridor routes using the bus priority lanes to be cordoned and supervised wherever road conditions permit. They also suggest that about 20 per cent of these buses be air-conditioned, but with fare only 30 per cent higher in peak direction and 15 per cent in off peak direction.

Table 19: Mumbai – Number of Persons People Using Regular, AC & Fast Track Buses

Item	Regular Buses		A.C. Buses		Current BRTS	
	Jan 08	Aug 08	Jan 08	Aug 08	Jan 08	Aug 08
No. Of Buses Running	3519	3812	37	31	11	15
No.of seats per bus*	45	45	45	45	47	47
No.of return trips/bus/day		10		4		3
No.of Kms/bus/day		211		127		177
Tickets/bus/day-nos.	1062	841	136	248	88	182
Revenue per bus per day-INR	5571	6102	4056	5132	2566	3295
Revenue per ticket-INR	5.24	7.26	29.85	20.73	29.24	18.08

Source: MNES

8.1.2. The Mumbai Urban Transport Project (MUTP) – Road Transport Component

MUTP was launched in 2003 with five implementing agencies (Government of Maharashtra, Indian Railways, MMRDA, MCGM, and BEST) with a commitment to improve the face of the city's public transport. The objectives of the road transport component were to reduce traffic congestion and increase vehicular speed on roads, increase the carrying capacity of BEST buses, ensure safe and smooth flow of vehicular and pedestrian traffic, improve the flow of passengers and vehicles in and around selected stations, minimise delays and accidents and reduce air pollution.

The key road components are the Jogeshwari-Vikhroli Link Road (JVLR) and the Santacruz-Chembur Link Road (SCLR) which will connect the Western Express Highway and Eastern Express Highway. Work JVLR and SCLR began in June 2003 and March 2008 respectively. While JVLR work is 95% complete, only 60% of the SCLR work has been completed. MUTP will also build flyovers/elevated roads, road over bridges, subways, bus corridors and new bus terminals/depots on key north-south and east-west links, provide 644 eco-friendly buses to BEST and install state-of-the-art traffic signal system in the island city (around 250 junctions).

8.2.Rail Transport

The main railroads follow the same paths as the highways. Two zonal railways, the Western Railway and the Central Railway operate the Mumbai Suburban Railway system. The fast corridors on Central Railway as well as Western Railway are shared for long distance and freight trains. Two pairs of lines (one local and other through) on the western line run northwards from Churchgate terminus parallel to the west coast up to Virar (60 km). Recently a fifth line (single track) has been introduced between Borivali and Mumbai Central, a distance of 30 km. In addition, a pair of lines between Andheri and Khar Road, connect with Central Railway at Matunga and Harbour line at Wadala Road. Beyond Virar and upto Dahanu Road (64 km) there is only a double track line which is used by both long distance and suburban trains. Western Railway Suburban has 36 suburban/long distance stations/terminii.

Central Railway suburban services run from Chhatrapati Shivaji Terminus (CST) to Kotputari (136 km) and Khopoli (115 km) in the north-east and south-east respectively. Central Railway has 47 suburban/long distance stations/terminii.

The Harbour Line suburban services extends from Mumbai CST to Panvel (46 km) on a double track line along the east side of the Island City to Raoli Junction where the line splits. One branch runs north-west to join the Western Railway main line at Bandra and further continues till Andheri.

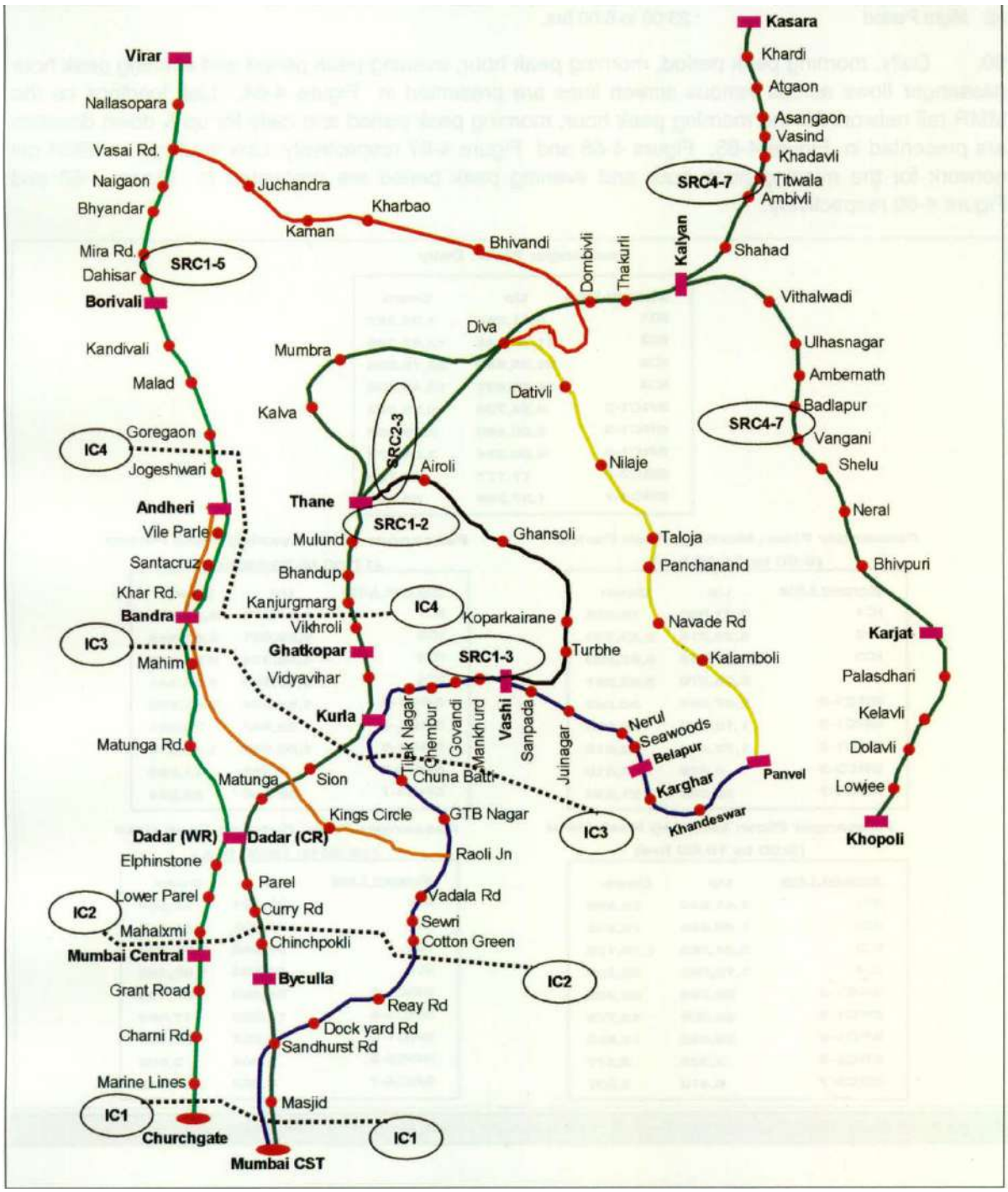
The other branch continues northwards to Kurla, where a connection is made with Central Railway main line, before turning east to Mankhurd and across Thane creek to Navi Mumbai upto Panvel. From CST to Wadala Road the line is exclusively for suburban traffic. North of Wadala the lines are shared with freight traffic to and from Mumbai docks.

The Mumbai Suburban Railway network caters to 6.3 million commuters daily. It has the highest passenger density in the world, ahead of even Tokyo and Seoul. More than half of the total daily passenger trips on Indian Railways are performed on Mumbai Suburban Railway system. The Western Railway operates 913 suburban services (up and down) per week day over the 124 km route between Churchgate and Virar, whereas Central Railway operates 1186 suburban services (up and down) per week day over the 280 km route between Mumbai CST and Kotputari, Khopoli, Panvel and Andheri. Average weekday suburban rail travel demand is estimated at 15 million passenger km in 2005, at an average rail journey length of 26 km. The number of weekday passenger trips is estimated at seven million.

Traffic on the suburban rail is growing differentially on different parts of the network. Lines on the Western Railway from Churchgate to Virar have a very low growth (0.65 per cent per annum). This is mainly due to the supply crunch. On the other hand, the network operated by the Central Railway is more diverse and has many under-utilised sections. Therefore, it has been growing at a higher rate of 2.65 per cent per annum.

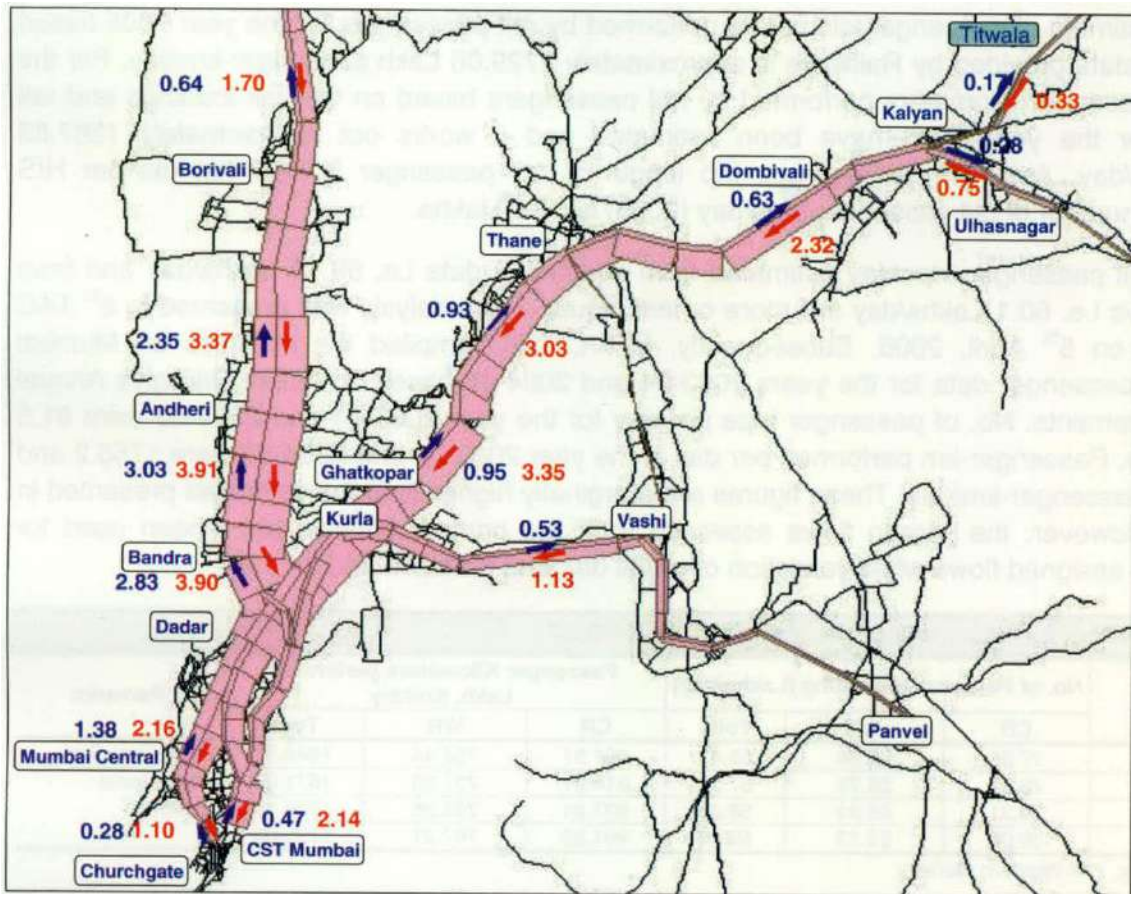
The remarkable attribute of the suburban rail system is the low fares compared to any other transit system in the world. However this low cost comes with a severe penalty. There are 10-12 casualties per day and 4,700 passengers traveling per 9-car train rake during peak hours, as against the rated carrying capacity of 1,700. This has resulted in, what is known as, super dense crush load of 14-16 standing passengers per square metre of floor space! There is thus an urgent need to augment the suburban rail system.

