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TERI was formally established in 1974 with the purpose of tackling and dealing with the immense and acute problems that mankind is likely to face in the years ahead. Over the years the Institute has developed a wider interpretation of this core purpose and its application. Consequently, TERI has created an environment that is enabling, dynamic and inspiring for the development of solutions to global problems in the fields of energy, environment and current patterns of development, which are largely unsustainable.

The central element of TERI's philosophy has been its reliance on entrepreneurial skills to create benefits for society through the development and dissemination of intellectual property. The strength of the Institute lies in not only identifying and articulating intellectual challenges straddling a number of disciplines of knowledge but also in mounting research, training and demonstration projects leading to development of specific problem-based advanced technologies that help carry benefits to society at large.

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Environment Status Report of Mumbai Metropolitan Region (MMR)

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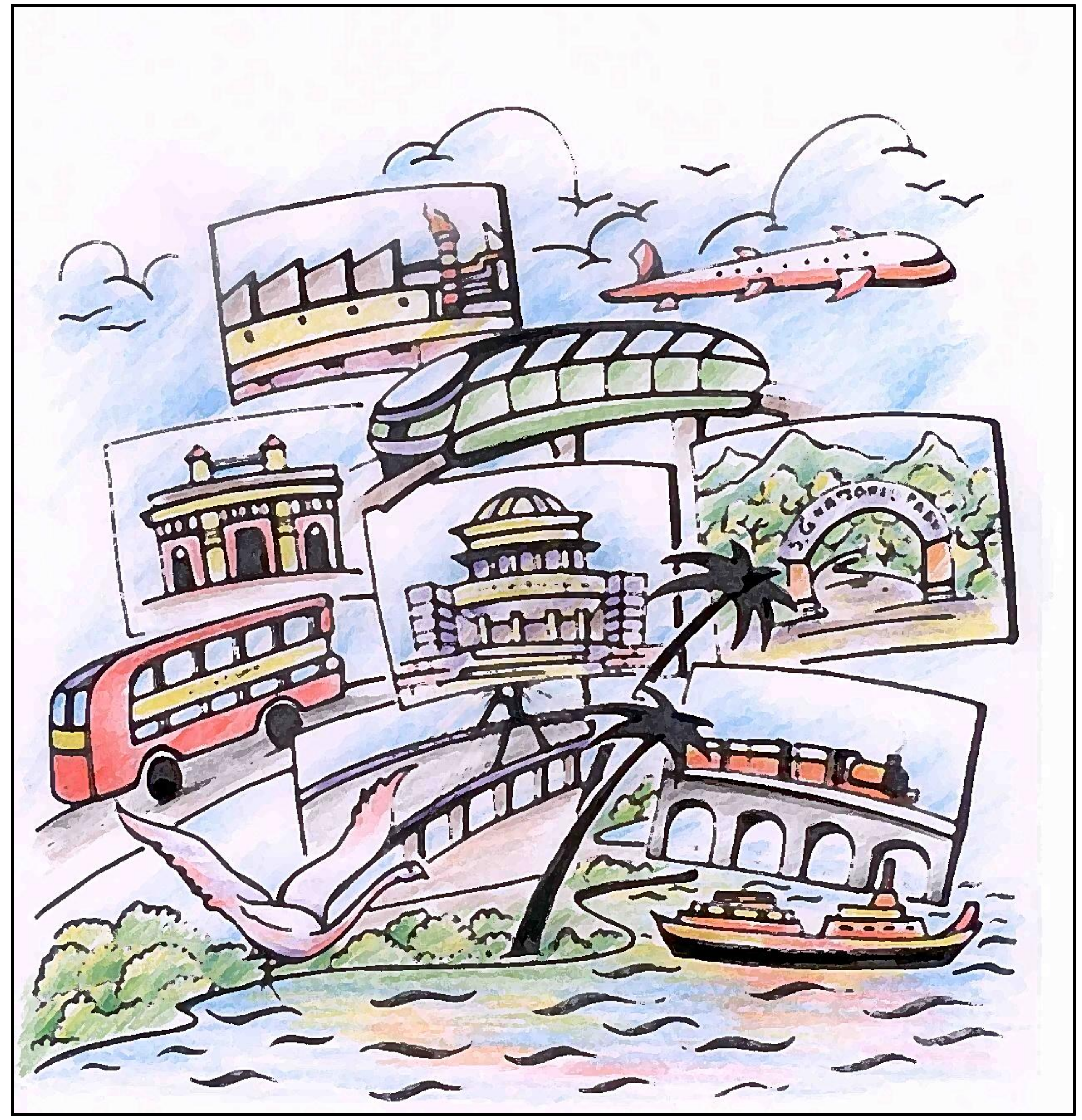
March 2015



Prepared by

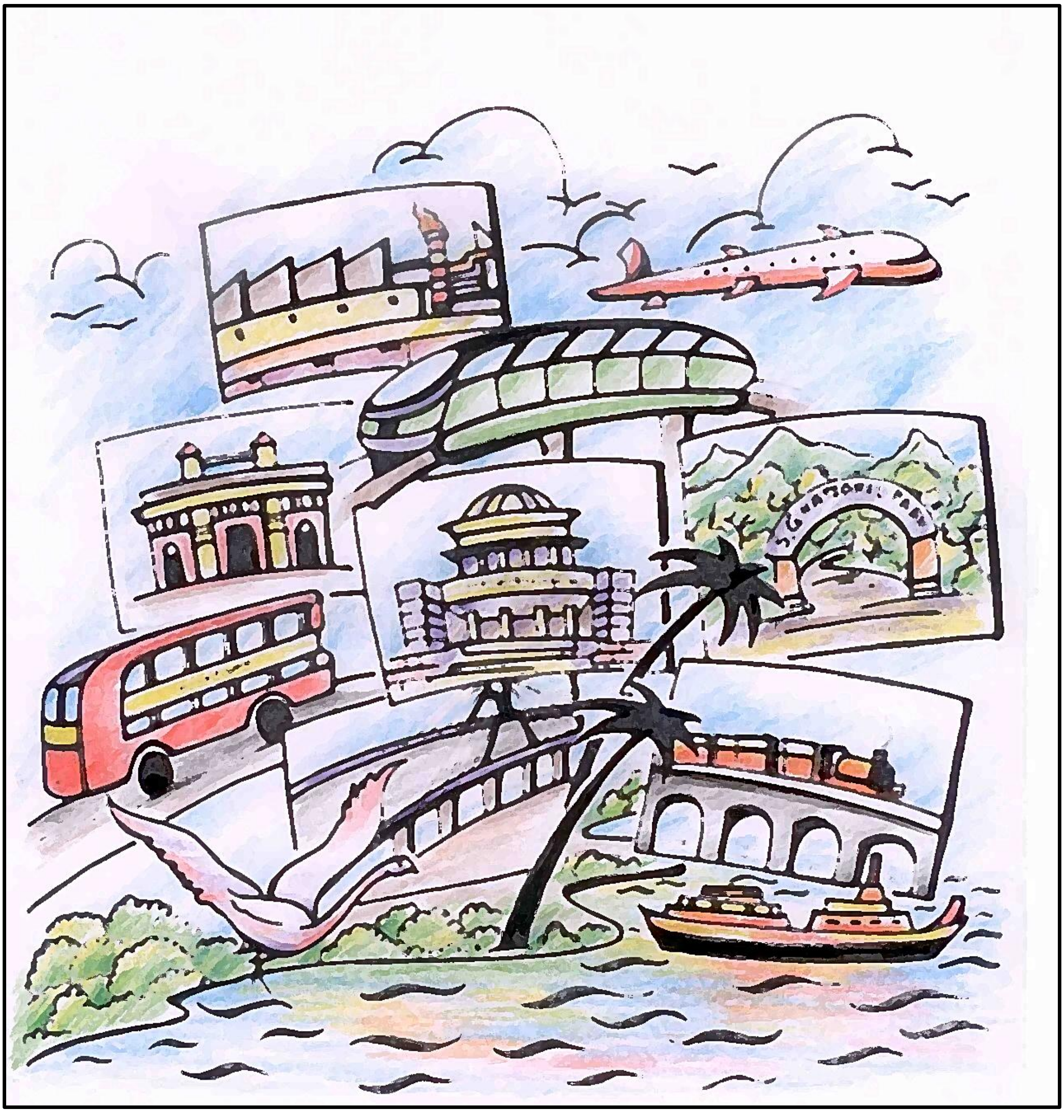
teri

The Energy and Resources Institute

Prepared for

Mumbai Metropolitan Region Development Authority

Environment Status Report of Mumbai Metropolitan Region (MMR)



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The preparation of the report titled "Environmental Status Report for Mumbai Metropolitan Region" for Mumbai Metropolitan Region Development Authority has been a memorable experience, which TERI owes to the cooperation and support extended by officials of MMRDA.

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Finally the authors thank each and every individual who have contributed to collate this report successfully.

Mumbai, November, 2014

Declaration

We hereby declare that the Environmental Status Report of MMR (Mumbai Metropolitan Region) is a record of an original work carried out by TERI (The Energy and Resources Institute) which is based solely on the assessment of secondary data provided by various government departments, ULBs (Urban Local Bodies), MMRDA (Mumbai Metropolitan Regional Development Authority) and observations recorded by TERI during various site visits, consultations and interviews with concerned officials. The references taken from various published and unpublished reports are appropriately cited in the report.

The spatial maps generated and incorporated in the entire report including sections on water and land are based on the data attributes for the sub-categories of the land use pattern as per MRSAC (Maharashtra Remote Sensing Application Centre) classification. Similarly, village map, land use and land pattern is based on the remote sensing done by MRSAC. The maps are only for representational purposes and may not be as per the scale. The spatial location marked on the maps are based on the addresses provided by various institutes and latitude and longitude as retrieved from Google Maps. The data for complete talukas of MMR has been considered to represent the MMR area for agriculture produce and coverage.

The data source for the concentrations of air pollutants has been procured from MPCB (Maharashtra Pollution Control Board) unless stated otherwise. The five RO's (Regional Offices) of MPCB namely Mumbai, Thane, Navi Mumbai, Kalyan and Raigad have been considered to represent the MMR for the study.

The analysis for climate variability has been prepared based on raw data procured from the National Data Center, Pune which is a data wing of IMD (India Meteorological Department). The climate change perception analysis undertaken for the chapter is based on the extensive assessments and consultations undertaken in the process with various district level officials and one to one interviews conducted with various departments in the corporations in MMR. Details of the same are provided as annexes in the chapter end for reference. The section extracts its fundamental theories from literature review based on published papers, government reports and so on. The same are detailed in the chapter as relevant.

Table of Content

How to use this report

The report has been divided into three relevant volumes in an attempt to present the full spectrum of issues relevant to the subject matter.

Section 1: (Executive Summary and Drivers)

The volume presents an executive summary and includes discussion on major driving forces of the region which attracts population growth as well as increase the pressure on various resources and urban services.

Section 2-5: (Technical Section describing the Pressures, Status, Impacts and responses on three important resources considered under the report)

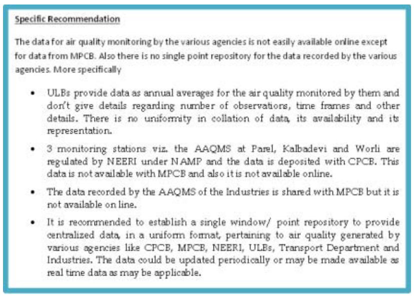
- Water
- Air
- Climate Variability
- Land

These sections discuss the status of these resources and also presents a special section on climate variability in MMR.