Figure 34: Suburban Rail Network



Source: MMRDA 2008

Figure 35: Mumbai Suburban Train Passengers
(Peak Period – 6.00 am to 11.00 am)



Source: MMRDA, 2008

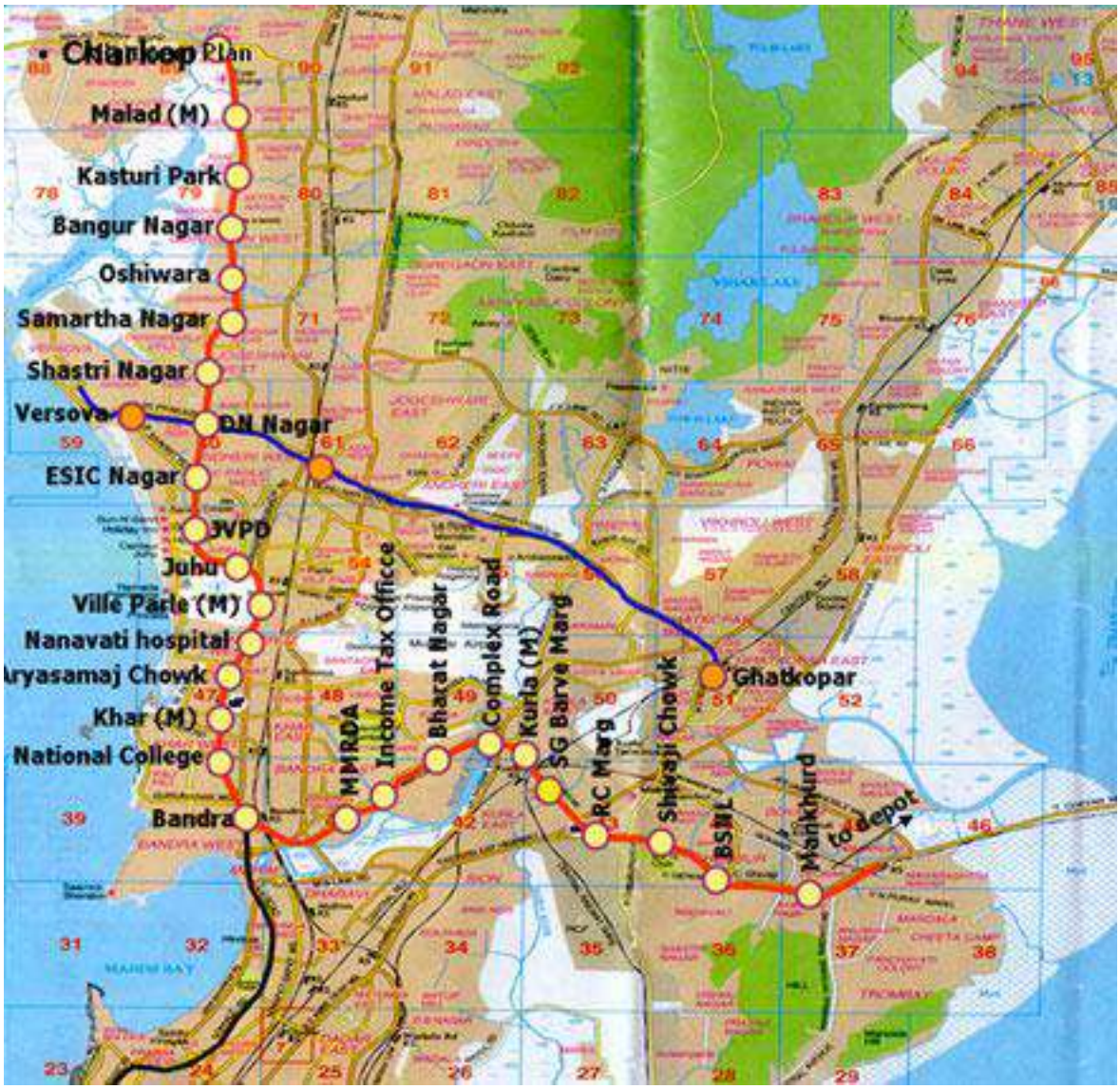
8.2.1. MUTP – Rail Transport Component

The objective of the rail component of the MUTP project is to increase the carrying capacity of suburban trains by 35 per cent. This is being achieved by adding a pair of lines between Borivali and Virar; the fifth and sixth lines between Kurla and Thane and the fifth line between Mahim and Borivali. A higher frequency of train services in the Virar-Dahanu Road is planned by widening of track centres to enable running of EMU services on this section. Segregation of through and suburban trains in the Borivali to Mumbai Central and Thane to Kurla sections is to be undertaken. Reduction in journey time and improved punctuality is being implemented by introducing 12 car rakes instead of 9 car rakes. The city has already received 94 new 12-car rakes. Another 35, at an average of three a month, are expected to be added by June 2011. From 2005-6 to July 31, 2010, the number of 12-car services increased from 435 to 788 on the Western Railway from 218 to 577 on the Central Railway, and from 468 to 566 on the Harbour Branch. Western Railway has also been running twelve 15-car services a day since 2009-10.

8.2.2. Mumbai Metro Project

The main objective of the metro project is to provide a rail based mass transit connectivity to people within an approach distance of 1 to 2 km and to serve the areas not connected by the existing suburban rail system. The project is to be implemented in three phases over a period of 25 years. The metro is also gearing to become Asia's first Green Metro right from the construction stage. With a strong focus on environment, the project will only use technology that is environment-friendly. An environment impact assessment has been undertaken and the feasibility for LEED certification is being explored.

Figure 36: Mumbai Metro Project



Source: MMRDA

Table 20: Mumbai Metro Project

Phase	Time Line	Distance (km)
I	2006 – 2011	62.68
Versova - Andheri – Ghatkopar		11.07
Colaba - Bandra – Charkop		38.24
Bandra - Kurla – Mankhurd		13.37
II	2011 – 2016	19.9
Charkop - Dahisar		7.5
Ghatkopar – Mulund		12.4
III	2016 – 2021	62.8
BKC - Kanjur Marg via Airport		19.5
Andheri(E) - Dahisar(E)		18
Hutatma Chowk – Ghatkopar		21.8
Sewri – Prabhadevi		3.5
Total Length	2006-2021	146.5

Currently the Versova – Andheri - Ghatkopar corridor is under construction. This section will provide east-west rail based connectivity to central and western suburbs. The journey time between Versova and Ghatkopar will be reduced from 71 minutes to 21 minutes, and it will provide rail based access to the MIDC, SEEPZ and commercial establishments in the suburbs. Construction of this corridor is scheduled to be completed by mid 2011.

Figure 37: Versova – Andheri – Ghatkopar Metro Project Corridor

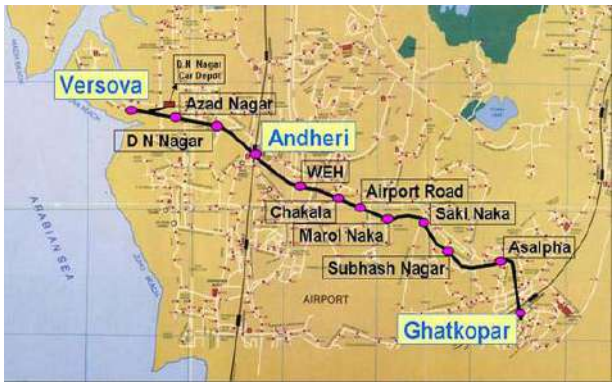


Figure 38:Metro Project under Construction

Source: MMRDA Source:skyscrapercity.com

8.2.2. Monorail Project

Considering the increase in population, increased travel demand and narrow road networks running through congested structures, there is a need of a transport system which will occupy less space as well as reduce travel time. In this context the Mono Rail system is currently being implemented by MMRDA. The objective is to support the public rapid transit system such as suburban rail system and metro rail system, to cover areas not serviced by them and areas where widening of roads is not possible due to structures on either side.

The monorail system is a light weight system which requires 1.00 m wide space (the space of a footpath) as it rests on a single pillar of height 6.5 m without disturbing the existing traffic. As compared to other systems the monorail produces less noise and is eco-friendly (it will reportedly save 200 tons of CO_2 per day) and hence easily acceptable in dense residential locales.

Figure 39: The Mumbai Monorail Project

Source: MMRDA

Source: news.inchembur.com

The project is to be implemented in two phases. Phase 1 is the section from Wadala to Chembur, a length of 8.26 km along which will be 7 stations. Phase 2 is the corridor from Wadala to Jacob Circle, a length of 11.28 km along which will be 11 stations. The fully air-conditioned system will run four-car trains. The average speed will be 30 km per hour and frequency of service every five minutes. The fare

would range between Rs 8 and Rs 20. Initially 15 sets of trains of four-car configuration will operate on the system from 5 a.m. to midnight with a carrying capacity of 568 passengers. Later six-car trains with carrying capacity of 850 passengers are to be introduced.. The first phase of the project is scheduled to be completed by December 2010 and the second phase by mid 2011.

8.3. Water Transport

The 135 year old Mumbai Port has been the principal gateway of the country for well over a century. It is situated almost midway along the west coast of India and is gifted with a natural harbour. In 2008-09 Mumbai Port handled 310.6 million tons of cargo, thereby catering to about 11 per cent of the total sea borne traffic handled by major ports of India in terms of volume. It accounts for about 20 per cent of Petroleum, Oil and Lubricants (POL) traffic and 21 per cent of general traffic handled by the major ports. 52.4 million tons of traffic was handled in 2006-7. There has been a rise in POL and Iron and Steel traffic is recent years. Growth of iron and steel imports has been fuelled by the needs of the growing manufacturing sector of Western India which is not served by JNPT. Container traffic has been decreasing since the last decade. The decline of Mumbai port has been due to the increasing trend of containerisation of break-bulk cargo. The focus in Mumbai Port therefore is on building infrastructure for handling break and break-bulk cargoes. The present draft of 9.2 m is however, not adequate for larger vessels to enter. It is now planned to utilise the harbour wall by increasing the draft from 8.5 m to at least 10 m. by dredging the rocky surface of the seabed.

The port contains three enclosed wet docks namely Indira, Prince's and Victoria Docks which together have 45 berths. In addition, for handling crude and petroleum products, there are four jetties at Jawahar Dweep, an island in the Mumbai harbour. Chemicals and other related products are handled at a jetty at Pir Pau. The port also includes Mazagaon Dock Limited. Taken over by the government in 1960, it is the principal builder of warships, submarines and offshore platforms. It is the largest shipyard in India and employs over 10,000 workers. There are three slipways, of which two are capable of handling ships upto 27,000 dwt, while the third has a capacity of 16,000 dwt. There are, in addition, two dry docks.

Besides the wet docks, there are, along the harbour front, a number of 'bunders', or open wharves and basins where the traffic carried by sailing vessels is handled. These bunders have extensive facilities for loading, unloading and storing cargo and have an aggregate quayage of 12,500 meters. There are also various container freight stations, empty container yards and warehouses, which, together with the docks' own storage area, provide a total of 32 hectares of covered storage area and 17.5 hectares of open storage area. In addition, there are 13000 slots for containers.

The main constraint at Mumbai Port is the limitation posed on the size of vessels due to the enclosed dock system with age-old lock gates. While an offshore

container terminal (estimated cost INR 10,000 million/US$ 216.36 million), is one option for overcoming constraints, deepening of the harbour wall berths is also being explored.

The proposed plans for Mumbai Port include the construction of two off-shore container terminals for handling vessels of 6000 TEU capacity, which will increase the port's cargo handling capacity to 10 million tonnes per annum. It is also proposed to upgrade four harbour wall berths at Indira Dock to handle large and deep drafted vessels. This will increase the cargo handling capacity by 7 million tons per annum. An additional berth is being planned at Pir Pau for handling chemicals and specialized grades of POL to increase the port's cargo handling capacity by 2 million tons. A 5th oil berth is proposed at Jawahar Dweep to increase the crude oil handling capacity by 15 MTPA. In addition, an international standard cruise terminal in being planned near the Gateway of India.

To alleviate the problem of traffic congestion in Mumbai, a project for providing water transport from Borivali to Nariman Point, along the west coast of the city is expected to commence from October 2010. The project is being implemented by Maharashtra State Road Development Corporation (MSRDC). The first six terminals will be at Borivili, Marve, Versova, Juhu, Bandra and Nariman Point. In the initial phase seven cataramans and five hovercraft will be used which eventually will be increased to 20 vessels. The service is expected to be used by 25,000 to 30,000 passengers every day. As per the blueprint finalized by MDRDC, the average travel time between Nariman Point and Borivili would be 35 to 40 minutes and the cost of tickets between the two jetties will cost INR 50 (US$ 1.08) to INR 150 (US$ 3.25) depending upon the vessels' speed. Currently a one-way journey on the Rajiv Gandhi sea-link costs INR 50 (US$ 1.08), while a two-way pass is INR 75(US$ 1.62). In addition to alleviating congestion on the roads, the project is expected to reduce pollution and fuel consumption.

Figure 40: Mumbai City Water Transport Project

Source: The Times of India

8.2.4. Air Transport

Mumbai has two airports-The Chattrapatti Shivaji International Airport and Santa Cruz Domestic Airport which are located in the heart of the city about 4 km apart. The airports are saturated. They handled about 15.3 million international passengers and 8.1 million domestic passengers as well as 379 thousand tons of international cargo and 151 thousand tons of domestic cargo in 2008-09. There are up to 45 landings and takeoffs per hour. Total aircraft movements handled (international and domestic) increased by 2.1 per cent from in April 2009-April 2010. Domestic aircraft movements increased by 6.7 per cent during the same period.

Because of heavy traffic the Airport Authority of India (AAI) is handing over 24.28 hectares of land for modernization. AAI has decided to increase the length of the runway to 7,500 ft and install an Instrument Landing system and Simple Approach Lightning System.

As Mumbai's current airport is operating to its capacity and there is no scope of any further expansion, a second airport is being proposed Navi Mumbai on 1,140 hectares which will handle an additional 40 million passengers a year. It is to be executed through the public-private partnership route by forming a special purpose vehicle in which the City and Industrial Development Corporation of Maharashtra, the AAI and private sector companies will hold equity. The proposed airport, however, has been held up because of environmental concerns, including the destruction of 161.87 hectares of mangrove forest and changing the course of two rivers.

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9. Public Utilities and Service Amenities

9.1. Water Supply

From just 32 mld (million litres per day) from Vihar Lake in 1860 for Mumbai's then population of only 0.7million, the city currently receives 3600 mld of water from various schemes for the city's current population of over 13 million.

Table 21: Lakes Supplying Water to Mumbai

Lake	Total Storage Volume (m3)	Supply to city (mld)	Owner	Year Constructed	Number of dams	Dam material type(s)	Distance from City	Type of outlet works	Location for water Treatment
Vihar	38.018 MCM	110	MCGM	1860	1	Earthen with masonry overflow section	In city limits	12oomm MS	Powai
Tulsi	10.415 MCM	18	MCGM	1879	1	Earthen with masonry overflow section	In city limits	600mm CI	Tulsi
Tansa	184.600 MCM	487	MCGM	1925	1	Masonry Dam	110 Km	Multi gate Outlet well	Bhandup
Vaitarna	204.981 MCM	455	MCGM	1957	1	Pre-cooled concrete	120 Km	Multi gate Outlet well	Bhandup
Upper Vaitarna	350.720 MCM	635	GOM	1973	1	Concrete	160 Km		Bhandup
Bhatsa	957.100 MCM		GOM		1	Masonry Dam	100 Km	Lift from Pise Weir	I, II & III @ Panjarapur and IIIA + IIIB @ Bhandup
I		455		1981					
II		455		1989					
III		455		1996					
III A		350		2004					
III B		300		2007					
Total		3720*							

*Including 120 mld enroute supply to Thane, Bhiwandi and others

Source: MCGM

9.1.1. Distribution System

Mumbai receives its water supply from six lakes which are impounded by the construction of dams across rivers and valleys, two of which are located within the city limits. Till 1957 three lakes, Vihar, Tulsi and Tansa supplied water to the city. Tansa was the major source of water to Mumbai and the water pipelines ran along the Mumbai-Agra road. Since then three other lakes, Vaitarna, Upper Vaitarna and Bhatsa have been commissioned. The Bhatsa project, which has been implemented five phases, today accounts for 56 per cent of water supplied to the metropolis. Water is supplied by gravity through aqueducts which pass through a tunnel under the Ulhas estuary. All the lakes are dependent on monsoon rainfall to provide adequate water to the city throughout the year.