The recommendations have been presented in two forms.

1. As a comprehensive list at the end of sub sections in the technical report for Air and water.
2. Specific recommendations have been elaborated in the running text as and where appropriate to enable understand the status of a specific issue and correlate the given recommendation. To make the recommendation more conspicuous, those are presented in a text box outlined in blue colour. Further, to highlight the key features of the report flow bars have been included in the running text

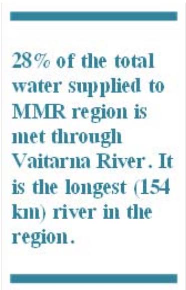
The citations have been presented either as a reference or as a hyperlink where relevant. The sourced data sets from various parameters have been included as a separate Annex to this report.



Specific Recommendation

The data for air quality monitoring by the various agencies is not easily available online except for data from MPCB. Also there is no single point repository for the data recorded by the various agencies. More specifically

- ULBs provide data as annual averages for the air quality monitored by them and don't give details regarding number of observations, time frames and other details. There is no uniformity in collation of data, its availability and its representation.
- 3 monitoring stations viz. the AAQMS at Parel, Kalbadevi and Worli are regulated by NEERI under NAMP and the data is deposited with CPCB. This data is not available with MPCB and also it is not available online.
- The data recorded by the AAQMS of the Industries is shared with MPCB but it is not available on line.
- It is recommended to establish a single window/ point repository to provide centralized data, in a uniform format, pertaining to air quality generated by various agencies like CPCB, MPCB, NEERI, ULBs, Transport Department and Industries. The data could be updated periodically or may be made available as real time data as may be applicable.



Sample of Recommendation Box (Left) and Flow bar

Section 6: (Annexes)

This section compiles the annexes of this report.

Abbreviations

AAQM	Ambient Air Quality Monitoring
ACCCRN	Asian Cities Climate Change Resilience Network
AIILSG	All India Institute of Local Self- Government
ALRI	Acute Lower Respiratory Infections
APC	Air Pollution Control
AQI	Air Quality Index
Ar	Argon
BCM	Billion Cubic Meters
BEE	Bureau of Energy Efficiency
BEST	Brihan Mumbai Electric Supply & Transport
BMC	Brihan Mumbai Corporation
BNMC	Bhiwandi Nizampur Municipal Corporation
BOD	Biochemical Oxygen Demand
BRIMDTOSWAD	Brihan Mumbai Storm Water and Drainage Report
BSUP	Basic Service to the Urban Poor
CAAQMS	Continuous Ambient Air Quality Monitoring Stations
CAGR	Compound Annual Growth Rate
CAT	Conservation Action Trust
CD	Compact Disk
CDTM	Center for Digital Technology and Management
CEPT	Common Effluent Treatment Plant
CGWB	Central Ground Water Board
CH_4	Methane
CHM	Chandibai Himathmal Mansukhani College
CHP	Combined heat and power
CIDCO	City and Industrial Development Corporation
Cl	Council
CMFRI	Central Marine Fisheries Research Institute
CNG	Compressed Natural Gas
CO	Carbon monoxide
CO_2	Carbon dioxide
COD	Chemical Oxygen Demand
COMAPS	Coastal Ocean Monitoring and Prediction System
COPD	Chronic Obstructive Pulmonary Disease
CPCB	Central Pollution Control Board
CPHEEO	Central Public Health and Environmental Engineering Organisation
CRZ	Coastal Zone Regulation
CTDM	Complex Terrain Dispersion Model
dBA	Decibel
DBESA	Dombivali Better Environment System Association
DCETP	Dombivali Common Effluent Treatment Plant
DEM	Digital Elevation Model
DG	Diesel Generator
DMCs	Deputy Municipal Commissioners
DMPs	Disaster Management Plans
DO	Dissolved Oxygen
DP	Development Plan
EC	European Commission
ECBC	Energy Conservation Building Code
ESRs	Environmental Status Reports
ESZ	Eco Sensitive Zone
EU	European Union

FC	Faecal Coliform
FOB	Foot over Bridge
GAIL	Gas Authority of India Limited
GBD	Global Burden of Disease
GDDP	Gross District Domestic Product
GEMS	Global Environment Monitoring System
GHG	Greenhouse gas
GIS	Geographic Information Systems
GoI	Government of India
GoM	Government of Maharashtra
GSDA	Ground water Survey and Development Agency
HC	Hydrocarbons
HDDVs	Heavy-Duty Diesel Vehicles
He	Helium
HIL	Hindustan Insecticides Limited
HOC	Higher Organic Content
HP	Hydrology project
HW	Hazardous Waste
IGM	Indira Gandhi Memorial
ILCS	Integrated Low Cost Sanitation
IMD	India Meteorological Department
INR	Indian National Rupees
IPCC	Intergovernmental Panel on Climate change
IS	Indian Standards
IUCN	International Union for conservation of nature and natural resources
JNNRUM	Jawaharlal Nehru National Urban Renewal Mission
JNPT	Jawaharlal Nehru Port Trust
KBMC	Kulgaon Badlapur Municipal Council
KBS	Karnala Bird Sanctuary
KDMC	Kalyan Dombivali Muncipal Corporation
Kr	Krypton
LMVs	Light Motor Vehicles
LPCD	Litres per capita per day
LPG	Liquefied Petroleum Gas
LSI	Large Scale Industry
M. Cl	Municipal Council
MAHAGENCO	Maharashtra State Power Generation Company Ltd
MBMC	Mira Bhayandar Municipal Corporation
MCGM	Municipal Corporation of greater Mumbai
MCM	Million Cubic Meters
MDDL	Minimum Draw Down Level
MIDC	Maharashtra Industrial Development Corporation
MINARS	Monitoring of India National Aquatic Resources Series
MLD	Million litres per day
MMR	Mumbai Metropolitan Region
MMRDA	Mumbai Metropolitan Region Development Authority
MMR-EIS	Mumbai Metropolitan Region- Environment Improvement Society
MOEF	Ministry of Environment and Forests
MoPNG	Ministry of Petroleum & Natural Gas
MoU	Memorandum of Understanding
MoUD	Ministry of Urban Development
MPA	Maritime Protection Authority
MPCB	Maharashtra Pollution Control Board
MPN	Most Probable Number
MRSAC	Maharashtra Remote Sensing and Application Centre
MRTS	Mass Rapid Transportation System

MRVCL	Mumbai Railway Vikas Corporation Ltd
MSAAPCC	Maharashtra State Adaptation Action Plan on Climate Change
MSI	Mangroves Society of India
MSI	Medium Scale Industry
MSRTC	Maharashtra State Road Transport Corporation
MSW	Municipal Solid Waste
MT	Metric Tonnes
MUTP	Mumbai Urban Transport Project
MVDM	Motor Vehicles Department Maharashtra
N_2O	Nitrous oxide
NAAQM	National Ambient Air Quality Monitoring
NAMP	National Air Quality Monitoring Programme
NAPCC	National Action Plan on Climate Change
NAQQS	National Ambient Air Quality Standards
NBWL	National Board for Wildlife
NDC	National Data Centre
NDMA	National Disaster Management Authority
Ne	Neon
NEERI	National Environmental Engineering Research Institute
NEP	National Environment Policy
NGO	Non- Governmental Organisation
NGOs	Non-Governmental Organizations
NH3	Ammonia
NIO	National Institute of Oceanography
NITIE	National Institute of Training in Industrial Engineering
NLCP	National Lake Conservation Plan
NMMC	Navi Mumbai Municipal Corporation
NO_2	Nitrogen Dioxide
NO3	Nitric tri-oxide
NO_x	Nitrogen Oxide
NRW	Non-revenue water
NSF	National Sanitation Foundation
NWMP	National Water Quality Monitoring Programme
PA's	Protected Areas
PCNDDP	Per Capita Net District Domestic Product
pH	power of hydrogen
PM	Particulate Matter
PMC	Panvel Municipal Corporation
PNG	Piped Natural Gas
PUC	Pollution under Control
PV	Photovoltaic cells
PWLS	Phansad Wildlife Sanctuary
RCUES	Regional Centre for Urban and Environmental Studies
RH	Relative humidity
RO	Regional Office
RSPM	Respiratory Suspended particulate matter
RTO	Regional Transport Office
SAMP	State Air Monitoring Program
SDMA	State Disaster Management Authority
SGNP	Sanjay Gandhi National Park
SLB	Service Level Benchmark
SLF	Sanitary Engineered Landfill
SO_2	Sulphur dioxide
SOP	Standard Operating Procedure
SO_x	Sulphur oxides
SPCB	State Pollution Control Board

SPM	Suspended particulate matter
SSI	Small Scale Industry
STPs	Sewage treatment plants
SWMP	State Water Monitoring Programme
TBIB	1,3,5-Tris(2-bromoisobutyryloxy)benzene
TC	Total Coliform
TERI	The Energy and Resources Institute
TMC	Thane Municipal Corporation
TTC	Trans Thane Creek
TWLS	Tungareshwar Wildlife Sanctuary
UHIE	Urban Heat Island Effect
ULB	Urban Local Bodies
ULBs	Urban Local Bodies
UMC	Ulhasnagar Municipal Corporation
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
USEPA	Unites States Environmental Protection Agency
VOCs	Volatile Organic Compounds
VVMC	Vasai Virar Municipal Corporation
WHO	World Health Organization
WQI	Water Quality Index
WQM	Water Quality Monitor
WQMS	Water quality monitoring stations
WWF	World Wide Fund for Nature
YAP	Yamuna Action Plan
ZP	Zilla Parishad

Section

1. Executive Summary and Drivers

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1.1 Executive Summary

Urbanization is on rise globally and India is no exception. It is evident from the fact that, for the first time since independence, the absolute increase in Indian urban population has been more than that in rural areas in the last decade. The level of urbanization in India has also increased significantly from 27.81% in 2001 to 31.16% in 2011[1]. Although, according to Ministry of Urban Development, GoI, 50% of India's population would be living in urban areas by the year 2039[2], the process of urbanization and development are highly resource intensive. On one hand, the escalating demands and limited supply for resources like water and energy are creating severe resource crunch, on the other hand, anthropogenic activities induce stress on the ecosystem due to release of pollutants. Waste water from residential and industrial units, emissions from vehicles and industries, generation of solid waste and so on create undesirable impacts on water, air and land resources.

In this background, promoting sustainable development through effective resource management becomes highly significant. However, to draft action plans and allocate appropriate budget for infrastructure development, one needs to assess the current status of resources and develop a baseline report. Towards this, developing an ESR (Environmental Status Report) becomes an effective tool to plan efficient resource management. The ESR presents the status of the quality of various resources in the region such as air, water, landuse and land cover, its changing patterns, biodiversity, and so on, thus, helping the decision makers to come up with specific strategies. In Maharashtra, GoM (Government of Maharashtra) has already initiated documenting ESRs at various levels, district and ULB's (Urban Local Bodies), apart from documenting the Stat of Environment (SoE) for the Maharashtra, biennially. MPCB with the Department of Environment, GoM in June 2009, released guidelines that suggest the ESRs to be prepared as per the DPSIR (Driving forces - Pressures - Status - Impacts - Response) framework for significant parameters (resources) in the context of the city's environment.

Since the city of Mumbai came into existence, it is one of the fastest growing cities in the world. With the increasing population, development and growing economic activities in Mumbai and surrounding regions, the need was felt to form these areas into the Mumbai Metropolitan Region. Once the region was formed, an Authority was set up to plan, coordinate and supervises proper, orderly and rapid development of these areas (Maharashtra Act No. IV of 1975[3]). Thus the MMRDA (Mumbai Metropolitan Regional Development Authority) came into existence in 1975, as a planning and co-ordinating body. Being a planning authority it is important to know the status of the region and a need was felt to develop the status report of the Environment as well as the quality of resources in the region.

Owing to the complexity and the vastness of the region, the project was completed in two phases with defined objectives of each phase as mentioned below:

1 http://censusindia.gov.in/2011-prov-results/paper2/data_files/india/Rural_Urban_2011.pdf
2 http://indiagovernance.gov.in/files/urbandemographictransition.pdf
3 http://bombayhighcourt.nic.in/libweb/acts/1975.04.pdf

1.1.1.1 Phase I: Data collection and compilation

- **To develop a standardized framework/channel for data compilation and collection from various agencies in MMR**

  During the process of compiling the ESR of MMR, the information and data was sourced in form of reports, questionnaire surveys, personal correspondence, published papers, online literature review and so on. The agencies which were approached included ULBs (Urban Local Bodies), MPCB, Zillha Parishads, Collector offices, MIDC (Maharashtra Industrial Development Corporation), and MRSAC (Maharashtra Remote Sensing Application Centre). TERI also conducted stakeholder interviews to gauge their perceptions about the critical issues like climate variability and their preparedness for combating the projected impacts of climate change. Also the data available with various other agencies like NEERI (National Environmental Engineering Research Institute), IMD (Indian Meteorological Department) and MPCB was collected through personal correspondence and interaction. Site visits were also been made to various locations to assess the status of resources in MMR.

  As a first step for developing the regional level ESR, the Environmental Status Reports compiled by the A class ULBs in MMR were collected and the ESR for the past five years were reviewed against the framework and guidelines released by MPCB. Out of the 10 ULBs respective for the A class cities in, 9 of them publish an annual ESR except for Ulhasnagar Municipal Corporation, MMR. While the Bhiwandi- Nizampur Municipal Corporation publishes the ESR once in two years. Given that MPCB recommends specific guidelines and DPSIR framework for publishing an ESR, a matrix was developed to compare the indicators assessed in the status reports compiled by the ULB's and develop a data gap matrix to identify the data which is not been presented in ESR of the respective ULB. The missing data gaps were saturated by TERI through obtaining data from other secondary sources, interviews with officials and data logs to develop a comprehensive data matrix (Annex 1). Apart from the components of the DPSIR framework data was also compiled and collected for the resources like agriculture, mangroves, quarrying activities, biodiversity, forests, climatic parameters, salt pans and so on.

1.1.1.2 Phase II: Data analysis and reporting

- **To analyse the collected data and prepare the ESR for MMR**

  Based on discussion with MMRDA and guidance from members of the Hon'ble subcommittee of MMR EIS (Environment Improvement Society), the environment status report has been developed as per the DPSIR framework. This report firstly discusses the growth in term of population, economy, industrial units and infrastructure and so on which by and large are the driving forces of the region which lead to pressure on the resources in terms of water, energy and land. Further the report discusses in detail the status of, (1) Air Quality, (2) Water Resource, (3) Land Resource and a special section on (4) Climate Variability in MMR. The summary and highlights of each of the technical subsections is given below.

1.1.1.3 Driving Forces

Availability of natural resources, easy access to urban services and markets, favourable climatic conditions, transport facilities, and abundant human resources are the major parameters which drive the financial, economic, commercial and social growth of MMR.

These parameters are largely interdependent on each other and a slight imbalance may result in severe implications on several dependent entities and allied sectors. But factors like population growth, industrial growth, economic growth, human resources and so on have induced severe pressure on natural resources like air, water and land. To support the increasing population, resource demand especially for water, food, clothing and energy (electricity & fuel), are simultaneously growing at an exorbitant and unprecedented rate.

Population growth is the most crucial driver of the region. It is evident from the fact that about 20% (23.13 million[4]) of Maharashtra's population reside in MMR. In terms of total population, MMR ranks 8th amongst the top 20 metropolis globally. Employment opportunities in MMR, has resulted in attracting the migration of population to the region. In the span of 40 years (1971-2011) the population of MMR has increased by almost 197%, with a CAGR (Compound Annual Growth Rate) of almost 2.75%. As on 2011, MMR accounts for almost 34% of Maharashtra's urban population of the state.

The MMR is highly influenced with the economic growth of Mumbai city and the region has registered significant growth over the years. The GDDP (Gross District Domestic Product[5]), in MMR has been increasing steadily at a CAGR (Compound Annual Growth Rate) of 14.92% over the past 4 years. In 2011-12[6] the GDDP of MMR was recorded to be INR 4,49,697 crores which is almost 1.5 times that of the year 2008-09[7] (2,96,238 crores). The economic growth of the region has also influenced the per capita economic growth of the population in MMR. In terms of PCNDDP (Per Capita Net District Domestic Product) the region has a steady CAGR of 13.31%. In the last four years the PCNDDP of the MMR has grown by almost 1.45 times from INR 2.82 Lakhs in the year 2008-09 to INR 4.11 Lakhs in 2011-12. One may note that the Raigad district has recorded the highest growth in the last two years; the PCNDDP in the region has increased 1.51 times in the same period with a CAGR of 14.81%.

Industrial growth is also one of the key driving forces for growth for MMR since it has a strong presence of corporate, prominent industries, research institutions, government sector, entertainment & media, retail, construction, hotel industry, educational institutes and so on. The major industrial belts in MMR area are spread across TTC (Trans-Thane Creek), Taloja, Waghale estate, Dombivali, Ambernath, Bhiwandi and so on. There are almost 16058 industrial units including SSI (Small Scale Industry), MSI (Medium Scale Industry) & LSI (Large Scale Industries) across red, orange and green categories as specified by CPCB (Central Pollution Control Board). The industrial units in Mumbai and Thane region have decreased by almost 32% and 17% respectively but there is a gradual increasing trend in number of industries in Navi Mumbai (17%) and Kalyan (38%) regions and a very sharp growth in the Raigad region of about 44% in the between 2008 and 2012.

[4] Provisional Census data 2011

[5] Average taken for the districts of MMR – Mumbai, Mumbai Suburban, Thane and Raigad

[6] Government of Maharashtra, and *Economic Survey of Maharashtra 2011-12*, Annexure 3.9, Gross/Net District Domestic Product And Per Capita Net District Income, pps 34

[7] Government of Maharashtra, *Economic Survey of Maharashtra 2008-09*, Annexure 3.8, Gross/Net District Domestic Product And Per Capita Net District Income, pps 32

1.1.2 Water Resource

MMR is bestowed with numerous water resources such as rivers, lakes, ponds, dammed reservoirs, underground aquifers, wetlands, estuaries and so on which have tremendous environmental as well as resource significance. Approximately 671.2 sq.km (15%) of the total area of MMR is covered with wetlands and water bodies as per the land use pattern netted by MRSAC, GoM in the year 2006. These wetlands maintain a natural balance in the environment, while supporting a wide variety of flora and fauna. They also provide protection against floods and act as a buffer zone for the region. Furthermore, MMR has a coastline of 256 km, which supports a large fishing community comprising of around 160 thousand people for whom fishing is the only source of livelihood.

In MMR, the surface water resources comprise 13 west flowing rivers; their 21 tributaries, more than 431 water bodies (lakes and ponds) and approximately 22 reservoirs/dammed reservoirs within the municipal limits of the various ULBs. However, the number of water bodies existing in the region is only a rough estimate as there is no comprehensive study or inventory been developed for the entire region. Further there are more than 5660 dug wells, 7511 tube wells, 1906 bore wells and 3715 hand pumps which form a source to extract ground water in the MMR municipal limits[8].

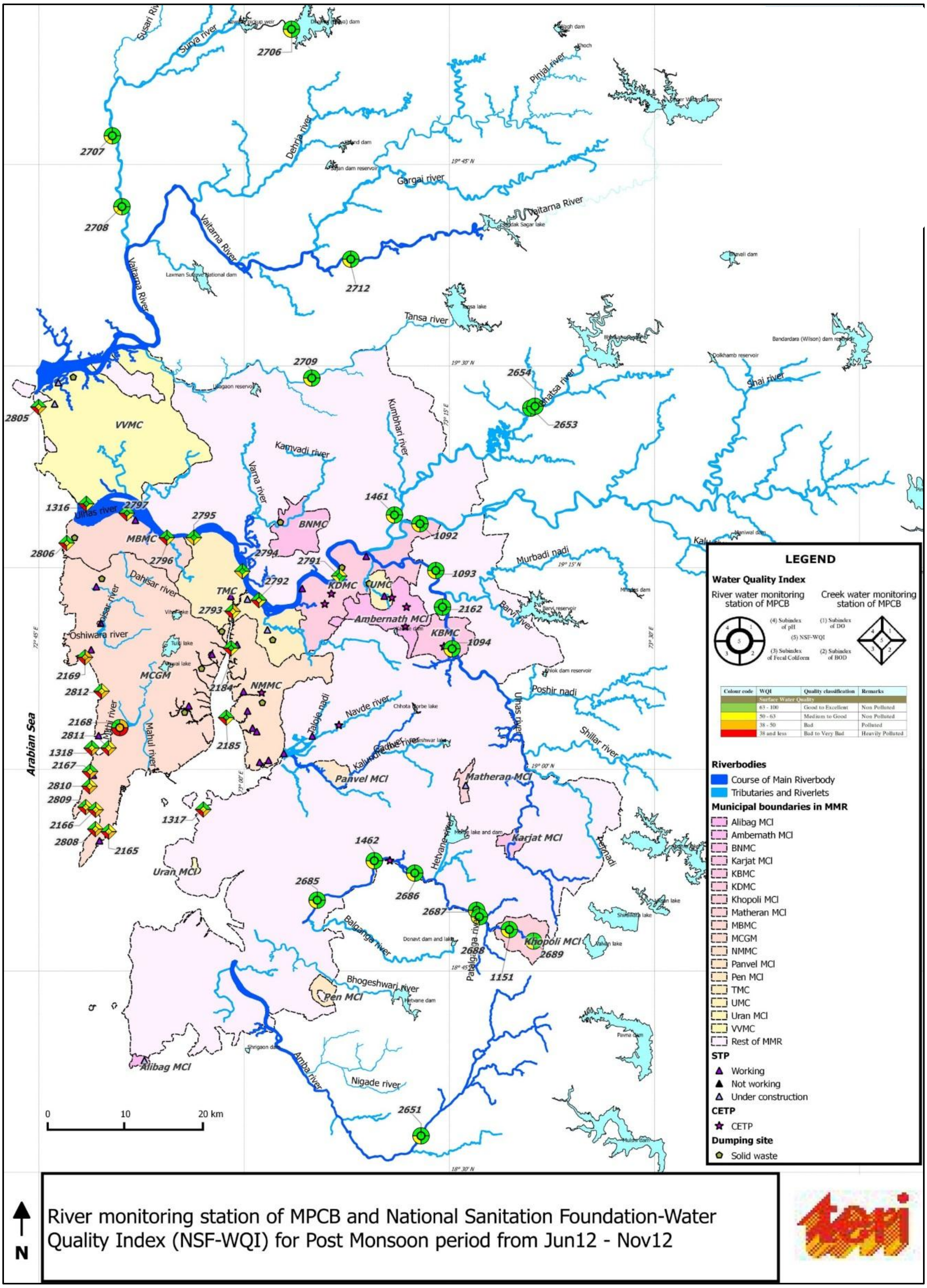
1.1.2.1 Water quality index of river & creek water[9]

The surface water quality in MMR is monitored at 44 WQM (Water Quality Monitoring) stations (21 on rivers & tributaries and 24 on creek/sea), under the NWMP (National Water Monitoring Programme), initiated by CPCB (Central Pollution Control Board) and SWMP (State Water Monitoring Programme) initiated by MPCB. The WQI (Water Quality Index) was computed by TERI using modified NSF (National Sanitation Foundation) formula for pre and post monsoon period for the year 2012-13 to get an overview of the status of water quality. The parameters considered were DO, BOD, FC and pH. Other statistical methods were also applied to arrive at the trend of the results as seen in Map No. 1-1.