Water from the lakes is piped to water treatment plants. There are four water treatment plants. In Vihar and Tulsi lakes the treatment plants are located in situ. The largest plant is at Bhandup which was commissioned in 1980 and has a capacity of 1910 mld. It receives water from Tansa, Vaitarna, Upper Vaitarna and Phases IIIA and IIIB of Bhatsa lake. The Panjrapur treatment plant which was commissioned in 1987 and has a capacity of 1365 mld receives water from Bhatsa Phases I, II and III. The water from this lake is lifted from Pise weir and pumped to the Panjrapur treatment plant. The water is treated with pre-chlorination, alum-dosing, settling, filtration and post-chlorination before supplying to consumers. The filters are back flushed about every 24 to 36 hours. The back wash water from the Bhandup Complex (about 45 mld) is sent to ponds where the sediments are settled out and the water decanted off into the Vihar Lake. The backwash from Panjrapur (about 20 mld) is discharged in nullahs.

The treated water is stored in a Master Balancing Reservoir (MBR); MBRI l at Bhandup (246 mld) receives water from the Bhandup treatment plant, while the treated water from Panjrapur (123 mld) is pumped to MBR II at Yewai Hills. From the MBRs water is distributed to 28 service reservoirs; 8 in the Island City and 10 each in the eastern and western suburbs by a network of inlet mains. All service reservoirs are equipped with gas chlorinators but as these are hazardous, they are being converted into electro-chlorinators.

The service reservoirs supply water to consumers in different supply zones. Mumbai does not have adequate water supply for continuous service. The estimated current demand is 4,300 mld – a shortfall of 700 mld. The Hydraulics Department switches valves around the clock to allow different parts of the city access to water at different times of the day. The allowance of water is 135 liters/capita/day for planned areas and 45 liters/capita/day for slum areas. The duration during which water is supplied varies from 24-hours to 90 minutes depending on area of the zone, topography, type of consumers etc. The pressure in the distribution system is in the range of 1 to 1.5 kg/cm^2 during water supply hours.

As water supply through service reservoirs is intermittent contamination of water takes place due to infiltration of sewage into water mains. This happens where water lines run parallel to sewage pipes, through dirty pools of water, or are damaged, either within the building compounds or in the streets. Poor maintenance of overhead and underground tanks is another important cause of contamination.

A small percentage of the total water used in the city is from wells. The water from the wells is used for flushing, cleaning, car washing, gardening, etc. In view of prevailing water shortages, MCGM has provided INR 510 million (US$ 11.02 million) in the budget for 2010-11 for cleaning the 12,314 wells and bore-wells owned privately and by MCGM. The Corporation has also provided INR 210 million (US$ 4.54 million) for constructing new bore-wells. It is estimated that 10-15 per cent of water supply can be procured from underground sources. In view of the looming water crisis MCGM has prohibited burying of existing wells from January 2003. The

location of wells is being digitized with available subsoil details to understand the water scenario in each locality and identify the danger zones from groundwater extraction considerations.

Table 22: Distribution of Wells in Greater Mumbai

WARD	NO OF WELLS					Total No. of Wells
	Open	With trap Door	HCC Wells Tube wells	Tube Wells	Ring Wells	
1	2	3	4	5	6	7
A	10	2	78	28	28	146
B	2	12	22	2	0	38
C	33	0	375	14	0	422
D	34	1	271	59	63	428
E	12	1	49	76	9	147
FS	26	6	78	87	8	205
FN	16	4	26	68	3	117
GS	40	0	86	60	0	186
GN	30	4	71	24	293	422
TOTAL	203	30	1056	418	404	2111
HE	29	19	18	24	0	90
HW	47	9	32	212	3	303
KE	185	10	77	620	272	1164
KW	249	51	164	371	171	1006
PS	125	21	38	569	0	753
PN	279	31	81	371	0	762
RS	231	20	71	709	0	1031
RN	174	19	19	326	15	553
RC	405	21	103	838	4	1371
TOTAL	1724	201	603	4040	465	7033
L	87	28	12	237	14	378
ME	111	2	2	166	0	281
MW	86	8	12	276	2	384
N	143	0	62	453	0	658
S	190	1	52	460	1	704
T	76	0	95	594	0	765
TOTAL	693	39	235	2186	17	3170
GRAND TOTAL	2620	270	1894	6644	886	12314

Source: Public Health Department, MCGM

In year 2008-09 approximately 8,102,665 liters of water were used for fire fighting. 15 bore wells, 112 wells and 10 'lakes' from the Island City and 20 bore wells, 207 wells and 31 'lakes' from the Suburban District were used for the purpose. Lakes probably refer to shallow open wells. Thus a majority of the wells in Greater Mumbai are not available for fire fighting. The fire brigade proposes to use sea water in future wherever possible, due to shortage of available water.

9.1.2. Augmentation of Water Supply

It is anticipated that water demand will increase to around 4408 mld by 2011 and 4949 mld by 2021. To cater to the increased demand a number of projects are being undertaken.

9.1.2.1. Middle Vaitarna Water Supply Project

The Middle Vaitarna project is in progress and is likely to be completed in 2012. It will provide an additional 455 mld water to the city. The dam will submerge 3,473 hectares of land in the Vaitarna basin and people from eight villages will be displaced.

9.1.2.2. Gargai and Pinjal Projects

Feasibility studies and detailed engineering work is in progress for the Gargai and Pinjal projects which are projected to supply 455 mld and 865 mld of water to the city.

9.1.2.3. Recharging groundwater

Earlier, rainwater was the main source of water supply and it was collected in tanks like Mumba Devi, Manamala, Babula, Govalia, Gilder, Banganga, etc. These tanks are now in disuse. According to Groundwater Survey and Development Agency, the area occupied by phreatic aquifers is limited between the seacoast and hill ranges in Mumbai and scope for recharge from rainfall is limited. Rainwater harvesting by capturing runoff from the rooftops/terraces and surrounding surface water will increase ground water recharge. In October 2002, MCGM initiated recharging of groundwater by making it mandatory for new buildings, having a plot area of 1,000 sq metres to have rainwater harvesting facility. In 2007, the same provision became mandatory for buildings having a plot area of 300 sq metres and above. Records at the civic body's rainwater harvesting cell in June 2009 indicate that 1,651 buildings that have set up such a facility since 2002. MCGM has budgeted INR 660 million (US$ 14.25million) in 2010-11 for rainwater harvesting on priority basis in its properties.

There are many benefits of rainwater harvesting. The groundwater table will rise, water quality will improve, ingress of sea water can be prevented, storm water discharge as well as the load of sewerage treatment reduced thus controlling monsoon floods. Water from the deep aquifers can be drawn for non-drinking purposes. If used for toilet flushing (50 lpcd) and cleaning (10 lpcd), the load on piped water supply will come down to 50% and the same water supply can cater to double the population.

9.1.2.4. Water recycling systems

Grey water comprises 50-80 per cent of residential waste water. This wastewater can be disinfected and reused for non potable purposes. Recycling grey water is already a norm in US, UK, parts of Europe, Singapore and Australia. Use of recycled water will bring down the demand for municipal water and reduce the burden on the existing sewerage network. On June 23, 2010 the law committee of the MCGM unanimously approved by-laws making recycling of grey water mandatory for housing premises with an area of more than 2,000 square meters, or premises that have more than 60 dwellings. The rule will also be applicable for all those buildings, societies and townships where the daily municipal water consumption is above 60,000 liters. It also applies to all new constructions as well as existing structures where the above criteria are applicable and have adequate space to create the wastewater collection and recycling plant. The aim is to limit the usage of municipal water only for potable purposes and save at least 200 million litres of water daily. The by-laws will have to be put before the civic general body meeting before being incorporated as a law, a process that will take about two months. In addition MCGM is setting up two recycling plants that will help recycle 250 million litres of water every day for non-potable purposes. The Ghatkopar plant will have a recycling capacity of 150 mld and the Bhandup complex will have a capacity of 100 mld. Though a budget provision of INR 52 million (US$ 1.12 million) has been made, it has been decided to implement the programme on Design, Build, Own, Operate and Transfer basis.

Some large residential complexes, hotels and industrial units have already installed a private sewage treatment plant on their property. For example, Chhatrapati Shivaji Terminus of the Central Railway set up a water recycling plant of 0.2 million litre capacity in 1999. The operational cost of the plant is INR 10 (US$ 0.22) per kilolitre which is less than the commercial water charges of INR 18 (US$ 0.39). The recycled water is used for cleaning concrete aprons of the railway platforms thus saving potable water.

9.2. Storm Water Drainage

The Storm Water Drainage (SWD) system of Mumbai comprises a hierarchical network of roadside surface drains (about 2000 km length, mainly in the suburbs), underground drains and laterals (about 440 km length in the Island city area), major and minor channels (200 km and 87 km length, respectively) roadside drains, dhapa drains and other water entrances (totaling 3,032 km) and 186 outfalls, which discharge all the surface runoff into rivers and the Arabian Sea. The system was designed for a rainfall intensity of 25mm per hour, at low tide, with run-off coefficient of 0.5. In the Island City, the storm water system is mostly underground whereas in the suburbs, they are open.

Though there are separate systems for disposal of sewage and storm water, there are inter-connections through which storm water is discharged into the sewerage network and vice-versa. Storm drains receive about 40 per cent of sewage from the city, either by direct discharge/overflow from sewers or by drainage across the ground. A number of industries also discharge effluents directly into the drains.

Table 23: Storm Water Drain Network

Type of drain	Island City	Eastern Suburbs	Western Suburbs	Total length (Kms)
Major nullah width > 1.5m	8.545	90.200	101.509	200.254
Minor nullah width < 1.5m	20.762	66.400	42.104	129.266
Arch/Box drains	59.20	40.00	51.93	151.13
Roadside open drains	20.00	669.48	1297.50	1986.98
Closed pipes or dhapa drains	443,180	36.200	86.031	565.411
No of water entrances	27893	609	1706	30208

Storm water is drained into the sea/creek/harbour through various outfalls. Of the 186 outfalls, 107 major outfalls in city drain to the Arabian Sea directly, four at Mahim creek and four at Mahul creek. There are 29 outfalls in western suburbs draining directly into the sea while 14 drain into Mithi River, which ultimately joins Mahim creek. The outfall levels range from -2.0 meters GTS to 3.5 meters GTS (22.4 to 28 meters Town Hall datum (THD). 45 outfalls are below mean sea level, 135 are above mean sea level but below high tide level and 6 outfalls are above high tide level.. During monsoon when heavy rains synchronize with high tide, the outfalls get blocked, causing inundation. The inventory of storm water drains is given below.

Table 24: Storm Water Drain Outfalls

Outfall	Island City	Eastern Suburbs	Western Suburbs	Total
Discharge in				
Arabian Sea	107	29	-	136
Mahim Creek	4	14	8	26
Mahul Creek	4	-	6	10
Thane Creek	-	-	14	14
Total				186

Figure 41: Mumbai City - Marine Outfalls

Source: Fact Finding Committee in Mumbai Floods, 2006

A master plan for augmentation of the SWD system, popularly known as the BRIMSTOWAD Report was prepared in 1993 to minimise the problem of flooding. Major deficiencies of the existing system identified were:

1. Due to flat gradients the drains are affected by tides.
2. The system is heavily silted.
3. Major outfalls discharge much below mean sea level.
4. Storm water drains discharge rain water directly by gravity through outfalls as floodgates have been provided in only three of the 45 outfalls. Falls discharge below mean sea level, tidal control is only at 3 places.
5. Capacity of drains inadequate for rainfall of 25 mm/hr
6. Numerous obstructions in the larger drains due to siphons and other utility services.
7. Poor workmanship and lack of attention to repairs when the drains are punctured by utility service providers.
8. Gullies are poorly placed and often not very effective.
9. Poor structural conditions.

In accordance with the recommendations of the Fact Finding Committee (under the Chairmanship of Shri Madhavrao Chitale) appointed by the Government of Maharashtra after the 26 July 2005 floods, and the BRIMSTOWAD Report, the following measures are being taken by the MCGM:

i. The SWD system is being designed for rainfall of 50 mm/hour with run-off coefficient of one i.e. the system is being augmented four times.
ii. Since 2006, the SWD system is being cleaned/desilted to the bottom-most level.
iii. Automated rain gauges have been installed at 35 locations.
iv. Widening, deepening and training of major nullahs
v. Rehabilitation of old arch/box drains, particularly in the Island City.
vi. Installation of storm water pumping stations at Haji Ali, Love Grove, Cleaveland Bunder, Irla (Vile Parle West), Britannia (Reay Road), Guzder Bandh (Santa Cruz West), Mogra nullah (Andheri West) and Mahul Creek. In addition, 196 smaller pumps have been provided at 189 locations on storm water lines to overcome invert problems and flat gradients.

Every year, MCGM ensures that the city's clogged drains are cleared before the monsoon. The civic body spends over INR 500 million (US$ 10.80 million) for widening and desilting of drains. 1,26,000 cubic meters of silt in the Island City, 2,22,500 cubic meters of silt in the Western Suburbs and 1,39,000 cubic meters of silt in the Eastern Suburbs have to be removed before the monsoon. This is a complex task as the nullahs fall under the purview of multiple agencies such as MMRDA, Public Works Department, Railways, Mumbai Port Trust and Airport Authority. In addition, as most minor nullahs are in the interior, it is difficult to place machinery at these spots. These nullahs are therefore cleaned manually at the ward level.

9.3. Sewerage

The sewerage system was introduced in the city after the first piped water supply from Vihar Lake was established in 1860. At that time, the sewage was simply discharged into the harbour at ebb tide. The first marine outfall was constructed at Love Grove in 1880. As the city expanded, the system developed further and, before Second World War, the Dadar sewage treatment plant was constructed. By 1979, almost 90 per cent of the city area was covered under the marine outflow system but only 40-50 per cent of the suburbs were covered. However, this marine outflow system was slowly phased out due to aging, and a new system implemented to replace it.

Table 25: Chronology of Development of Sewerage System in Greater Mumbai

Zone	First Sewered in	1979 Pump Stations	2005 Pump Stations
Colaba	1860	2 + 9 ejector stations	6
Worli	1860	8 + 2 ejector stations	16
Bandra	1900 – 1940	13	16
Versova	1959	1	2
Malad	1971	1	6
Bhandup	Post 1979	None	3 (+2 private)
Ghatkopar	1950s	3	3 (+2 private)

Currently, Mumbai has a two-tier sewerage system. One is the underground sewerage system that discharges about 3.5 km into the sea. The other is the surface system which is present in the suburbs and which discharges directly into the sea right at the sea shore. All non-slum population is provided with basic sanitation facilities and 80 per cent of them are provided with underground sewerage network whereas only 65 per cent of the slum population is provided with basic sanitation facilities of toilet blocks and septic tanks. Only 2 per cent of slum population is covered under pipe sewered network.

The collection and disposal of waste water and sewage in Mumbai is divided into seven zones, viz., Colaba, Worli, Bandra, Versova, Malad, Bhandup and Ghatkopar. The sewerage network, over 1,400 km, comprises 46 satellite pumping stations and seven major pumping stations, one for each zone, each with their own sewage collection and treatment system. Sewage is collected in sewer lines through gravity and conveyed to satellite pumping stations. From here it is pumped to the main sewage pumping station (SPS). The SPS sends untreated sewage to the sewage treatment plant of a zone, for treatment and final disposal into the sea. The treatment plant at Malad is a very primitive plant as it can remove only flotsam and grit. Of the 6 full-fledged treatment plants, three (Colaba, Love Grove and Bandra) have marine outfalls. Here the sewage is treated and is discharged 3.5 km from the coast. The plants at Versova, Bhandup and Ghatkopar have man-made lagoons which are huge holding ponds where the sewage is

accommodated for 120 hours and atmospheric oxygen is dissolved into the sewage with the help of aerators to improve their environmental quality so that they do not harm the ecological system. There are 54,000 manholes for maintenance of 1,400km long network of the sewerage system.

The underground drainage pipes of the sewerage system in Mumbai are more than 100 years old and needs renovation. In congested parts, the sewerage lines and water pipelines run together and leakages contaminate drinking water. The unplanned and unauthorised growth of the city makes it difficult and, at times, impossible to replace old sewerage lines. The problem of sewer lines of small diameters getting choked due to solid waste and silt entering them is rampant. The result is that instead of getting drained, sewage overflows on to the surface.

Table 26: Area and Population Serviced by Sewerage Zones in Greater Mumbai

Zone	Population (mn)	Area (sq km)
Colaba	0.2	6
Worli	2	39
Bandra	3.4	77
Versova	0.95	21
Malad	2.85	115
Bhandup	1.2	43
Ghatkopar	2	77

What complicates the already overloaded sewerage system is the presence of a large percentage of the city's population that has no access to it in the first place. While toilets in buildings and establishments are connected to the underground sewerage system, this facility is not available to the slum dwellers. Nearly 60 per cent of Mumbai's population of 13million, i.e., about 7.8 million people live in slums, of which 50 per cent live in authorised slums with some toilet facility. The other 50 per cent i.e. about 4 million slum residents have no choice but to ease themselves in the open spaces, along roads, highways, railway tracks, parks, playgrounds, open plots and beaches. During monsoons, this excreta flows through open drains and nallas into the storm water drains and gets discharged right near the coast.

MCGM, with financial support from the World Bank, is implementing an integrated water supply and sewerage project and has prepared a sewerage master plan till 2025. According to a recent paper, Sewerage operations of MCGM, by P R Sanglikar, deputy municipal commissioner, MCGM, the master plan is a five-phase programme (2005-2025) with a total cost of INR 55,704 million (US$ 1203.11 million), of which INR 39,451.5 million (US$ 852.08 million) is for sewerage work and INR 16,252.5 million (US$ 351.03) for water supply. The project includes the development of demographic forecasts and the construction of a hydraulic model for each of the seven zones of the Mumbai sewerage system. A range of options for collection, transfer, treatment and

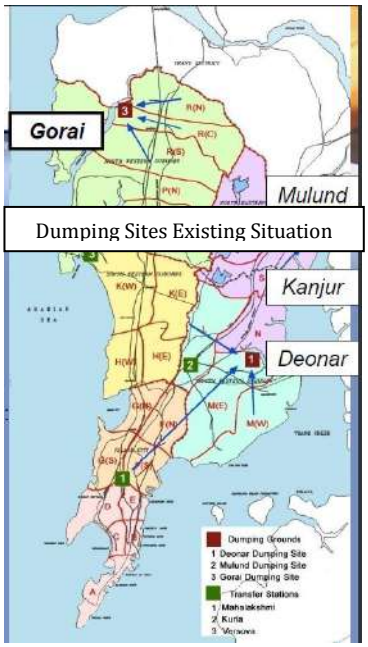
discharge wastewater flows is being developed to allow the optimum solution to be selected. Treatment processes are being optimised for local conditions, including climate, land take, environmental impact and slum sanitation.

Of the 3600 million litres of water distributed daily in the city, 80 per cent turns into sewage water. Of the 2,880 mld of sewage generated, primary treatment is given to 1,600 mld. 350 mld is treated for non-potable purposes by commercial and bulk users. The first sewage treatment project was undertaken in 1972 by Air India at its building at Nariman Point. The plant processed 0.225 mld and the water was used the water for air-conditioners and toilets. Oberoi Hotel (0.30 mld), Mafatlal Building (0.125 mld) and State Bank of India (0.125 mld) commissioned sewage treatment projects in 1974. Botanical Garden in Colaba, Rashtriya Chemical Fertilisers and Bakhtawar Towers also recycle sewage water. MCGM is planning to make it mandatory for large complexes over 19,180 m^2 to set up sewage water treatment plants.

9.4. Solid Waste Management

The approximate quantity of solid waste generated in Mumbai is over 8500 metric tons per day (mtpd). Of this, approximately 45 per cent is biodegradable waste, 20 per cent recyclable materials, 12 per cent inert matter and 23.5 per cent construction waste and silt. Citizens on an average generate 475 gm of garbage per day. This comprises 52 per cent wet organic matter, 13 per cent dry organic matter, 15 per cent tons sand and earth and 10 per cent paper and recyclables.(Environment Status of Brihanmumbai, 2008-09)

Figure 42: Mumbai – Landfill sites



Source: Rajeev AS, 2010

Approximately 6500 metric tons of refuse and 2,500 tons of debris and silt are collected daily from 3654 collection centres and 26 dry waste segregation centres. The waste is transferred by 1160 vehicles to four transfer stations at Mahalaxmi, Versova, Gorai and Kurla. The refuse is taken to 2 dumping grounds namely, Deonar which has an area of 132 hectares and receives 4,800 metric tons per day (mtpd) of garbage, Mulund with an area of 25 hectares and receives 700 mtpd of garbage. A third dumping ground is being developed at Kanjur with a garbage capacity of 6,000 mtpd and an area of 141.77 hectares at a cost of INR 200 million (US$ 4.35 million). Decentralised treatment system is limited to 100/150 tons per day.

Earlier the waste was simply dumped and levelled. The project work of scientific treatment/processing of garbage at the dumping grounds has been initiated through Pubic-Private-Partnership and it is being part funded through the JNNURM fund. At the Deonar dumping ground 65 hectares are being scientifically closed and 2000 tons per day of waste is being composted in a 55 hectare area. A sanitary landfill and emergency sanitary landfill are other project components. At Mulund a bio-methanisation project comprising 5 units of 100 mtpd each has been initiated on 4 hectares. The Kanjur site will be developed scientifically and have waste processing technology, composting, bio-methanisation, pelletisation and waste-to-energy plant. The Gorai disposal site, spread over an area of 19.6 hectares, was operational since 1972 and received up to 1,200 tons per day of solid waste. It was scientifically closed on December 31, 2007. The site contained about 2.34 million of tons of waste up to an average height of 26 meters when it was handed over to the contractor in May 2007. Methane emissions will be captured from 40 landfill gas collection wells and destroyed by anaerobic decomposition of solid waste to generate energy. The waste will be isolated from coastal water bodies and the area will be converted into a green belt. The project will not only reduce the carbon footprint of the city but will also generate 1.2 million Certified Emission Reductions over a period of 10 years.

Figure 43: Gorai Dumping Ground –Eco-friendly Landfill Closure Project

Leveling of waste *Reformation of Slope* *Capping*

Landfill after closure

9.4.1. Zero Garbage Project

In an attempt to achieve zero garbage status the Corporation has initiated segregating, recycling and composting of non-biodegradable and biodegradable waste. Vermiculture within residential complexes is being encouraged, vegetable market waste is being diverted to gardens for vermiculture (currently 43 metric tons per day of market waste is being disposed at 24 sites) and rag pickers are being employed for house to house collection. The project includes the segregation of dry and wet waste for which MCGM has provided separate bins, bio-degradable bags and separate ward wise vehicles for dry waste collection.

9.4.2. Bio-Medical Waste

A centralized bio-medical waste processing plant with a capacity of 10 metric tons per day has been set up near the Deonar dumping site.

9.4.3. e-Waste

According to a survey conducted by IRG Systems Management Pvt Ltd on behalf of the state reveals that Mumbai tops the list of Indian cities generating the most hazardous e-waste {11017.1 tons per annum (tpa)} beating Delhi (9730.3 tpa) and tech-hubs like Bangalore (4648.4 tpa), Pune (2584.2 tpa) and Hyderabad (2833.5 tpa) by a wide margin. Currently, processing of e-waste is being done by hundreds of small establishments leading to the emissions of hazardous dioxins and heavy metals. The main areas for reprocessing are Saki Naka, Safed and Wire Lane in Andheri, Dharavi and Shastri Nagar in Mahim, Sonarpur in Grant Road, Don Taki in Kamathipura, Kutubmandal and Masarani lane in Kurla, Proctor Road, Tara Temple Lane, S V Road and Chor Bazaar in Lamington Road and Mankhurd. The process of scientifically disposal of e-waste has begun. A landfill site is being developed at Vasai-Virar. In addition MMRDA has identified five sites at Taloja, Shil Phata near Navi Mumbai, Bhiwandi and Ambernath-Ulhasnagar for e-waste disposal.

9.4.4. Advanced Locality Management (ALM)

The ALM programme was initiated in 1997 by MCGM with the main objective of mobilizing citizens in a participative approach in setting up a system for dealing with the problem of solid waste management in an environmental friendly manner. The focus of the initiative was decided as 'waste minimization' and 'segregation of waste at source'. Wet waste is segregated at household level and composted locally in any available area, planters, etc., and sweepers or rag pickers take dry waste away. Currently there are 780 ALMs and about 5 tonnes of biodegradable waste is composted per day. Thus approximately 25-30 tons of garbage per day is prevented from reaching the dump yards. An encouraging fact is that women run 80 per cent of the ALMs. MCGM has also established vermi-compost projects on its own, one each in the eastern and western suburbs respectively, to demonstrate to the citizens, the benefits of vermi-culture technology.

Organisation of the community, training and initiation is done jointly by residents and MCGM, and is initially funded by residents and the Corporation. At a later stage the activities are completely funded by the residents.

9.4.5. Slum Adoption Scheme

Because of the heterogeneous population in slums there is very little community involvement in solving the problem of disposal of solid waste. To keep slums of the city clean the Corporation provides necessary equipment to community-based organizations (CBO) at local locality level and it also takes care of the salaries of the slum cleaners for a period of three years. The amount provided by MCGM reduces gradually over a three year period. Then, the CBO is expected to raise INR 10.0 (US$ 0.22) per household for collection of segregated waste from house to house and for the maintenance of toilet blocks. The scheme has been so designed that by the end

of the third year, the CBO would be self- sufficient in managing services related to waste management and sanitation at the primary level.

9.4.6. Slum Sanitation Programme (SSP)

This is an innovative approach in providing toilet facilities to slum dwellers.The programme is implemented through strategic partnerships with other key stakeholders, each contributing with their comparative advantage to the process. MCGM provides the initial capital and creates the enabling environment to facilitate the participation of other stakeholders and to scale up, while the private/corporate sector, represented by construction agencies, has the technical knowledge to build toilet blocks. NGOs mobilize communities and facilitate their participation by building a bridge with the local government. The community of users are organized in CBOs who effectively act as end-service providers, taking charge of the management of the service and the full payment of utilities. Every family must contribute INR 500 (US$ 10.88) or individual adults must contribute INR 100 (US$ 2.18), whichever applicable, towards operation and maintenance. The money generated is used by the CBO to maintain their toilet, pay for electricity and water and pay cleaners and caretakers their monthly salary. Phase I of the SSP, implemented from 1997-2005, was initiated with financial aid from the World Bank. About 330 community toilet blocks with more than 5,100 toilet seats were constructed and handed over to community groups to use and maintain. The program is estimated to have benefited about 400,000 slum dwellers. Phase II of the SSP commenced in 2006. Its objective is to make available 35,000 toilets by 2011. MCGM has made a provision of INR 200 million (US$ 4.35 million) in 2010-11 towards the project. No upfront contribution from the slum dwellers is being collected. Once construction is complete, every family living in the area is issued a monthly pass costing between INR 10 (US$ 0.22) and INR 50 (US$ 1.09) depending on local conditions. If the head of the family is physically challenged, his family is issued a pass for free. A person who does not have a pass can use the facility by paying INR 1 (US$ 0.22).