The data monitored at the WQMS for all the river in MMR indicated 'Good to excellent' water quality during post monsoon period except at Mithi River. Whereas during pre-monsoon period, 2 locations (WQMS no. 1092 on Ulhas and WQMS no. 2685 on Patalganga river) indicated medium to good water quality and WQMS on Mithi River indicated 'Bad to Very Bad' water quality. The water quality was majorly affected due to increase in the fecal count which may be due to direct discharge of human sewage, fecal waste of mammals and birds, or from agricultural and storm runoff.

Further, the seafront/creek water quality during post monsoon was found to be good quality except at a sampling location near Oshiwara River (WQMS 2169). Whereas during pre-monsoon, 21 WQMS (87% of the sampling locations) revealed bad water quality due to higher BOD and FC content. Hence, it is strongly recommended to implement strategies to ensure that the creek water quality is in the acceptable range and the prevailing norms for improving & maintaining the creek water quality is been strictly followed and executed. Also it is recommended to have uniform distribution of WQMS to get an overview of the water quality of the entire coastline. The infrastructural and institutional gaps need immediate attention and appropriate co-ordination between the nodal agencies, regulatory bodies, the respective ULBs and MMRDA.

[8] Details in respective sections on water of this report- Volume 2
[9] Details in respective sections of this report- Volume 2



Map No. 1-1: Water Quality Index for rivers for post monsoon period

Source: MRSAC, MPCB and Environment Status Reports (Refer Annex 18 for A3 size map)

1.1.2.2 Issue with water bodies (lakes and ponds) & dammed reservoirs

The water bodies in MMR are in extremely bad condition and in varying degrees of environmental degradation due to illegal encroachment, dumping of sewage, garbage, construction debris and embankment of the edges. Hence it is recommended, to formulate stringent regulations for sustainable development in the vicinity of the water bodies and marking of all the water bodies in the Development Plan to ensure that they are protected and the land use pattern remains unchanged.

Further in MMR, there are currently 12 major dams planned or under construction for supplying drinking and industrial water. It is estimated that, the development of dams/dammed reservoirs, would displace more than 30000 tribes and submerge more than 14000 hectares of primarily tribal land, including 6062 hectares forest land[10] within the global biodiversity hotspot of Western Ghats. Hence it is strongly recommended to carry out a detailed impact assessment study, to conserve the remaining forests and tribal communities of Western Ghats of Maharashtra.

1.1.2.3 Status of ground water resources & its quality[11]

The dependence of the region on the ground water resources is to the tune of 293.35 MLD (Million Litres per Day). The ground water quality is monitored by CGWB, GoI (Central Ground Water Board, Government of India) and MPCB. In all, there are 47 ground WQM stations in MMR *(44 WQMS installed by CGWB and 3 by MPCB).* However the data for all the parameters for the MPCB WQMS was not available and hence the detailed assessment could not be carried out. For the remaining 44 WQMS, the assessment revealed that 71% of the sampling locations had good water quality whereas 9% showed poor water quality due to agricultural run-off, leakages from septic tanks and so on.*(For the remaining 20%, the secondary data was not available for assessment*.) Further, 43% of the monitoring locations exhibited decreasing trend in the water level due to over extraction, especially the Vasai Virar and parts of Raigad district. Hence, it is strongly recommended to improve the groundwater level by recharging the ground through rainwater harvesting.

1.1.2.4 Status of water supply and sewerage[12]

The water demand of the region is primarily met through surface water resources which includes 4 major rivers namely Vaitarna, Ulhas, Patalganga, and Amba. These river basins constitute the Mumbai hydrometric area and are spread across a total catchment area of 5756 sq. km. The present demand of the entire region is estimated to be 6725 MLD which includes demand from domestic, industries, and irrigation sector. As against this demand, the amount of water supplied is to the tune of 5449 MLD indicating a deficit of 1276 MLD. Water resources have also been identified for augmentation to reduce this demand supply gap. A number of government agencies namely Maharashtra Jeevan Pradhikaran (MJP), Maharashtra Industrial Development Corporation (MIDC), various municipal corporations/councils and Irrigation Department are involved in water resource development and supply. However, these agencies have been developing resources to suit their individual requirement and without any

[10] Parineeta Dandekar, Himanshu Thakkar,South Asia Network on Dams, Rivers and People (SANDRP) *Report- Dams in tribal belt of Western Ghats for the Mumbai Metropolitan Region: None are justified – Better options exist*

[11] Details in respective sections of this report

[12] Details in respective sections of this report

organized holistic plan of action for the entire region. Hence it is recommended to have unified perspective in planning, management and efficient use of water resources.

Further, 4753 MLD of waste water is generated in the region, out of which only 59% is treated to some extent (either primary or secondary). Hence it is recommended to set up efficient sewage treatment facilities and treat 100% of the wastewater generated in the region to an extent of tertiary treatment followed by biological treatment before its further recycling. Lastly in the report, the service level performance of all the ULBs, were compiled and collated to get an overview of the water and sanitation sector in MMR.

1.1.3 Air Quality

Air pollution in MMR is of major concern owing to presence of industries and heavy traffic in the region. High population density in the region makes the issue worst, exposing them to high pollution levels. In the background, monitoring the air quality parameters with appropriate and state of art monitoring infrastructure in a scientific manner is of critical importance. To determine the quality of air it is essential to monitor the level (concentrations) of air pollutants in the air as against the concentration which may lead to harmful health effects. Air quality in MMR, is monitored by MPCB (Maharashtra Pollution Control Board), ULB's (Urban Local Bodies) and some Industrial units.

1.1.3.1 Monitoring Infrastructure

As on March 2013, there were 25 monitoring stations under NAMP (National Air Monitoring Program) and SAMP (State Air Monitoring Program). These stations monitor the ambient air quality with a frequency of almost two monitoring days per week for SO_2 (Sulphur dioxide), NOx (Oxides of Nitrogen) and RSPM (Respirable Suspended Particulate Matter) levels. However 25 AAQMS for a vast region like MMR is very less. As per CPCB (Central Pollution Control Board) guidelines a minimum of 160 regular monitoring stations are required in MMR to appropriately represent the air quality of the region. The highly congested areas like Saki-Naka, Ghatkopar, Kurla, Andheri, Vasai Virar Mira-Bhayandar have no monitoring stations. Also the sensitive areas in MMR, like the Sanjay Gandhi Park, Matheran eco-sensitive zone and Karnala bird sanctuary has no air monitoring setups. Establishing state of art infrastructure for monitoring air quality with real time data transmission at a centralised centre is highly recommended for the region.

1.1.3.2 Air Quality

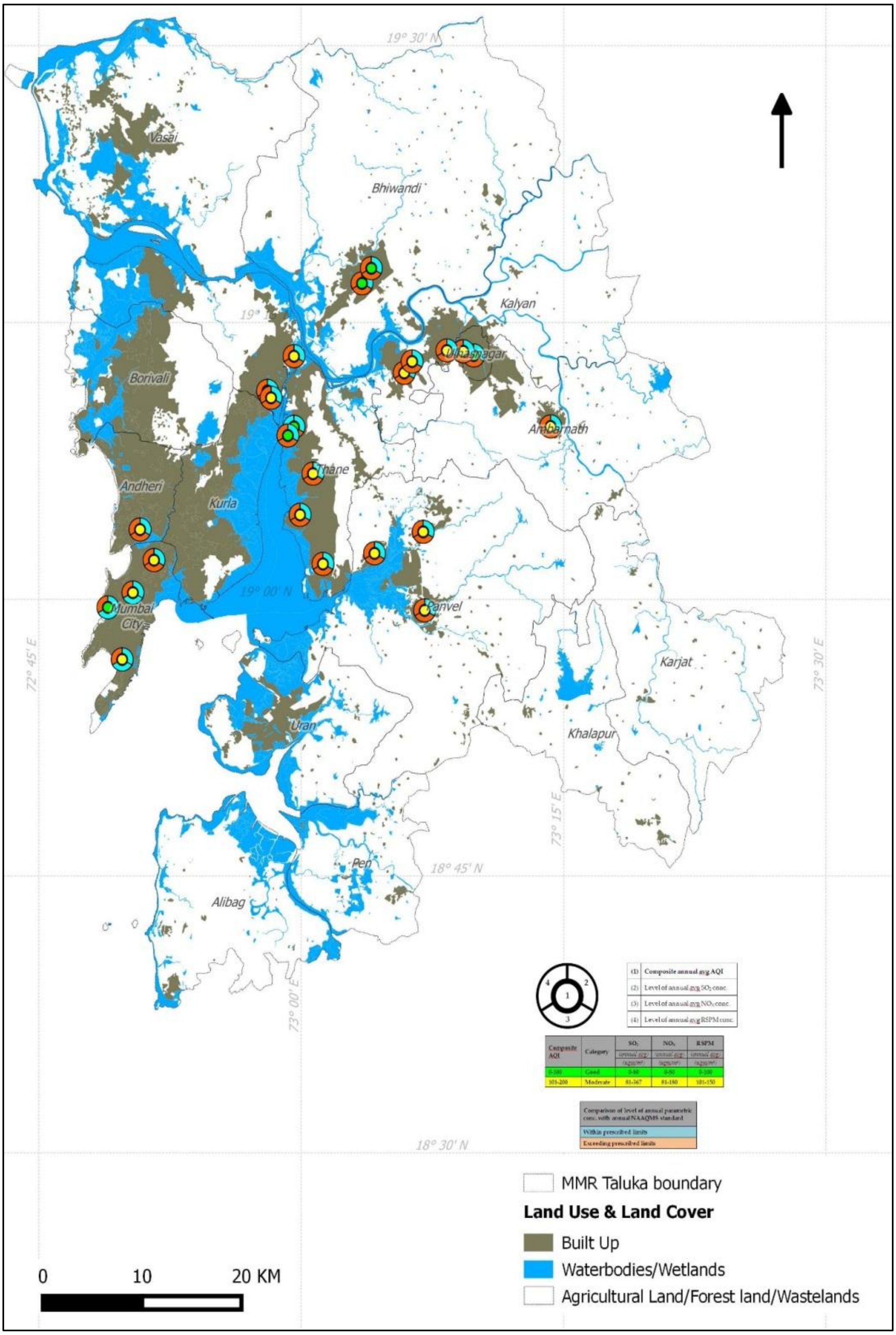
Determining the quality of air based on different pollutants becomes a bit complicated. Hence, to provide an easy to comprehend information about the air quality for general public, the AQI (Air Quality Index) was developed based on the data recorded by the AAQMS in MMR and the calculation is further elaborated in the technical section. As seen in Map No. 1-2, high concentrations of RSPM and NOx are of major concern in the MMR region especially in the regions of Mumbai, Navi Mumbai and Thane. The industrial areas of Dombivali, Ambernath are highly polluted since the concentrations of all the three pollutant exceeded the respective standards. These are the most preferred areas for migration since the accommodation in these areas is still economical as compared to the other regions in MMR. These regions are amongst the most polluted regions not only in MMR but also in the state of Maharashtra. Further a SPA (Special Panning Authority) is highly recommended for this region to appropriately plan the development of this region since this region is a booming sector for real estate and population migration owing to affordable housing and better connectivity to South Mumbai