9.4.7. Key Issues and Concerns

The total solid waste generation in Greater Mumbai is expected to reach about 10,000 mtpd by 2125. While MCGM is currently managing to collect and export a large proportion of the waste to the existing disposal sites, these sites are nearing their usable life. MCGM will need to identify additional disposal sites and adopt technology and mechanisms that ensure substantial reduction in quantity of waste to be land filled. An estimated 1,595 million tons of solid waste are uncollected or disposed of improperly each day. The illegal dumping and burning of such materials lead to the clogging of rain gutters and storm drains, as well as the release of toxic gases. The Corporation has attempted to create public awareness through advertisements, newspapers, television, etc. as a preventive/discouraging measure.

MCGM has appointed Nuisance Detectors Mukadams in each ward to check polluters.

Another significant concern is the substantial quantities of construction waste being generated by the continuous building activities throughout the city. It is estimated that only 25 per cent of such waste is being collected and transported to landfill sites (NRCUP & AIILSG, 2009). The remaining debris is often surreptitiously dumped in the numerous creeks that crisscross the city.

MCGM is resorting to mere dumping/land-filling at the disposal sites with very little localized treatment and disposal in the form of vermin composting and biogas generation

9.5. Education

Mumbai is a major centre of learning and education. The University of Mumbai was founded in 1857 as an affiliating and examining body patterned after the University of London. Although it still has numerous constituent colleges, the institution has also taken on teaching functions. Other important educational and research institutions include SNDT Women's University, Indian Institute of Technology, Bhabha Atomic Research Centre, Tata Institute of Fundamental Research, National Center for Software Technology and Tata Institute of Social Sciences. Haffkine Institute is an important centre for research in medicine and allied sciences.

Greater Mumbai has 6 medical colleges, 7 dental colleges, 36 engineering colleges, 85 Science, Arts and Commerce colleges, 9 law colleges, 15 colleges of applied arts, 3 media and 5 vocational institutes (www.collegesmumbai.com). These include both, government and private institutions.

The country has a mandate to provide free primary education, although parents pay for text books and school uniforms. MCGM imparts free primary education in eight different languages to approximately 388,976 students from Standards I to VII through 1,189 primary schools and 12,925 teachers. In addition the Corporation imparts Secondary Education to nearly 42,380 students in 40 secondary schools wherein 1,263 teachers are employed. There are 18 special schools where 889 differently abled children are studying. Apart from the syllabus prescribed by the State Government, vocational training is also imparted to these students to make them self-reliant, self-sufficient and independent. During the year 2009-10 three Junior Colleges of science were started in partnership with 'IITn's PACE" and "YUKTI" academy. 132 students from Municipal Schools were enrolled in these colleges. MCGM pays 50 per cent of the fees of these students. In addition, MCGM also supports private schools through various support programs.

MCGM provides free text books to students of Municipal schools from Standards I to VIII and during the current academic year has made a provision of INR 6,919,000 (US$ 150,543.95) for distributing free textbooks and reference books to students of

Standards IX and X. Uniforms, shoes, socks, school bags and flavoured milk are supplied free to all school students.

According to the data published in the White Paper by Praja Foundation, during the period January 2008 to March 2009 the number of dropouts students from Municipal schools across Mumbai was 33, 065. There is a higher school dropout rate among girls. Surveys conducted by NGOs Sahayog and Pratham reveal that the primary causes relate to accessibility to schools, affordability, course content and the absence of toilet facilities in the school premises (AIILSG, 2009). In an attempt to encourage girl students attending school regularly, MCGM is giving INR 1 (US$ 0.02) per day to girls as attendance allowance. Computer training is imparted to students from Standard V to X under the guidance of qualified computer teachers.

Table 27: Schools in Mumbai (2003-04 and 2007-08)

Sr No.	School Level	2003-04			2007-08		
		MCGM	Private	Total	MCGM	Private	Total
1.	1st to 7th*	1596*	477	2073	1612*	631	2243
	Secondary						
1	SSC	49	1235	1284	49	1299	1348
2	ICSE	-	42	42	-	52	52
3	CBSE	-	18	18	-	21	21
4	IB**	1	1	1	-	8	8

*MCGM and MCGM Aided Schools ** International Baccalaureate Board

(Source: AIILSG, 2009)

Due to the small number of secondary schools run by the civic body, there is an acute problem of providing education to the students completing their primary education. Secondary education in Mumbai is by and large being provided by the private sector (Table 27). Secondary schools in Mumbai offer certificates of four different School Boards namely SSC, ICSE, CBSE and the International Baccalaureate Board (IB). The rapid growth of IB schools shows that a larger number of children in Mumbai are opting for international level school education.

9.6. Health

Mumbai's birth and death rates are consistently declining even as the population has been on the upswing. However, the average life expectancy in Mumbai is lower than that it is elsewhere in the State and the country. The average life expectancy in Mumbai as of 2007 was 52.6 years for males and 58.1 for females with an overall life expectancy of 56.8 years while the country's average overall life expectancy was 63.7 years. (AIILSG, 2009)

Table28: Mumbai - Death toll due to major diseases 2007-08

Sr. No.	Disease	Death toll 2007	Death toll 2008	% increase 2007-08
1.	Heart Diseases	23,200	23,849	2.79
2.	Tuberculosis	9,850	9,930	0.81
3.	Cancer	6,112	6,682	9.32
4.	Pneumonia	4,102	4,352	6.09
5.	Respiratory Tract Infections	2,687	3,229	20.17

Source: MCGM

Heart diseases, commonly referred to as lifestyle diseases, are the top killers in the city and registered an increase of 2.8 per cent from 2007. Tuberculosis trailed behind by a huge margin followed by cancer and pneumonia. There were however 23,987 notified cases of tuberculosis in 2008. 1098 leprosy cases were recorded of which 847 were active cases.

Malaria is fast emerging as a major health risk in the city. Till 1980 there was no indigenous transfer of malaria in Mumbai. The parasite was brought into the city by people coming from other cities and towns, which led to sporadic incidence of the disease. Today the city has become a malarial hub. The epidemiological report of National Vector Borne Diseases Control Programme for the period between April 2009 and April 2010 shows a 55 per cent increase in positivity cases and another 15 per cent increase of falciparum malaria, the deadlier form of malaria. In the first 17 days of July, 2010 there were over 8,600 cases of malaria in the city. (Malathy Iyer, July 2010) Mumbai's health infrastructure, in both private and public sectors, is relatively better compared with other cities in the country. MCGM has started and maintains 18 general hospitals, a tuberculosis hospital, an infectious diseases hospital, an E.N.T. hospital, an eye hospital and a leprosy hospital. It runs three medical colleges and a dental college with under-graduate and post graduate training facilities. In addition, it runs 163 general dispensaries (including 4 Ayurvedic and 2 Unani), 26 maternity homes, 14 maternity wards attached to 14 general hospitals, 5 tuberculosis clinics, 5 clinics for sexually transmitted diseases, 23 post partum centres, 168 health posts and a drug-de-addiction centre. Currently there are 10,169 beds in municipal hospitals.

In April 2007 the Epidemiological Cell of the Public Health Department was established at Kasturba Hospital to control communicable diseases like dengue, leptospirosis, malaria, gastroenteritis etc.

Health infrastructure has not kept pace with the growing demand. Despite being cost-prohibitive compared with the government-administered facilities, the private sector plays a dominant role in public health service delivery. In fact, there are more privately-owned hospitals, nursing homes and dispensaries than those which are run by the government or by the MCGM. These private facilities get 80 per cent of

the total share in terms of household patronization. There are many contributing factors such as distance, cost and quality of health services offered. (AIILSG, 2009)

9.7. Fire Brigade

Started as a part-time function of the police, the fire protection function was first passed on to the Municipality on 1st April, 1887 as an obligatory function. Today, the Mumbai Fire Brigade is responsible for the provision of fire protection in the city as well as responding to building collapses, drowning cases, gas leakage, oil spillage, road and rail accidents, bird and animal rescues, fallen trees and taking appropriate action during natural calamities. In November 1998 the Mumbai Fire Brigade constituted a High Rise Inspection Cell to inspect high rise buildings as well as malls, multiplexes, commercial office buildings and industrial estate buildings and issue notices concerning rectification of their deficiencies with respect to fire prevention and life safety measures adopted by them.

The fire brigade is under the command of the Chief Fire Officer. Greater Mumbai is divided into six regions for operational purposes, each headed by a Deputy Chief Fire Officer. There are eleven Divisional Fire Officers in charge of mobilization, administration (city), administration (suburban), stores and workshop (city), stores and workshop (suburban), proposals highrise (city), proposals highrise (suburban), proposals headquarters, highrise (city), highrise (suburban), and one in charge of the six regions. The Divisions are further divided into 16 sub-divisions, each comprising a certain number of fire stations. The sub-division is headed by an Assistant Divisional Officer, while a Fire Station is managed by a Station Officer. Currently there are 33 fire stations in Greater Mumbai. An additional fire station is proposed at Mankhurd in the eastern suburbs.

Table 29: Fire Stations in Mumbai

Island City Area (15)	Western Suburbs (12)	Eastern Suburbs (6)
1. Colaba 2. Nariman Point 3. Fort 4. Indira Dock 5. Mandavi 6. Memon wada 7. Gowalia Tank 8. Byculla 9. Worli 10. Dadar 11. Shivaji Park 12. Wadala 13. Rawli Camp 14. Dharavi 15. Sewree	1. BKC 2. Bandra 3. Vile Parle 4. Andheri 5. Marol 6. Malad 7. Goregaon 8. Chincholi 9. Dindoshi 10. Kandivali 11. Borivali 12. Dahisar	1. Kurla Kamani 2. Chembur 3. Deonar 4. Vikhroli 5. Mulund 6. Gavanpada

The Brigade Control Room located at Byculla handles about 25 emergency calls besides ambulance calls every day and is responsible for emergency mobilization of about 2,700 personnel and more than 2000 appliances. The fire service department also maintains a state-of-the-art centralized training center at the Wadala Fire Station. The fire stations are equipped with specialized equipment/apparatus including firefighting and rescue vehicles, ambulances, breathing apparatus sets, chemical protective suits and Rescue Rocket Devices.

10. Environment

10.1. Pollution

In 1994, the Mumbai Municipal Corporation Act of 1888 was amended, in line with the provisions of the 74th Constitutional Amendment Act and the Maharashtra Government Ordinance making environmental protection and the promotion of ecology and urban forestry obligatory duties of local authorities. In fulfillment of these responsibilities, MCGM conducts regular monitoring of the city's air and water quality, as well as the state of Mumbai's water supply, sewage and solid waste management, traffic and transportation, and the impact of pollution on the public. The Environmental Status Report, published annually, gives an account of the condition of the environment and the city's environmental infrastructure.

10.1.1. Air Pollution

MCGM monitors the air pollutants sulphur dioxide (SO_2), nitrogen dioxide (NO_2), ammonia (NH_3), suspended particulate matter (SPM) and lead from six monitoring sites (Worli, Khar, Andheri, Bhandup, Borivali and Maravali) spread all over Mumbai.

Table 30: Mumbai – Ambient Air Quality at Fixed Monitoring Sites 2008, 2010

Site	SO_2 ($\mu g/m^3$)		NO_2 ($\mu g/m^3$)		NH_3 ($\mu g/m^3$)		SPM ($\mu g/m^3$)		Lead ($\mu g/m^3$)	
Worli	April 2008	March 2010	April 2008	March 2010	April 2008	March 2010	April 2008	March 2010	April 2008	March 2010
Khar	13	9	67	41	54	81	183	201	0.12	0.69
Andheri	12	9	84	47	58	47	252	250	0.17	0.13
Bhandup	13	12	86	53	66	82	263	227	0.16	0.10
Borivali	18	14	67	29	59	46	206	200	0.19	0.16
Maravali	16	16	89	65	265	293	389	603	0.31	0.34
CPCB standards	60	60	60	60	100	100	140	140	0.75	0.75

Source: Environmental Status Report, (2008,2010)

As observed in the above table, there has been an improvement in all air pollution parameters during the last two years. Levels of SO_2 and lead which were below Central Pollution Control Board (CPCB) air quality standards throughout the city in 2008 have declined further at all the sites with the exception of levels of lead at Khar, which though still within limits, have increased significantly. Levels of NO_2 and ammonia too have declined and are below CPCB standards at all sites except Maravali. However, SPM exceeded CPCB standards at all sites and has increased significantly at Maravali. It has also been reported that the vehicular emission load dropped from 413.31tons per day (tpd) in 2009 to 383.69 tpd in March 2010. This is despite the increase in the number of cars by 5.3% during the same period. Mumbai's vehicular emission load is much below Delhi's 1046 tons. However, Delhi

has nearly 450,000 vehicles, twice the number that Mumbai has. The improvement is attributed to increase in the number of vehicles which run on gaseous fuels like CNG and LPG. Of the 18,06,974 vehicles on the city roads today 1,63,548 run on CNG and LPG. Other factors contributing to the drop in pollution is the improvement in the quality of fuel (unleaded petrol and low sulphur diesel) and the fact that the average age of a vehicle has also decreased as more vehicles are being added to the fleet.

Air pollution levels are low during the monsoon and high during the winter season due to stable atmospheric conditions and temperature inversion. The reversal of the wind direction during winter to north/north-east from south/south-west also has an impact as majority of the industries are located in the north-eastern part of the city.

Transport, industrial and domestic emissions are the main sources of air pollution in Mumbai. The industry emission load has reduced considerably since 2001 due to closing of industries in the city. The overall emissions in the city from all sources have also reduced from 606.28 last year to 588.57 in March 2010.