In terms AQI of the MMR, only three AAQMS in MMR, viz Kalyan (Bail Bazar), Bhiwandi (Pematai hall and IGM Hospital) recorded 'Good' AQI for almost all the readings/ observations at that AAQMS. While industrial areas like Dombivali, Ambernath, Taloja, Ulhasnagar recorded Moderate and Poor AQI for more than 50% of the observations. The AAQMS at Sion recorded Good Air Quality for mere 26% of the observations while recorded 'Poor' Air Quality for more than 42% of the times.

Although the other regions in MMR recorded SO_2 concentrations well within the annual standards (50µg/m^3), the MIDC areas of Dombivali (50µg/m^3) and Ambernath 42µg/m^3 recorded annual SO_2 concentration close to standards indicating high concentrations of SO_2 in those areas. As for the NOx concentrations 16 out of 25 monitoring stations violated the annual standards. The regions of Kalyan, Ambernath, Dombivali, Badlapur, Ulhasnagar and Navi Mumbai recorded high levels of NOx concentrations. Owing to heavy traffic, congested roads and idling emissions from vehicles the NOx levels at Sion region have recorded the highest annual NOx concentrations (106µg/m^3) in MMR followed by Dombivali (94µg/m^3), Ambernath (91µg/m^3) and Ulhasnagar (81µg/m^3) areas which are highly industrially influenced.

High concentrations of RSPM are of great concern in MMR. All the regions recorded high levels of RSPM and violated the annual standards (60µg/m^3) of RSPM set by CPCB. Since these are fine respirable particles they have severe health impacts in terms of cardio-vascular, respiratory tract and lung related diseases. Panvel (168µg/m^3), Taloja (129µg/m^3) and all the AAQMS in Navi Mumbai region recorded high RSPM levels in MMR. These areas are highly influenced with quarry sites and construction activities. Moreover, road dust re-suspension, movement of vehicles and irresponsible construction activities could be directly attributed to high RSPM levels in MMR. Towards this, strict measures need to be taken at the construction sites by adopting green building guidelines, efficient operating measures at quarry sites, appropriate sweeping of the roads and so on.

Noise pollution is also a major concern in MMR especially in the residential and silence zone. As per trend in the noise monitoring the industrial locations maintain the noise levels within the standards. The average noise level at all the 42 locations, during Ganesh Utsav exceeded the 65 dB(A) limits, the stringent among the residential, commercial and silence zones. The highest noise levels were recorded in areas of Bandra and Mulund of about 97.5 dB(A). While the areas of Dadar, Chinchpokli, Wadala, and many areas of Thane and Kalyan, recorded peak noise levels of more than 90 dB(A). Similarly during the Diwali festival also MPCB records noise levels across 72 locations in spread across Greater Mumbai, Thane, Mumbai, Kalyan, Ambernath, Dombivali and Ulhasnagar in MMR. The peak readings for all the areas in MMR exceeded more than 75 dB(A), exceeding the limits of 65dB(A), by more than 10dB(A), set as day time limits for residential area.



Map No. 1-2: Annual average Air Quality across monitoring locations in Maharashtra 2012-13

Source: Data Sets from MPCB, GIS attributes from MRSAC Map generated by TERI

(Refer Annex 18 for A3 size map)

1.1.4 Climate change

With its ever increasing population density of 4549/sq km in 2001 to 5403/sq km in 2011 and by the virtue of being large and highly multidimensional in nature, the Mumbai Metropolitan Region (MMR) poses several inherent challenges and vulnerabilities which are further compounded by the climatic variations. Thus in this section an attempt has been made to assess the impacts of the climatic variations pertaining to four parameters viz; rainfall, temperature, humidity and wind speed on various resources and sectors pertinent to the region while further establishing linkages with the preparedness of the Urban Local Bodies (ULBs) within the region.

1.1.4.1 Rainfall and Flood assessment

The assessment of monthly rainfall datasets showed a clear decrease by 7.7% and 6.5% of the very light rainy days and light rainy days respectively for the region, whereas, there was 23.6% and 26.9% increase in the category of heavy rainy days and very heavy rainy days. Further, the rainfall was observed to be exceeding the long term average in July and August months especially in the past decade. Thus, the region is expected to be wetter in coming years with these variations. A detailed flood assessment undertaken for the region comparing heavy rainfall events with high tide levels and the consequent impacts showed that water logging situation in the region is essentially a compounded impact of heavy rainfall and high tides together. Various low lying areas were identified and were cross validated through accuracy analysis with the published government literature available.

1.1.4.2 Wind and Humidity

The study showed an increase in the humidity levels by nearly 2% especially during the day whereas 3% decrease in the evening humidity levels with the variations remaining more or less the consistent with no specific trend identified over the years. However, it was observed, that the wind speed showed a sudden and sharp decrease of 12km/hr to 6.5km/hr in four decades which seemed to be debateable. Thus, a further research as recommended for this parameter to deduce conclusive findings.

However, the consultations with the government officials of the Urban Local Bodies (ULBs) and the local communities revealed a slightly different picture. While there were agreements on the temperature rise, the communities experienced an increase rainfall along with a prominent delay in its onset, whereas the data assessment did not reveal shift in the onset dates. Further to these, discussions with the officials in the ULBs, it was learnt that there lacks a definite understanding about the difference between climate change and environmental degradation. Thus, a very specific training for the officials on climate change, its impacts and its significance on improving the urban resilience is required to be imparted.

1.1.4.3 Temperature

The average annual temperatures showed a clear increase over the past 4 decades. The assessment showed a clear increase in the minimum as well as maximum temperatures over the region. It was very prominently observed that the maximum temperatures are seen to be increasing between the range of 0.7°C- 1.0 °C, whereas the minimum temperatures are also showing a rising trend between 0.4°C-0.6°C.Similarly the hot days for the region also observed a rising trend in the past 4 decades, where the number has been increased from 4 in 1971 to around 12 days in 2011. It could be thus said that the region is becoming hotter with increase in time.

As a response to these assessments, very specific (region as well as sector) recommendations have been articulated to further strengthen the regional plan. Undertaking a **detailed spatial study for assessing the vulnerability and resilience** of the region to flooding and heavy rainfall, orienting the Disaster Management Plans to integrate the climatic variations and feedback from these plans to be provided to the planners and policymakers in order to increase resilience of the ULBs towards untimely climate catastrophes, formed some of the key recommendations pertaining to flooding and rainfall variations in the region. For mitigating the Urban Heat Island Effect and its impacts coupled with rise in urban temperatures, recommendations like the making the use of **pervious surfaces in the new developments** to be made mandatory while also undertaking detailed assessment of the Urban Heat Island Effect for the entire region were proposed. Apart from the specific recommendations, other overarching recommendations like making the implementation of **Energy Conservation Building Code (ECBC) and Solar Passive architecture** techniques mandatory for the upcoming and new construction in urban as well as peri urban areas were also prominently highlighted.

1.1.5 Land Resource

1.1.5.1 Land Cover and Land Use

MMR (Mumbai Metropolitan Region) possess a variety of land cover types such as the coastal front, mangroves, forest area, hillocks, agricultural land and numerous water bodies within its jurisdiction. Out of the total 4427 sq. km (Table No. 1-1), almost 35% (1536 sq.km) of the land is covered by agricultural land (Map No. 1-3) followed by forest which is almost 21%. Being a coastal city, mangroves, saltpans, marshes, tidal zones and mud-flats accounts for a total of 13% (~565sq.km) of the land use while 14% is shared by the built up area. This built up area accommodates 23million individuals indicating a high population density with more than 37,000 persons per sq.km. The land resources and the land use has undergone various changes over a period of 20 years, and there has been a remarkable reduction in the share of agricultural and forest land by 7% and 5% respectively. The built-up area in MMR has increased by 2% accounting to an increase of about 58 sq.km. Quarrying activity is rampant in the region, mainly in the talukas of Thane, Bhivandi, Panvel and Kalyan largely affecting the environment and ecology of the region. As on January 2014, there are about 200 operators in MMR who have been provided with lease to undertake stone quarrying and stone crushing activities. The total active sites under quarrying activity add to a total of 4.5 sq km area within MMR.

1.1.5.2 Agriculture Land

Agriculture is an important source of livelihood for the rural population in MMR, where paddy is the main Kharif crop which contributes significantly to the production of rice in the state. On an average MMR has been contributing about 10-11% of the state's rice production in the past few years. Cultivation of horticultural plants like Banana, mango and Sapota (Chikoo) is also practiced on a large scale in Thane district especially in Ambernath, Bhiwandi, Kalyan Thane and Vasai talukas, while Agro-horticultural plantations are abundant in all the talukas of Raigad district in MMR. Although agricultural land is a significant resource, it is under tremendous stress as the owners of these lands usually sell or abandon the cultivable land for high economic values offered by the builders and developers leading to high conversion rate of agriculture land to NA (Non –Agricultural) plots. The highest change in land use land cover in past 20 years has been recorded in the agricultural land under paddy cultivation in the highly urbanised areas of Thane (50%), Vasai (19%), Ambernath (12.5%) and Kalyan (4%). If this land conversion/loss in MMR could have been avoided over the years, it would have then produced about 8,400 tons of rice in the year 2011-12 as per the decadal average productivity of paddy in those talukas.

1.1.5.3 Biodiversity

The MMR region is also rich in biodiversity it comprises of nearly 1484 species of flowering plants, 169 species of birds, 52 species of mammals, 64 of herpeto-fauna (52 reptiles and at least 12 amphibians) and about 115 of butterflies. The PA's and other habitats prove to be a home for variety of faunal species consisting of mammals, birds, herpeto-fauna and so on of which many are found to be belonging to International Union for Conservation of Nature and Natural Resources (IUCN) red data book categories and also endemic to the western Ghats.

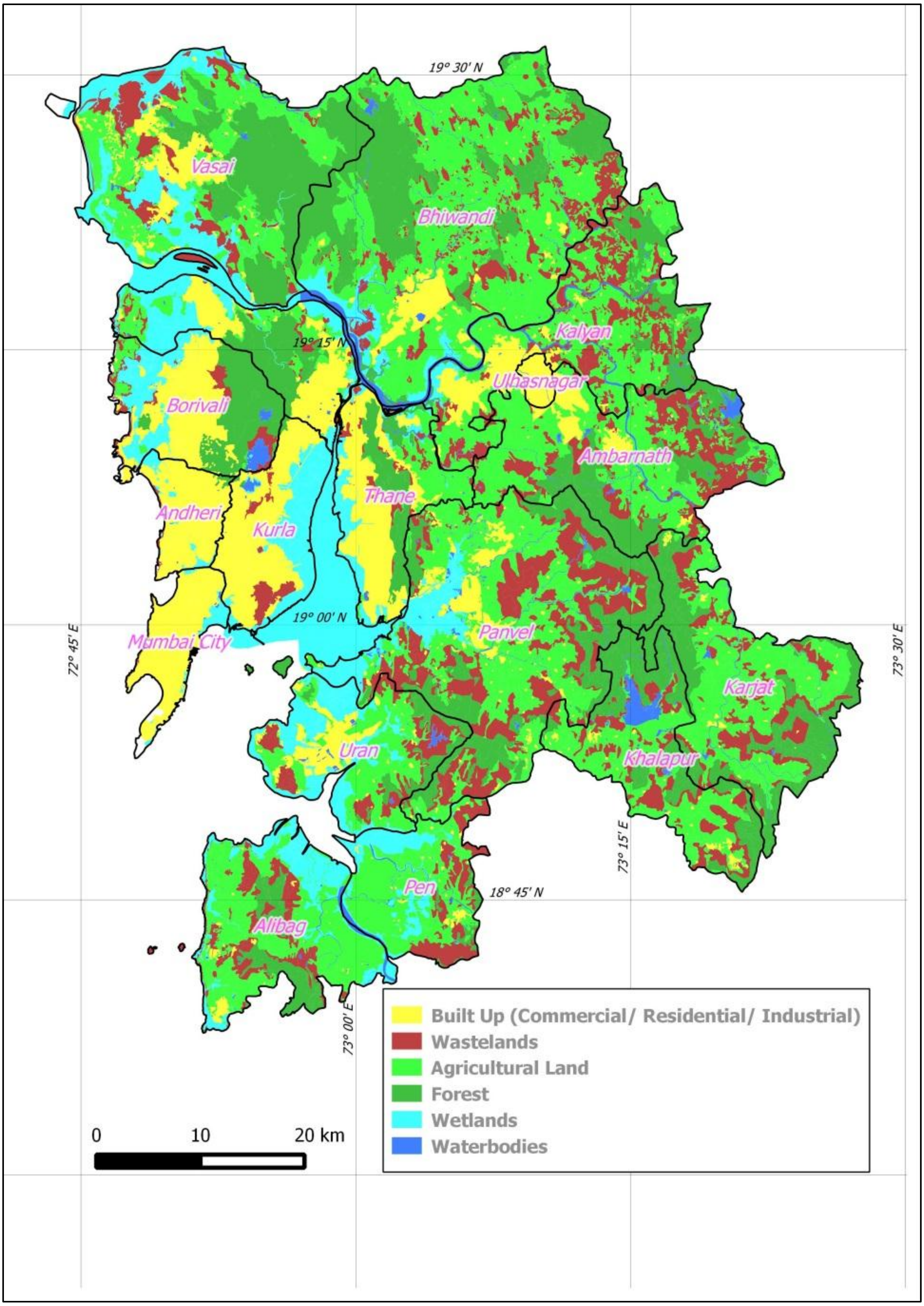
1.1.5.4 Protected Areas

MMR has 3 Protected Areas (PA's), viz the Sanjay Gandhi National Park (SGNP), Karnala bird sanctuary and Tugareshwar sanctuary and 1 eco-sensitive zone of Mahtheran within its limits. In addition 2 PAs, Phansad and Tansa wild life sanctuary, lie along the periphery of MMR. The forest in MMR is dominated by the southern mixed-deciduous forest type, with a lesser extent of dry-deciduous, semi-evergreen and evergreen types and is known to be a major carbon sink absorbing carbon-monoxide and carbon dioxide. However, urbanisation has resulted in severe deforestation reducing the forest covers in the region. In 1987, the forest cover of MMR accounted for almost 1142 sq.km, i.e. more than 1/3rd area of MMR was under forest cover. However, there has been a drastic change in the same and the absolute area under forest cover has reduced by around 225sq.km almost leading to an overall reduction by 5%. Also illegal encroachment, forest fires, tourism activities and so on prove to be potential threats for these PAs leading to a situation of fragmentation of the habitats.

Table No. 1-1: Existing land use share in MMR

Land use type	Area (Sq Km)	Share (%)
Agricultural Land	1563.3	35.3
Forest	917.1	20.7
Wastelands	656.2	14.8
Built Up	619.2	14.0
Wetlands	564.7	12.8
Water-bodies	106.5	2.4
Grand Total	**4427.0**	**100.0**

Data Source: As per attributes provided by MRSAC, GoM, 2006



Map No. 1-3: Spatial representation of existing land use in MMR

Source: MRSAC, GoM (Refer Annex 18 for A3 size nap)

1.1.5.5 Mangroves and Saltpans

Wetland ecosystem forms integral part of MMR with major habitats like mangroves and saltpans. Other habitats present are mudflats, freshwater lakes, rivers and creeks. The total area of wetland present in MMR is around 564.7 sq.km. Mangrove wetlands prove as a boon for the regions as it provides a barriers against any oceanic calamity like tsunami and sea level rise. Around 15 species of mangroves are found in the region spread across 193 sq.km[13]. But they are under tremendous stress owing to various pressures from developmental changes, pollution, dumping of debris, solid waste, reclamation, deforestation and so on which has resulted in a loss of almost 40%[14] of the mangrove area in last ten years. Proper legal implementation and management of the CRZ (Coastal Regulatory Zone) norms would help reduce the impacts on mangroves leading to its conservation. MMR coast has been ideal for the production of salt. Mumbai's saltpans are spread over 13 pockets across the eastern suburbs of Ghatkopar, Chembur, Wadala, Kanjurmarg, Bhandup, Mandale, Turbhe, Nahur and Mulund, and the western suburbs of Dahisar, Mira Road, Bhayander, Malvani and Vihar. In the year 2013-14 the total salt production from the districts of MMR was about 2.52 lakh MT (Metric Tons) accounting to about 98% of the states salt production. The saltpans today face serious threat from the construction lobby of the region leading towards a mild decline in the overall area and production.

1.1.5.6 Solid Waste

As, MMR is highly industrialized, urbanised and densely populated high amount of municipal, biomedical and hazardous waste is generated. As on March 2014, it is estimated that about 13,000 MT/day of MSW (Municipal Solid Waste) is generated in MMR, the highest than any other metropolis in the country. Greater Mumbai generates more than 70% of the total solid waste generated in MMR. As per statistical record of MPCB, there are about 17,681 HCE's (Health Care Establishments) in MMR which generate about 13,000 kg of BMW (Biomedical Waste) per day. There are about 5 agencies in MMR which operate the collection, transportation and treatment of BMW which includes incineration, autoclaving, shredding, effluent treatment and washing. In MMR about 1.11 Lakh tons of hazardous[15] waste is generated per year and its management is under the purview of MPCB. The hazardous waste from the regional offices of MPCB, segregated into 5 regional offices namely Mumbai, Navi Mumbai, Thane, Raigad and Kalyan. Treatment of the hazardous waste is undertaken at two facilities at Taloja and TTC (Trans Thane Creek) centres. According to a survey carried out by MPCB in 2007, MMR region is the highest e-waste generating region in the country. MPCB has authorized centres for collection, dismantling and recycling of e-waste. Currently, there are twelve centres authorized and registered to dismantle e-waste generated in MMR region. Solid waste management and disposal is one of the sectors which needs urgent attention both at the regional and ULB level.

[13] As per data retrieved from data attributes shared by MRSAC

[14] V. U. Joshi, et al., Chapter 8, *Environmental Conflicts in Coastal Metropolitan Cities in India: Case Studies of Mumbai and Chennai Metropolitan Regions*, Solutions for Environmental contrasts in Coastal Areas, Vol. 4. Environmental Conflicts in Coastal Urban Areas, pps. 320-354

[15] Annual Report of MPCB 2010-11

1.2 Driving Forces of the Region

1.2.1 MMRDA establishment and evolution

Mumbai city, formerly known as Bombay, is not only the capital of the Maharashtra but also regarded as the most important financial hub of the country. Although Mumbai is one of the most populous cities across the globe, originally it was inhabited by small groups of fishermen community locally known as '*Koli*', across a group of seven islands. There have been several records regarding the names of these islands as they may have been called during the respective eras.

The oldest records of the names of the islands have been documented in a letter written by Dr. John Fryer, a physician by profession working with the East India Company, visited Mumbai in 1672-81. According to him the names of the islands were Mumbai, Salsette, Trombay, Elephanta, Khanderi, Underi and Henery[16]. While, a report by Mumbai Port Trust mentions the islands as Colaba, Bombay, Mazgaon, Worli, Mahim, Matunga, which is illustrated in

Map No. **1-4**.

Dr. Fryer further stated that the island was initially called 'Salsette', a word whose etymology is unknown, but in Portuguese, '*sal*' means salt and '*sete*' means island[17,18]. There are other records of the islands being known as '*Bombaim*' or '*Boombay*', by the Portuguese, meaning good bay, however as per Dr. Fryer, the name '*Salsette*' came from the Marathi word '*Shashti*', which also means sixty six, the number of villages that the island was supposed to be composed of. Until 1996, the city was known as Bombay, after which it was changed to 'Mumbai' according to Corporation Resolution No.512 dated August 12, 1996, Maharashtra Act, XXV of 1996, of Municipal Corporation of Greater Mumbai[19], owing to the presence of temple of Hindu Goddess 'Mumba Devi' in the city[22].