The air pollution index has been calculated by giving weightage to three air pollutants, namely SO_2, NO_2 and SPM. The values range from 14% to 158%, with the higher values observed at all sites during winter and Maravali being the most polluted site.

10.1. 2. Water Pollution

Table 31: Coastal Water Quality of Mumbai, 2008-09

Location	PH	Turbidity in NTU	Conductivity in mhos/cm	D.O. ppm	BOD ppm	COD Ppm	SS ppm
Gateway of India	6.9-8.3	2.53	11310-66040	0.0-7.1	7.0-70.0	232.0	30.0
Nariman Point	6.3-8.2	0.32-8.42	12270-66250	0.0-5.7	7.0-68.0	64-320	296.0
Malabar Hill	7.0-8.2	0.2-9.74	9203-66020	1.1-5.1	7.0-58.0	64-380	58.0
Haji Ali	7.1-8.1	0.26-10.8	15610-66360	1.0-5.7	7.0-62.0	64-256	70.0
Worli Seaface	7.0-8.1	3.0	12370-65310	0.0-7.2	6.0-80.0	232	84.0
Shivaji Park	7.2-8.1	0.64-7.43	10570-66260	0.0-5.8	7.0-72.0	76-356	88.0
Juhu Beach	6.9-8.4	0.46-7.13	18810-65110	3.4-5.6	7.0-14.0	100-344	20.0
Versova Beach	7.0-8.1	4.25	18770-63660	3.0-7.3	6.0-16.0	260	32.0
Mithi River	7.0-7.8	17.8	268-55830	0.0-5.4	7.0-270.0	204	114.0

Source: MPCB

The coastal water quality is regularly monitored by MPCB. The present status of the coast and creek is alarming with respect to Dissolved Oxygen (DO), Bio-chemical Oxygen Demand (BOD) and organic pollution levels (Table 31).

However in recent years there has been some improvement - general turbidity has reduced and the quantity of dissolved oxygen has gone up. Quality of water within one kilometer of the coast has improved moderately and as a result the quantity and variety of fish has increased. The city has three marine outfalls at Colaba, Love Grove and Bandra with a capacity of 41.1 mld, 756.90 mld and 796.80 mld respectively. After preliminary treatment and aerated degritting the sewage is let into a tunnel and discharged 3.5 km from the coast. The outfalls have considerably reduced the existing pollution levels in the coastal areas along the Arabian Sea. At Versova, Bhandup and Ghatkopar man-made lagoons have been constructed where the sewage is accommodated for 120 hours and atmospheric oxygen is dissolved into the sewage with the help of aerators. The aerated lagoons reduce the BOD of wastewater by 75%-90% in 1.5 days to improve their environmental quality and protect the ecological system. The discharge quality of the major discharge at Versova does not meet MPCB norms and the Malad Creek further north is already saturated and has no further assimilative capacity.

The creeks and coast lines are polluted mainly because of non availability of sanitation facilities to slum dwellers which result in open defecation and waste water discharges.

Of the three fresh water lakes of Mumbai, Tulsi, Vihar and Powai, the first two have water of potable quality. Powai water is polluted due to domestic sewage, industrial waste discharge, silt etc. The lake is silted all along its southern boundary.

10.1.3. Noise Pollution

The conventional sources of noise pollution in Mumbai are vehicular transport, commercial activities, railways, factories, and the airport. Secondary sources of noise are loudspeakers, radios, television sets, hi-fi music systems, and open-air theaters (NRCUP & AIILSG, 2009). Data gathered by the Central Pollution Control Board (CPCB) and MCGM from 2000 to 2008 indicate that noise levels in all six zones of the city (residential, commercial, traffic, airport, silence zone, industrial) exceed the daytime and night time standards set by the CPCB. The maximum noise levels are at the airport and in industrial areas.

Table32: Mumbai - Noise Levels in Land Use Zones

Area	Prevailing Noise Levels	CPCB Standards	
		Day dB/A	Night dB/A
Residential	53-83	55	45
Commercial	66-106	56	55
Traffic	64-96	65	55
Airport	80-99	65	55
Silence Zone	48-91	50	40
Industrial	86-99	75	70

Source: Human Development Report Mumbai, 2009

10.1.4. Land Pollution

Land pollution in Mumbai, as with all major metropolises, is associated with the problem of solid waste. Dumping of garbage, is not only an ugly sight, but isalso hazardous to health as they are breeding grounds for mosquitoes, flies, rodents etc. which are carriers of diseases. It also causes water pollution, ground water pollution and soil pollution.

Gorai, Mulund and Deonar dumping grounds have been in use for more than thirty years. The Gorai dumping ground which had exhausted its capacity has been closed down, and Mulund and Deonar dumping grounds are expected to last for another 1-2 years and five years respectively. In October 2005, as per the Supreme Court's directions, a saltpan land admeasuring 141.77 hectares at Kanjur village was handed over for development as a scientific landfill site by the Central Government and State Government to MCGM.

Earlier the waste was simply dumped and leveled resulting in a foul smell, prevalence of insects and rodents and incidents of fire at the sites. Today, tractors spray water mixed with eco-friendly quality disinfectants. Spraying of refuse vehicles at check posts to control foul smell is also being done. Gas vent pipes to vent out gas have been provided at the landfill sites and a tree plantation programme is being implemented. Scientific land filling and installation of large scale processing plants at landfill sites is the need of the hour.

10.2. Challenges

Estimates of mean sea level rise made from past tide gauge data at selected stations along the coast of India indicate a mean sea level rise of 1 to 2 mm/year during the last century. However, these estimates need to be corrected by including rate of vertical land movements, whose measurements are not available at present. Being a coastal megacity, Mumbai will be significantly affected by way of beach erosion, the loss of coastal wetlands and more frequent flooding. Higher temperatures brought about by changing environmental conditions will lead to increased rainfall intensity

and frequency. The amount of precipitation during the summer monsoon is predicted to increase by 20 per cent over the present rate. Coupled with the city's deficient storm water drainage system, the increase in rainfall will lead to a higher incidence of flooding that will primarily displace low-income residents inhabiting the 25 per cent of Mumbai's land area that is at or below mean sea level. Increased rainfall and warmer temperatures will also facilitate the spread of disease vectors, causing outbreaks of three major illnesses: diarrhoea, malaria and leptospirosis (Kumar et. al., 2008). More frequent flooding and saltwater intrusion may also affect the structural stability of the numerous high-rise buildings in the city.

Without timely and appropriate adaptation strategies, certain studies predict that at least 40 per cent of Mumbai's population will be affected by such climate change impacts. The economic cost of sea level rise, flooding, and increased incidence of diseases is expected to reach at least INR 1 trillion (US$ 21,758,050,478.7) (Kumar et. al., 2008).

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11. Planning

11.1. The Planning Process

The planning process in Mumbai, which includes the preparation of the Development Plan and regulating development of land, is governed by the Maharashtra Regional and Town Planning Act 1966 (MR&TP Act). This involves a three tier planning process. At the regional scale the Metropolitan Planning Committee (MPC) prepares the Regional Plan for the metropolitan region with the assistance of MMRDA. Following the framework of the Regional Plan MCGM (as all other local municipal authorities in the region) prepares a more detailed Development Plan. For the implementation of the Development Plan, Town Planning Schemes or schemes for Comprehensive Development could be prepared.

Greater Mumbai has a history of planning dominated by physical plans prepared within the closed national economic framework. The spatial growth of the city has been guided and managed by the Development Plan (DP) and Development Control Regulations (DCR) therein, the preparation of which is a statutory requirement for MCGM. The first DP for Greater Mumbai was prepared by MCGM in 1964. It was sanctioned by the State Government in parts between1965-1967. The first DP was revised by MCGM in 1977 for the period 1981-2001. The revised Development Plan for Greater Mumbai was sanctioned in parts from 1991 to 1994 and the DCR for implementing the Revised Development Plan came into force on March 25, 1991. The last part of the plan, Development Plan for M ward, was sanctioned on March 4, 1994. Since the last part of the Revised D.P. was sanctioned in 1994, as per provisions of Section 38 of the MR&TP Act, it is obligatory for MCGM to revise the Development Plan before 2014.

The Development Plan is expected to be an integrated plan covering land use zoning, designation of land for public purposes, provision of infrastructure services, conservation of natural and built heritage and regulations for controlling the development. However, in the case of Mumbai, preparation of the Development Plan has not been an integrated exercise. The Development Plan in force at present was prepared in the early 80s and is largely concerned with land use zoning and designation of land for public purposes. The sectoral master plan for water supply was prepared in the seventies, sewerage in eighties, and for transport in 1962, 1994 and 2007. The master plan for storm water drainage called BRIMSTOWAD was prepared in 1992. The drainage plan was thoroughly reviewed by the Fact Finding Committee in 2005-06 after the deluge on July 26, 2005. Given the expertise required and specialized sectoral considerations demanded in addressing various aspects of planning, it is unlikely that Development Plan will ever become a single integrated one time exercise. However what is possible and necessary is that cognizance is taken of plans of the different sectors and the adequacy of those plans are assessed more frequently and periodic revisions undertaken.

The most critical problem has been that land use planning provisions in the Development Plan is based on axiomatic assumptions related to desirable densities and FSI, prohibiting habitation of vulnerable areas like flood prone creek sides, exposed coastal areas, unstable hill-slopes, tracts below the high tension power lines etc. This has resulted in setting the minimum price of a legal house so high that a majority could not afford a legal house. In 2001, 54 % of Mumbai's population lived in squatter settlements at locations that the Plan excluded for habitation.

MCGM proposes to undertake the work of revision of the Development Plan for Greater Mumbai for the period 2014-2034 by commissioning the services of urban planning consultants.

11.1. Revised DP 1991-2013

The revised DP was prepared considering many of the critical problems faced during the previous DP. While revising the DP, two major options were examined at length. The first option was to continue with mono-centric pattern while the second option was a poly-nucleated development which would foster decongestion and distribution of activities thereby stabilizing the population by the year 2000. The revised DP was prepared by adopting the second option.

Figure 44: Proposed land-use plan for Greater Mumbai DP 1991-2013

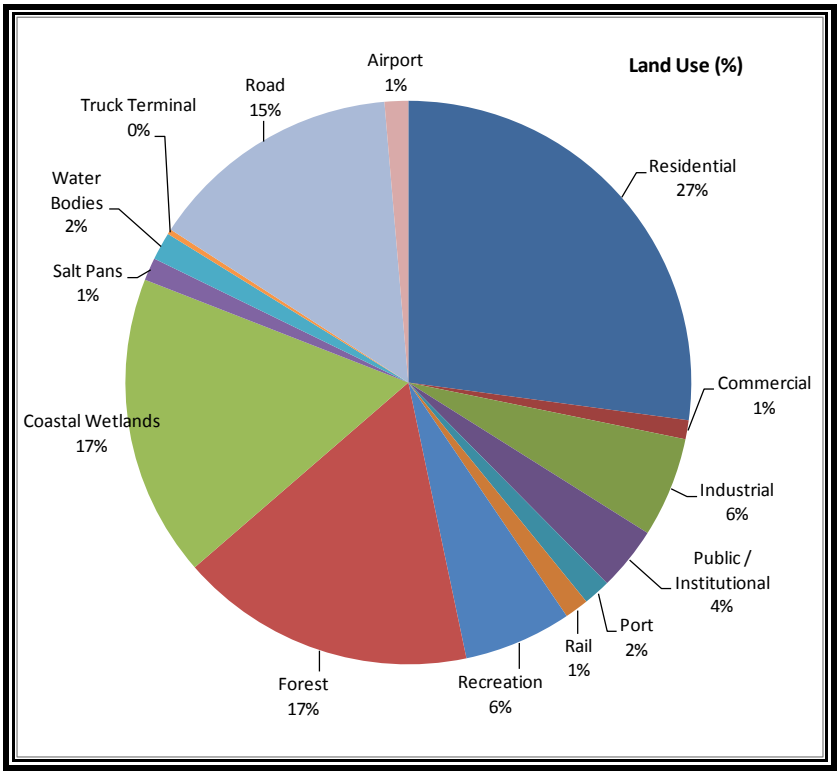


Table 33: Proposed land-use plan for Greater Mumbai, DP 1991-2013

Sr. No.	Land Use Category	Area (sq km)	Percentage
1	Residential	118.8	27%
2	Commercial	4.75	1%
3	Industrial	25.07	6%
4	Public / Institutional	15.97	4%
5	Port	6.82	2%
6	Rail	6.02	1%
7	Recreation	27.02	6%
8	Forest	74.15	17%
9	Coastal Wetlands	75.74	17%
10	Salt Pans	5.69	1%
11	Water Bodies	6.97	2%
12	Truck Terminal	1.28	0%
13	Road	63.61	15%
14	Airport	5.92	1%

The salient features/proposals of the sanctioned revised DP are as follows:

- Creation of commercial centers at various suburbs – e.g. BKC, Central business district at Oshiwara in the western suburbs and Kanjur Marg in the eastern suburbs
- Shifting of wholesale market from the city to the suburbs and to Navi Mumbai.
- Ban on new office premises in the city
- Reduction of FSI in the city to 1.33 for residential and commercial zones and 1.0 for industrial zones
- Reduction in area of industrial zones, MMRDA directed about 800 hectares of industrial land to be placed in residential zone
- Upgrading the mass transportation system by developing North-South Expressways and East-West Connectors.
- Earmarking a No Development Zone for future developments
- Laying down policies to satisfy housing needs within available resources

11.3. Key Issues and Strategic Options with Regard to DP 1991-2013

11.3.1. Demographic and Land-use Inconsistencies

The magnitude of migration to the urban areas was grossly underestimated. While planning the DP for 1981 – 2001, the estimated population in 2001 was 9.87 million, this was surpassed in 1991. The population has further increased from 9.91 million in 1991 to 11.98 million in 2001. The growth reflects an increase of about 200,000 people per annum. The population exceeded the projected population as visualized in the DP in most of the wards.