Table No. 1-2: Names of the islands of Mumbai

Name of the islands	Source
Bombay, Salsette, Trombay, Elephanta, Khanderi, Underi and Henery	Book titled '*South Asia*'; By Donald Frederick Lach, Edwin J. Van Kley
Bombay, Colaba, Old Woman's Island (Little Colaba), Mahim, Mazagaon, Parel, Worli	As published by TATA institute of Fundamental Research[20]
Colaba, Bombay, Mazgaon, Worli, Mahim, Matunga	Mumbai Port Trust

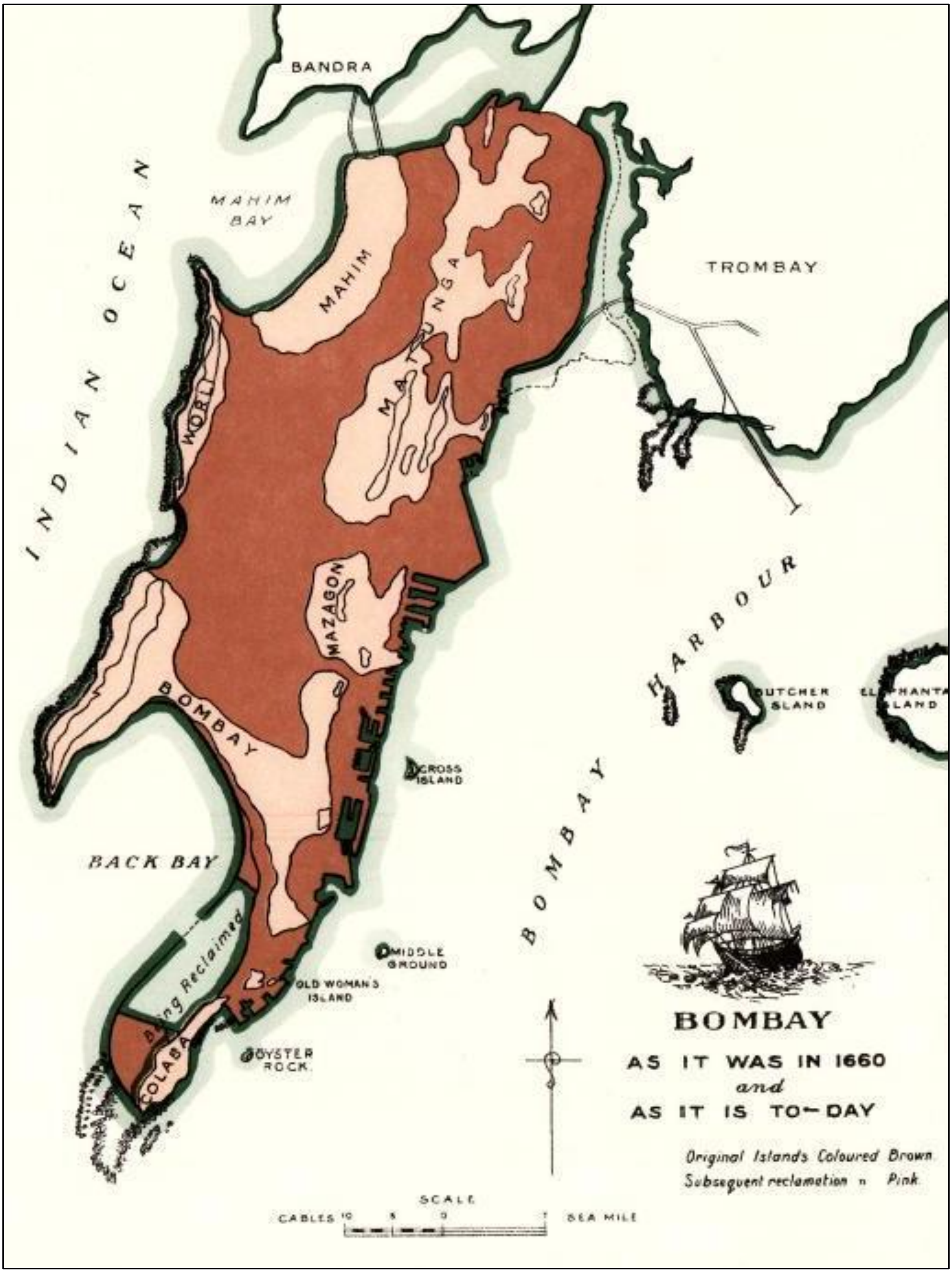
[16] Lach D. F. and Van Kley E. J. (1993). *Asia in the Making of Europe*, Volume III: A Century of Advance. The University of Chicago Press, pp 756

[17] Kleniewski N. and Thomas A. R. (2011). Cities, Change and Conflict. A Political Economy of Urban Life. Wadsworth Cengage Learning. USA. Pp. 153

[18] Derived from Google Translate. Retrieved from https://translate.google.co.in/?hl=en&tab=wT#pt/en/sal

[19] http://www.mcgm.gov.in/irj/portal/anonymous?NavigationTarget=navurl://d20cb3d618ee8cb6c3a780df7c5 8030c

[20] TATA Institute of Fundamental Research



Map No. 1-4: Islands of Mumbai as per records maintained by Mumbai Port Trust

Source: Mumbai Port Trust

1.2.2 From Portuguese to English

The Portuguese were the first to inhabit these islands in A.D.1543[21]. In 1661, when Princess Catherine de Braganza from the Royal House of Portugal married King Charles II of England, these islands were given as a part of dowry. With this event, the British officially started inhabiting the islands. King Charles further leased it to East India Company who made 'Mumbai', as the company's headquarters and principal trading port[22]. Gradually, the city became the capital of Bombay Presidency, which included many parts of Western India, Pakistan and Arabian Peninsula[22].

1.2.3 Development: From 1600 to 1700

Governor Gerald Aungier (1672-75) was among the pioneer contributors who helped in shaping the city of Mumbai. He realised the potential of the coastal city and quoted Mumbai as *"the city which by God's assistance is intended to be built*". He took special efforts to encourage the best of families from different regions to settle in the city. It was during his administration that the trade flourished in the city as he exempted all goods, imported or exported, from custom duties. He established the first mint in the city in 1672. The Parsis from Gujarat, who are said to be the migrants from Persia, settled in Mumbai as officers and merchants during his tenure. Hereon, the city prospered mainly through trade and it is what is known to have contributed largely to the development and cultural fabric of the city.

In the latter half of the next century (1750-1800), Governer Hornby Vellard, commissioned the first civil engineering project in Mumbai. Although the directors of East India Company opposed it, Governer Vellard started this project of transforming the original seven islands into one land mass in 1782 and completed it by 1784[23,24]. The purpose of the project was to block the Worli creek and prevent the low-lying areas of Mumbai from being flooded at high tide. This helped connecting Mumbai to other regions of the state as well as the nation.

1.2.4 British Era

During the period when British colonized the city and after their fall, the city progressively developed into metropolis of world renown. The city being one of the busiest port and trade centre flourished with time and became one of the leading financial centres in the world. This brought rampant development and urbanization. Most of these commercial structures such as mills, important government and financial offices were located in the south region of the city, as it was closer to the area where majority of the ports are located. This led to development of southern Mumbai into a commercial area, shifting the residential population to the suburbs. Gradually, the neighbouring towns and villages also started developing and the population in these areas started increasing. The city started expanding its border and encompassing the surrounding rural areas, turning them into peri-urban areas. With passage of time, these surrounding areas which were earlier categorized as towns transformed into cities. The region was eventually characterized by ever- increasing development and

[21] http://www.the-maharajas.com/luxury-train/CityWise_Pdf/Mumbai.pdf
[22] Kleniewski N. and Thomas A. R. (2011). Cities, Change and Conflict. A Political Economy of Urban Life. Wadsworth Cengage Learning. USA. pp 153.
[23] http://theory.tifr.res.in/bombay/architecture/civil/hornby-vellard.html
[24] http://www.suezcanal.gov.eg/sc.aspx?show=8

urbanization. The important milestones which boosted the growth of the city have been tabulated in Table No. 1-3.

Table No. 1-3: Bombay Diaries[25]

Year	Events/ Milestones
1853	Telegraph started, First train between Bori Bunder to Thane started
1854	Textile mills started
1860	Vihar Water Works completed
1864	First official census carried out
1867	Local train service commences between Virar and Backbay
1869	Crawford Market established[26]
1872	Bombay Municipal Corporation was established
1873	Bombay Port Trust was formed
1874	First tram-car, drawn by horses, started running in South Bombay
1875	Establishing- first wet dock of India- Sasoon Dock, first stock exchange of Asia- Bombay Stock Exchange[27]
1882	First electric street lighting in Crawford Market[28]
1905	Bombay Electric Supply & Tramways Company (B.E.S.T.) was set up
1907	First electric tram car
1928	First electric suburban train ran from Colaba to Borivali and Juhu Aerodrome as India's First civil aviation was started
1972	Total no. of suburban train services crossed a number of 500 (501 trains)
1995	The name 'Bombay' was changed to 'Mumbai'
2003	Number of suburban services per day crossed a number of 1000
2009	Bandra Worli Sea link was inaugurated
2013	Eastern Freeway was opened for public
2014	Monorail and T2 terminal at Chhatrapati Shivaji International, Mumbai were open for public

As it can be seen in Table No. 1-3, major development in terms of establishing Mumbai as a financial hub took place in the 19th century. Post-independence, migrants were drawn from northern and southern parts focussing on non-traditional sectors such as small scale manufacturing units. The economy of the city started shifting towards banking and finance, with the transition to informal employment sectors. Increasing globalization, exposed the city to international capital with its neo-liberal policies which put the city on the verge of being a global city of tremendous economic development and opportunities.

[25] http://www.premchand-group.com/BombayBonanza%20Brochure.pdf
[26] http://en.wikipedia.org/wiki/Crawford_Market
[27] http://www.bseindia.com/static/about/heritage.aspx?expandable=0
[28] http://www.bestundertaking.com/mumbai.asp

1.2.5 Establishment of the Metropolitan Region

Since the city of Mumbai came into existence, it is one of the fastest growing cities in the world. As per a report of UN-Habitat, between 1968 and 1975, Mumbai experienced significant population growth and greater population density. This signalled an expansion of the greater Mumbai area in a rampant and unplanned manner to meet the basic demands of the growing population in terms of food, water and shelter, leading to crisis in terms of its environmental sustainability and quality of life.