The requirement of residential areas for this additional population is 12 sq m per person. There is only about 10 sq km of developable land available in the city, of which only 6 sq km is available for residential purposes. This is against the requirement of 64 sq km. The option therefore is to increase the FSI suitably to accommodate the residential population.

11.3.2. Public Amenities

Given the higher than projected population growth, public amenities planned for the year 2001 were required to have been provided in 1991. The planning therefore has been deficient in terms of public amenities and housing for the additional population since 1991. The projected population for 2031 would require proportionate increase in the allotment for Public Amenities. Apart from the cost, the most important aspect is the land availability for developing the amenities. Increasing the FSI for the available land with compulsory open space reservation may become innovative methods to cope with the deficiency in available land.

11.3.3. Slums

It has been observed that the percentage of slum population to the total population has increased from 39 per cent in 1991 to 48 per cent in 2001. An estimated area of 35 sq km is under slum housing which accounts for almost 50 per cent of the city's population. The land use plan in the DP has not accounted for such a large magnitude of urban poor. The rapid increase in immigrant population estimated at 200,000 annually from rural areas has far exceeded the rate of construction of houses which is estimated to the order of 20,000 tenements per annum. The DCR 1991 with subsequent amendments had addressed the problem of rehabilitation while permitting incentive for redevelopment of slums. However, the scheme of SRA had several limitations.

11.3.4. Housing

The DP has envisaged the need for creation of housing stock 1,940,000 in a phased period of 20 years to cater to meet the demand of projected population of 9.19 million. However this target could not be met. There are 1,620,000 formal housing tenements in Greater Mumbai which cater to a population of 6,140,000. The remaining 4,840,000 live in slums. In addition to the need to cater 1,430,000 slum households, there is also a need to generate about 40,000 houses per annum for additional population of 200,000 per annum. Initiatives on increasing the housing stock should be considered to tackle the housing problem in the city.

Though many initiatives were taken in the DP 1991, considering various factors, it is felt that urban planning should include the following:

- A long term structure plan for the city for a period of say, 20 to 25 years based on long term projections in terms of major infrastructure augmentation especially with respect to water supply and sewerage disposal which should also be in conformity with the regional plan and associated long term policies of the government.

- A number of short term plans along with associated regulations which shall have a period of 5 years or so and shall take into account the prevailing socio-economic trends and government. policies in the next 5 years.

- Several changes need to be made in the MRTP Act with respect to the acquisition of land for public amenities.

- A coherent slum policy to address the complex issues involved in Slum Rehabilitation which shall be in consonance with the broad land use regulation, socio-economic trends and legal framework.

- An effective housing policy to solve shortage of housing stock while striking a balance between the available resources and the steep demand by necessary legislative initiatives.

11.4. Special Planning Agencies

Specific areas within the jurisdiction of MCGM as municipal authority have been notified and Special Planning Authorities (SPAs) have been appointed for them under section 40 of the MR&TP Act.

11.4.1. Mumbai Metropolitan Region Development Authority

MMRDA was set up on the 26th January, 1975 under the Mumbai Metropolitan Region Development Authority Act, 1974 Government of Maharashtra as an apex body for planning and co-ordination of development activities in the Region. In addition to formulation of a Regional Plan for MMR which is a statutory responsibility, MMRDA is a Special Planning Agency for Bandra-Kurla Complex, Oshiwara District Centre, Backbay Reclamation Area, Oshivara District Centre and Gorai-Manori Tourism Zone in Greater Mumbai.

MMRDA conceives, promotes and monitors key projects for developing new growth centres and bring about improvement in sectors like transport, housing, water supply and environment in the Region. The Bombay Urban Transport Project aims at improving public bus services and easing traffic conditions by constructing fly-overs on selected road corridors in Greater Mumbai. Shifting of wholesale markets from congested parts of Mumbai was also successfully implemented by MMRDA. Mahim Nature Park, previously a garbage dumping ground, has been converted into a park for recreational and educational purposes. Under the on-going projects development of Wadala Truck Terminal is expected to provide a centralised facility for goods transport activities at a well planned site. It would relieve traffic congestion and resultant air pollution on the roads of Greater Mumbai. Work is in progress on establishing an International Finance and Business Centre at Bandra-Kurla Complex.

11.4.2. Other Special Planning Agencies

The other SPAs in Mumbai are SRA and Maharashtra Industrial Development Corporation (MIDC). SRA is the SPA for Dharavi Redevelopment Project while MIDC is the SPA for Marol Industrial Area and Santacruz Electronics Export Processing Zone (SEEPZ) which is a Special Economic Zone. SEEPZ mainly houses software companies and jewellery exporters of India. More than 40 percent of India's total jewellery exports ($2,222.31 million) out of $5,210.69 million during year 2006-2007 came from units within SEEPZ.

12.Disaster Profile of Mumbai

12.1. Hazards in Mumbai

Mumbai faces high risk to natural disasters. Natural hazards such as floods, earthquakes, cyclones and droughts put additional pressure on Mumbai's socio-economic systems and urban environment, which are already strained as a result of surging population growth. Climate change intensifies the uneven distribution of risk, skewing disaster impacts even further towards poor communities and other vulnerable groups.

Some hazards which have impacted or may potentially impact Mumbai can be divided into the following groups:

1) Hydrological and Climatological Disasters

- Floods
- Cyclones
- Cloud Bursts
- Sea Erosion

2) Geological Disasters

- Earthquakes
- Landslides

3) Chemical, Industrial & Nuclear Disasters

4) Accident Related Disasters

- Fires
- Oil Spills
- Major Building Collapses
- Festival related Disasters
- Air, Road & Rail Accidents

5) Epidemics

- Malaria
- H1N1
- Gastroenteritis
- Tuberculosis
- Leptosporosis

etc.

Mumbai is also a target for human-induced disasters such as bomb blasts, terrorism and riots.

12.2. Vulnerabilities of Mumbai

The vulnerabilities of a city make it susceptible to the damaging effects of a hazard. There are many aspects of vulnerability, arising from various physical, social, economic, and environmental factors. Some of the factors that contribute to risk creation in Mumbai City are:

- *Concentrated Political, Economic and Other Resources*

The concentration of political, industrial, financial or other resources in Mumbai can have regional, national or even international repercussions. On July 26, 2005 the commercial and financial hub of India, came to a virtual halt. There was a total collapse of the transport and communication system. The domestic and international airports were closed for two days and the major roads linking the city to other centres in the country were submerged. Intercity train services were cancelled for over a week, while suburban trains, which are the lifeline of the city, could not operate for 36 hours. 40,000 commercial establishments suffered heavy losses. Banking transactions across the counters were adversely affected and many branches and commercial establishments were unable to function for two days. ATM transactions could not be carried out, not only in the city, but in several parts of the country during this period due to failure of connectivity with their central systems located in Mumbai. The Bombay Stock Exchange and the National Stock Exchange of India, the premier stock exchanges of India, could function only partially. As most of the trading is eTrading, trading terminals of the brokerage houses across the country remained largely inoperative.

On November, the city was target by terrorists as it is a major business centre and the commercial and financial capital of the country.

- *Fourteen different agencies are responsible for the governance of the city*

There is no single organisation or body really accountable for all of Mumbai. Each agency operates independently and there is little co-ordination between the different agencies.

- *Insular location*

Mumbai, formed by the amalgamation of two groups of seven islands each, is connected to the mainland across the major water bodies surrounding it via roads and railways. This makes the city relatively inaccessible to the rest of the country during a major hazard, as witnessed during the floods of 2005.

- *Physiographic constraints*

The city is confined to a 35^0 wedge resulting in an acute paucity of land in the city. Sea and water bodies occupy 66% of the total area of the circle drawn with a radius of 25 km from the city center. This results in limited land supply and consequently very high density of population and exorbitant property prices.

- *Large tracts of reclaimed land*

Large tracts of the city including most of the city centre, which houses the Bombay Stock Exchange, the main train stations and train lines, and numerous high rises, are located on landfill. Landfill areas have high risk of liquefaction during an earthquake. In addition, few buildings in the city have been built to withstand a major earthquake, much less an earthquake magnified by liquefaction.

- *Rainfall characteristics*

Rainfall characteristics make the city prone to flooding. Almost 60 % of the average rainfall falls during two months in a year - July and August. The average monthly rainfall for July is often higher than London's average annual rainfall. In addition, sometimes 35-40% of this rainfall is received in just 2-3 events. Probability of flooding is high when rainfall exceeds 40 mm in an hour on a given day, which occurs between 1-7 times a season. The problem of flooding becomes acute when heavy rainfall coincides with high tide of more than 4.5 meters which takes place 2-3 times a season. MCGM has identified 266 flooding spots within the city, of which 55 are chronic flooding spots.

- *Extensive coastline*

Mumbai has a 170 km long coastline. The 57 slum settlements within the high tide line are the most vulnerable.

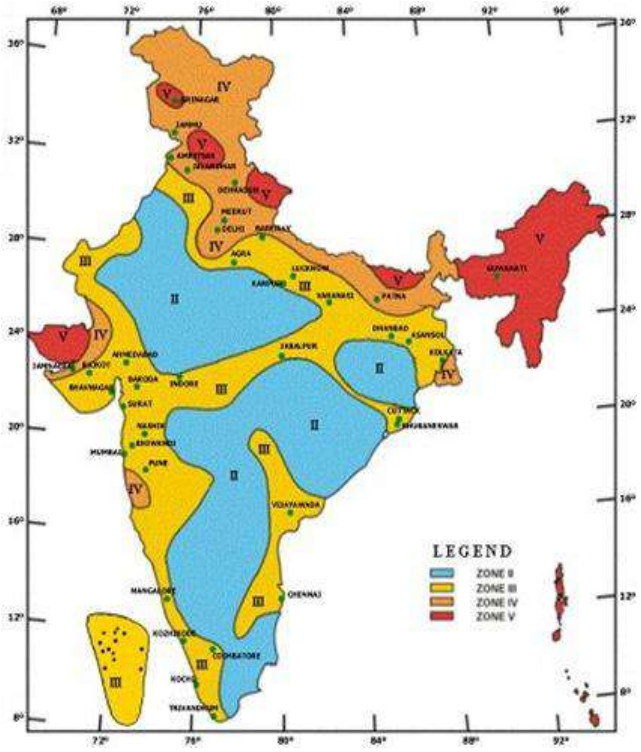
Figure 45: Vulnerability of coastal slum settlements to flooding

Source: citymayors.com

- *Location in* a Seismically Active Zone

Mumbai falls in seismic risk zone III, which represents "moderate risk". Mumbai can experience earthquakes measuring up to 6.9 on the Richter scale.

Figure 46: Seismic Zone Map of India



Zone	*Magnitude*
Zone V	*Very High Risk Quakes of Magnitude 8 and greater*
Zone IV	*High Risk Quakes upto Magnitude 7.9*
Zone III	*Moderate Risk Quakes upto Magnitude 6.9*
Zone II	*Seismic Disturbances upto Magnitude 4.9*

Source: rahat.up.nic.in/seismic.htm

- *Economic Polarization*

Though the per capita income for Mumbai is higher than that of both the State of Maharashtra and India, 40 per cent of the households in Mumbai are below the poverty line. Poverty in general limits the self-help capabilities of large parts of the population and compels people to settle in endangered areas.

- *50-60% of the population living in slums*

Disaster risks are unevenly skewed towards poor communities. Slums are vulnerable primarily because of their location, density and lack of access to infrastructure. These settlements are located in areas that invariably get flooded during high tides, in coastal locations, along water mains or open drainage, within industrial zones or under high tension wires. As Mumbai continues to grow exponentially, marginal land is often all that is left for the poor. Slums are often located on steep hillsides, which are prone to landslides during the monsoons. Many

squatter structures are single storey and built of salvaged materials which are vulnerable to collapse. World Bank estimates indicate that these communities suffer from inadequate access to potable water and sanitation, and that 170 persons depend on each public latrine in these areas, and that one-third of the 35,000 latrines in Mumbai are out of service.

- *Quarrying of hills*

The city's hill ranges are being systematically carved by developers with disastrous environmental consequences. On July 21, 2010, due to excavation of the hill at Dindoshi, torrential rain caused a landslide at the New MHADA Colony. Six row-houses were flooded by rivers of mud and a part of one house collapsed. Quarrying in the hills outside the National Park is triggering landslides within the forest as they are part of a continuous chain. MCGM has listed 117 landslide prone sites in hilly areas like Kurla, Mulund and Saki Naka.

Figure 47: Part of Slum Destroyed

Source: thehindubusinessline.com

Figure 48:Landslide at Dindoshi July 21, 2010by Landslide

Source: Times of India

- *High levels of spatial concentration of population*

When people are concentrated in a limited area, a natural hazard will have a greater impact than if people are dispersed. In 2001, the average population density for Mumbai city was 27,000 persons per km^2, one of the highest in the world. Ward C, the most densely populated area had a density of 114,001 persons per km^2.

South Mumbai has a large floating population during office hours. In ward A, for example, the diurnal population varies from 17,528 people per sq km at night to 394,390 people per sq km during the workday.

The Mumbai Suburban Railway network is the life line of the city and caters to 6.3 million commuters daily. It has the highest passenger density in the World, ahead of even Tokyo and Seoul. It is for this reason that the suburban trains have been a target for terrorist activities. Any disruption of the train services has a major impact on the functioning of the city.

Figure 49:Crowded Suburban Trains

Source: mumbaiinsomniac...

Figure 50: Train targeted by terrorists on July11,2006

Source: www.jameslogancourier.org/index

Population densities for are also very high in the slums. Densities in roughly one-half of Mumbai's squatter communities are estimated to be as high as 94,000 people per square km, making them one of the most densely settled districts in the world (A de Sherbinin).

Figure 51: Slums in Mumbai

Source: pwindia.in

- *Building stock*

One of the most vulnerable elements exposed in Mumbai is it building stock, which contributes to increasing risk of its population. The building stock exhibits a rich mix of several different building technologies. The most commonly used building categories are:

(1) reinforced-concrete frame buildings with partition walls;
(2) brick masonry buildings with reinforced concrete roofs and using cement mortar;

(3) informal brick masonry buildings (which may or may not use cement mortar); (4) buildings made of other materials such as tin sheets, thatch and other lightweight elements.

Several reinforced concrete and brick masonry buildings have been constructed without the assistance of qualified engineers. Due to this reason, these buildings may be improperly designed or constructed resulting in lower strength.

Almost 90% of the buildings located in the 'A', 'B' and 'C' wards in Island City are dilapidated - many in a state of imminent collapse. These structures act as a death trap in case of tragic accidents, like fire.

- *Inadequate transport facilities*

The transport network is characterized by extremely overcrowded trains, slow moving buses on extremely congested roads and acute paucity of parking space. There is no redundancy in the existing systems and the existing transport network is composed of long unidirectional corridors without adequate alternatives to fall back on in case these arterial communication lines are severed.

- *Utilities and services*

Utilities like water supply, sewerage systems and garbage collection and disposal deficient, and health services inadequate. Mumbai's water supply depends on several rain fed lakes located to the north of the city. Their location on hills makes them less susceptible to impacts from sea-level rise, although their dependence on local rainfall means that increasing rainfall variability could threaten local supply. This happened in 2009, when there was inadequate rainfall in the catchment areas.

- *Presence of hazardous industries*

Trombay, in the eastern suburbs with a cluster of two oil refineries, a petro-chemical complex, a fertiliser plant, a thermal power unit, and the Bhabha Atomic Research Centre is highly vulnerable to accidents associated with these hazardous industries.

- *Storage of hazardous substances*

The chlorine gas leak from two cylinders at the Mumbai Port Trust highlights the vulnerability of the city due to storage of hazardous substances. There are over 750 such substances which are stored legally in different parts of the city. Care must be taken to ensure that neutralising agents for these substances are also readily available at these sites in case of an accident/disaster.

- *Marine Pollution*

Due to its proximity to Bombay High and the presence of two ports Mumbai is highly vulnerable to marine pollution. The collision between two cargo ships on August 8, 2010 is a case in point. About 879 metric tons of oil spilt into the sea from the damaged fuel tanks of one of the ships. By August 10, 2010 the spill had spread over 20 sq km and beaches surveyed by the Bombay Natural History Society team revealed that in Sasavane and Madhwa beaches in Raigad district the oil residues on the beach were six inches deep in the sand. There were 31 containers with 251,000 kg of sodium hydroxide and 53, 614 kg of pesticides which had fallen off the stricken ship. Bottles of pesticides had drifted onto the shore indicating that a container had broken open. The pesticides were in aluminum bottles which could break open if they hit rocks resulting in chemical pollution of the beaches. In addition, more than 500 containers had fallen into the sea, posing a major hazard to navigational channels of Mumbai Port Trust and JNPT whose operations were expected to remain suspended for a week.

- *Poor enforcement of regulations*

Despite institutional measures being in place, they are often flouted. For instance, buildings constructed for residential purposes, are often used to house unregulated hazardous industries without retrofitting or strengthening.

- *Uncontrolled development*

Uncontrolled development has led to severe environmental degradation and increased vulnerability. Wanton destruction of mangroves and the haphazard and unregulated reclamation of the sea-coast are examples.

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13. Disaster Risk Management

13.1 National Perspective

India has traditionally been vulnerable to natural disasters on account of its unique geo-climatic conditions. Floods, droughts, cyclones, earthquakes and landslides are recurrent phenomena. About 60 per cent of the landmass is prone to earthquakes of various intensities; over 40 million hectares are prone to floods; about 8 per cent of the total area is prone to cyclones and 68 per cent of the area is susceptible to droughts. Every year, about 30 million people are affected by disasters. The country's vulnerability to disasters has also grown due population imbalance. Population has gone up manifold in urban areas. India is also vulnerable to man-made disasters. The poor, particularly those who settle in marginal areas, are the ones who are severely affected. About 4344 people lost their lives between 1990 and 2000. (Disaster Management in India Status Report, August 2004)

The magnitude and the number of disasters have meant huge sums being incurred on post-disaster relief. Appropriate risk management measures need to be in place to sustain the pace of development.

13.2 Paradigm shift in India

Two major disasters, the super cyclone in Orissa in October 1999 and the Bhuj earthquake of Gujarat in January 2001 brought into sharp focus the need for a major rethink of existing strategies. It was felt that a multi-dimensional endeavour that would involve diverse scientific, engineering, financial and social processes, multi-sectoral and multi-stakeholder would be an appropriate solution. The underlying belief was that risk reduction must be an integral part of all development plans and strategies, and stakeholders' local capacities must be built up to create significant impact (Disaster Management in India Status Report, August 2004). In view of this in February, 2002 the Government of India transferred the subject of Disaster Management (except drought and epidemics) to the Ministry of Home Affairs by virtue of an amendment of the Allocation of Business Rules 1961.

Transfer of disaster management to the Ministry of Home Affairs, resulted in gradual shift in orientation—from a reactive to a proactive approach and from mere post disaster rehabilitation to holistic preparedness and mitigation response. In its attempt to develop a systematic, comprehensive and holistic approach towards disasters the Government constituted a High Powered Committee on Disaster Management with members drawn from the Ministries/States /NGOs and experts from relevant fields. The Government increasingly insisted on intensive multi-departmental involvement and proactive mainstreaming of disaster management into all Government activities, particularly developmental initiatives. The multi-disciplinary approach involved partnership with a large number of ministries/departments.

13.3 The Disaster Management Act (DMA), 2005

The tsunami disaster in December 2004, marked a turning point in disaster risk management in the country. The Disaster Management Act (DMA), 2005 was enacted on 9th January, 2005. The Act demonstrates the national vision of a paradigm shift from post-disaster response to improving the pre-disaster disaster preparedness, initiating disaster mitigation projects and strengthening emergency response capacities in the country. The Disaster Management Act, 2005 stipulated the establishment of requisite institutional mechanisms for drawing up and monitoring the implementation of disaster management plans, ensuring measures by various wings of the government for prevention and mitigating the effects of disasters, and for undertaking a holistic, co-ordinated, and prompt response to any disaster situation.

The Disaster Management Act, 2005 envisaged the establishment of the National Disaster Management Authority (NDMA), chaired by the Honorable Prime Minister of India, as the apex body for disaster management in the country. The Union Minister for Home Affairs, Union Minister for Finance, Union Minister for Agriculture and the Deputy Chairman of the Planning Commission are permanent invitees for NDMA meetings so as to facilitate greater synergy in decision making and for more effective mainstreaming of disaster management in development planning. The functions of NDMA include formulating policies on Disaster Management as well as approving the national plan and plans prepared by ministries/departments of Government of India. It lays down guidelines to be followed by State authorities in drawing up state plans. NDMA also coordinates enforcement and implementation of policies and plans, recommends provision of funds for mitigation, takes measures for prevention, mitigation, preparedness and capacity building for dealing with threatening disaster situation or disasters, lays down broad policies and guidelines for NIDM and recommends guidelines for minimum standards of relief.

A dedicated agency called the National Disaster Response Force (NDRF) has been established with personnel from the para military forces for strengthening the preparedness and emergency response in the country. The NDRF personnel are also trained for preparing and responding to Chemical, Biological, Radiological and Nuclear (CBRN) emergencies.

The National Institute for Disaster Management (NIDM) has been established as the apex training institute for disaster management in India. NIDM coordinates the capacity building efforts of disaster management faculty in State Training Institutes and offers distance education programmes in disaster management in collaboration with the World Bank Institute. The NIDM also hosts the SAARC Centre for Disaster Management.

DMA sets out the framework for institutional mechanisms at the State and District levels expressing that the task of disaster management should jointly be undertaken

by different government levels. The Act assigns the State Governments and State Disaster Management Authority (SDMA) primary responsibility to monitor and assess disasters and any developing situations and to keep the national agencies, NDMA and NEC, apprised of the same. The State has to evaluate its own capabilities to handle disasters and to project resources to be mobilized as necessary. Capacity building includes training and equipping of state response forces, community preparedness, training and creation of response caches at the district level. The state response capabilities are to be strengthened from within their existing resources i.e. each state was required to equip and train its respective State Disaster Response Force (SDRF), including women members, through the NDRF and its training institutes.

Local authorities, Panchayati Raj Institutions and Urban Local Bodies play a significant role in the disaster management process, particularly in response and rescue operation, relief and rehabilitation, training and maintenance of resources related to disaster management, disaster preparedness, restoration of livelihood options and coordination with NGOs and civil society.

13.4 Civil Defence

The Civil Defence in India operates under the authority of the Civil Defence Act, 1968. The Act aims at providing for continued maintenance of Civil Defence services which are already in position in all India's States and Union territories. It also enables the Central Government and the State Governments to extend the scope of Civil Defence if and when necessary. On December 2009, both the Houses of Parliament approved the Amendment to the Civil Defence Act, 1968. The amendments expanded and reinforced the task of Civil Defence to cover all disasters, natural and manmade and included disaster management in the definition of Civil Defence. Civil Defence plays a key role in all facets of disaster response.

13.5 Disaster Management in Maharashtra

The Maharashtra SDMA was constituted on May 24, 2006 with the Chief Minister as its chairperson. Most important aspects of disaster risk management under the present legal regime are vested in State officials. The laws with respect to relief works for the victims of natural calamities are likewise within the purview of State responsibilities.

The State Executive Committee (SEC) was formed, with the Chief Secretary as chairperson, as the policy-making body at the state level. The Committee is empowered to give directions to any department of the State or any authority or body of the State to take actions in response to any disaster situations or disasters. The State can take action as it deems necessary in order to effectively implement the provisions of the DMA. The Municipal Commissioner of MCGM has been appointed by the Chief Minister as a member of the SDMA. A composite secretariat, presently with strength of 40 staff, supports SDMA as well as SEC.

The DMA also mandates the organization of Disaster Management at the district level that coordinates with Disaster Management Committees in the tasks of disaster response, preparedness, prevention and mitigation.

13.6 Disaster Management in Greater Mumbai

The National Government, on the recommendation of the SEC designated Greater Mumbai as the nodal agency for all aspects related to disaster management and assigned the Municipal Commissioner of Greater Mumbai as the District Disaster Officer[1] for Greater Mumbai in 1994. Thereafter the Commissioner assumed the function of managing disasters in Greater Mumbai and mobilized his own resources. Under the Municipal Commissioner is the Chief Officer, Disaster Management Centre who takes care of all aspects of disaster management including coordination of all measures related to disaster prevention, mitigation, preparedness, response and relief.

As disaster risk management has been delegated to MCGM by the State, the civic body with its 42 units and departments has become pivotal in this important task in Greater Mumbai. If the disasters fall within the managerial capacity of MCGM, the city government will manage the disaster situation with minimal or without intervention from State authorities (Mumbai DMP, 2005). This is because disaster impacts are strongly felt at the local level and MCGM is in a good position to undertake the broad spectrum of disaster risk management practices and processes as they are the closest level of organized government to the people (Fernandez et.al 2004). The MCGM disaster management plan (DMP) provides disaster-related information as well as an action plan for the city to prevent, avoid and reduce disaster risks, and effectively respond to emergencies.

MCGM maintains an Emergency Operations Center (MCGM Control Room) which is equipped with state-of-the-art communication system.

[1]The appointment was done via order No.ENV/1093/DEA/CR/36/TK dated 16th February, 1994.

Figure 52: MCGM-DM & CCRS Control Room

Source: MCGM

Supporting the city-level disaster management plan are the ward level plans of the 24 wards. The roles and responsibilities of ward officials in disaster risk management have been specified. When the disaster is localized and can be managed locally, the Assistant Commissioner acts as the site officer responsible for the coordination of field activities of various line departments including coordination and providing support to line agencies so as to enable them to operate efficiently (Mumbai DMP, 2005). He has to be in constant communication with the MCGM Control Room and the field officers from the police, traffic police, fire brigade, railways, BEST, BMC Hospitals, MTNL, BSES, TEC, revenue, state government when necessary, among others.

Disaster situations that cover a large portion of the city call for coordination of activities at the city level. In such conditions, the ward level plans would be in place along with the Mumbai DMP. The Assistant Commissioners maintain their coordination functions and activities at the ward level while inter-ward coordination is the responsibility of the MCGM Control Room.

The Municipal Commissioner also ensures that disaster response drills are conducted by the Assistant Commissioners and other agencies on a regular basis, especially in the disaster-prone areas to maintain the readiness of the various departments and the local communities.

Many vital installations in the city like Hindustan Petroleum Corporation Limited, Reliance Energy Ltd, Bhabha Atomic Research Center, Tata Power Corporation Ltd, Maharashtra Telephone Nigam Ltd, and Mumbai Port Trust have their own Emergency Response systems that cater to their needs and are available to MCGM on request. The informal arrangement is functional despite the absence of a MOU between these organizations and MCGM.

Some non-government organizations provide complementary relief and rehabilitation activities in Greater Mumbai. These include the Agriculture Produce Market Committee, Bharat Sevashram, CARE, CARITAS, CASA, Indian Red Cross, Mahalaxmi Trust, Ramkrishna Mission, Salvation Army, Somaiya Trust, Swami Narayan Trust, Service Clubs of Rotary, Lions and Giants, Tata Relief Committee. NGOs also assist MCGM at the local level during any disaster, especially in shelter activity.

MCGM has also established links with other organizations and stakeholders, such as academic institutions and professional organizations working in the city in order to increase participation and mobilize additional technical and financial support for DRM activities in Greater Mumbai.

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Disaster Management & CCRS Department

Municipal Corporation of Greater Mumbai

Basement of Annex Building, Mahapalika Marg, Mumbai 400 001. Maharashtra.

Tel: +91 (22) 2269 4725/27 Fax: +91 (22) 2269 4719. Website: mcgm.gov.in, www.emi-megacities.org

Email: mmarvel.arpn.drmmp@gmail.com