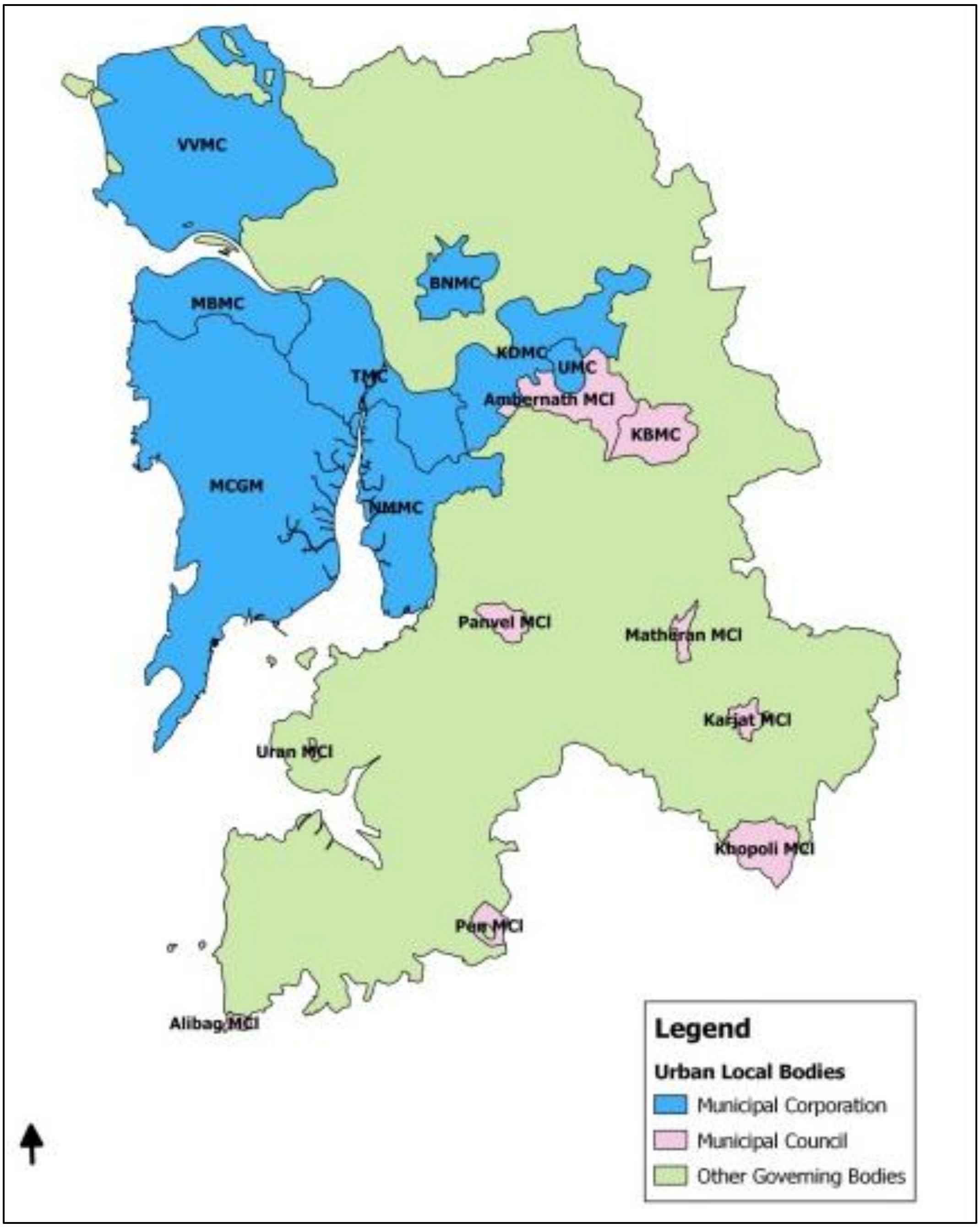
To properly plan the growth of the greater Mumbai area an Act was passed by Bombay high court for forming greater Mumbai and certain areas around. The purpose of the act was to promote and monitors the key projects for developing new growth centres and brings about improvement in sectors like transport, housing, water supply and environment in the Region. Based on the Urban Development Plans Formulation and Implementation (UDPFI) guidelines issued by the Ministry of Urban Affairs and Employment, Government of India[29]; any area may be notified as metropolitan if its population exceeds ten lakhs and more (≥ 10,00,000) comprising of one or more districts and consisting of two or more municipalities/ panchayats. With the increasing population, development and growing economic activities in Mumbai and surrounding regions, the need was felt to form these areas into the Mumbai Metropolitan Region. Once the region was formed, an Authority was set up to plan, coordinate and supervise proper, orderly and rapid development of these areas (Maharashtra Act No. IV of 1975[30]). Thus the Mumbai Metropolitan Regional Development Authority (MMRDA) came into existence in 1975, as a planning and co-ordinating body. Thereafter, the evolution of Mumbai Metropolitan Region (MMR) was regarded as gradual and strategic in nature.

The boundaries of MMR are spread across Vaitarna Creek and Tansa River in the north, Patalganga River in the south, foothills of Sahyadri in the east while defining the western boundaries by Arabian Sea. MMR today, encompasses a total area of 4355 sq.km[31] consisting of 8 Municipal Corporations viz. Greater Mumbai, Thane, Kalyan-Dombivali, Navi Mumbai, Ulhasnagar, Bhiwandi- Nizamapur, Vasai-Virar and Mira-Bhayandar; and 9 Municipal Councils viz. Ambarnath, Kulgaon-Badalapur, Matheran, Karjat, Panvel, Khopoli, Pen, Uran, and Alibaug, along with more than 1,000 villages in Thane and Raigad Districts. MMRDA is responsible for the balanced development of the MMR. A spatial representation of the administrative boundaries of MMR is presented below in Map No. 1-5.

[29] http://p2.mpcdp.com/PDF/UDPFIVolume2A.pdf

[30] http://bombayhighcourt.nic.in/libweb/acts/1975.04.pdf

[31] https://mmrda.maharashtra.gov.in/about-mmr



Map No. 1-5: Jurisdiction of ULBs (Urban Local Bodies) in MMR

Data Source: MRSAC (Maharashtra Remote Sensing Application Centre), GoM and approved by MMRDA authorities

BNMC: Bhiwandi Nizampur Municipal Corporation;
KDMC: Kalyan Dombivali Municipal Corpration;
MGCM: Municipal Corporation of Greater Mumbai;
TMC: Thane Municipal Corporation
VVMC: Vasai Virar Municipal Corporation;
KBMC: Kulgaon Badlapur Municipal Council;
MBMC: Mira Bhayandar Municipal Corporation;
NMMC: Navi Mumbai Municipal Corporation;
UMC: Ulhasnagar Municipal Corporation;
Cl: Council

Other Governing bodies include land under various government bodies like CIDCO, MIDC, Forest department,

1.2.5.1 Regional Setup

MMR is bestowed with rich resources such as water, favourable land characteristics and moderate climatic conditions and so on. Since, MMR is a coastal region, the climate, topography and location of the region gives an additional impetus for development and urbanization. MMR is located in the north Konkan region and can be regarded as one of the most vibrant and diverse geographical regions of the state.

The climate in the region does not fluctuate much and is moderately hot and humid most of the year. The weather tends to be cool and dry during winter months especially during December and January. May is the warmest month and monsoon season spans from June to September, though the retreating rains continue till October. The average climatic parameters observed/recorded in the region are documented at 4 AWS (Automatic Weather Stations) maintained by IMD (India Meteorological Department) in MMR. The climatological normal for a period of thirty years (1961-1990) have been presented in Table No. 1-4.

Table No. 1-4: Average of climatic parameters observed at the AWS in the region

Climatic Parameter	Alibaug	Colaba	Dahanu	Santacruz	Avg for MMR*
Average Daily Maximum Temperature (°C)	30.6	31.2	30.8	31.8	31.1
Average Daily Minimum Temperature (°C)	22.6	23.7	22.4	22.4	22.8
Relative humidity (%)	79.0	79.0	75.0	72.0	76.3
Annual Avg Rainfall (mm)	2164.5	2107.4	1851.4	2258.0	2095.3
Wind Speed (Kmph)	13.3	8.4	12.6	9.7	11.0

Source: Climatological Normals Published by IMD (1961-1990)
**Arithmetic average of the 4 stations has been considered for determining the average for MMR*

As observed in Table No. 1-4, the wind speed is higher in peri-urban areas such as Alibaug and Dahanu as compared to urban areas of Santracruz and Colaba. The humidity tends to be higher in the morning as compared to evening and highest in monsoon and least in winter months.

In terms of atmospheric catastrophes such as typhoon, storms and cyclone, the Arabian coast is relatively safer. '*Phyan*' is the only cyclone which was experienced by the city in the last 43 years, which reached Mumbai in November 2009[32]. Thus it is evident that the climate of the region is moderate and favourable for stakeholders from different sectors such as business, trade, agriculture, maritime and so on.

[32] http://articles.timesofindia.indiatimes.com/2009-11-12/pune/28065226_1_cyclonic-storm-phyan-deep-depression

1.2.5.2 Natural Resources are finite

Land Resource

A brief estimate on the share of the Land use pattern reveals that region is blessed with large patches of forests, and cultivable land which comprises more than 56% of the region. Also there is a huge coastline comprising of wetlands (mangrove, marshes, mudflats) making it evident that the region is blessed with green and open spaces. On the western side it is surrounded by the waterfront, beaches, estuaries, salt pans and mangroves of the Arabian Sea and on the eastern side it has the rich Sahyadri ranges.

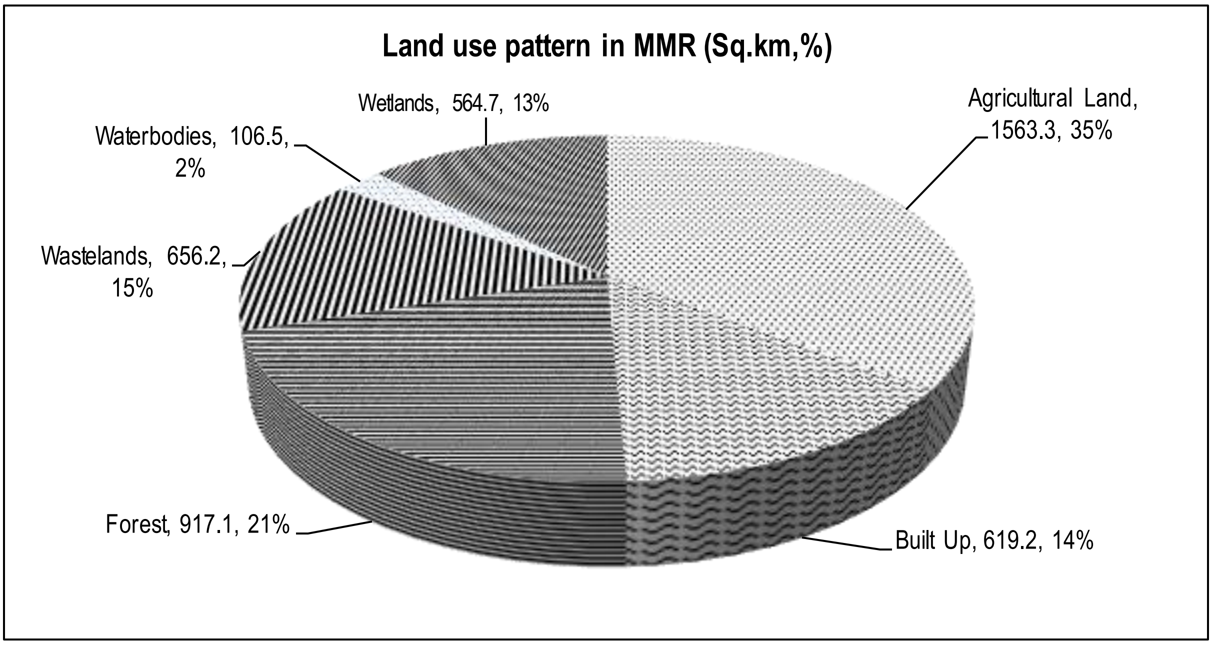


Figure No. 1-1: Land use pattern in MMR (Sq.Km,%)

Source: Data Attributes derived from remote sensing data shared by MRSAC

Forests

Forest and grasslands in the region share about 40% of the land cover. It is also bestowed with rich biodiversity hotspots such as Tungareshwar Wildlife Sanctuary in the north, Sanjay Gandhi National Park (SGNP) in the western suburbs, the Parsik hills in Navi Mumbai region and the Eco-sensitive zone of Matheran. SGNP is one of its kind national parks which is located in the heart of Mumbai city and surrounded by urban areas on all sides. Two of the lakes that supply water to Mumbai city, viz. Tansa and Vihar are located inside the SGNP. Powai Lake borders the national park in the south. Thus the city is blessed with large green pockets which act as sinks to absorb the emissions from the region.

Wetlands

Being a coastal city, and blessed with high rainfall, MMR has very unique wetland resources like mangroves, mudflats, marshes and swamps. Also man made wetlands like salt pans and paddy fields are a significant resource for the region. The total area of wetlands in MMR is about 564.7 sq. Km[33]. The districts of MMR are known to contribute to more than 98% of the salt production from the state while the paddy fields contributes to more than 10% of Maharashtra's paddy production. The unique wetlands of MMR are known to be haven for migratory birds like Lesser Flamingos. The mudflats of Sewri, Vashi creek and Thane are the major sites visited by these birds during November to March.

Biodiversity

Similarly the diverse landscape of MMR provides a unique habitat for various species of flora and fauna. Several biodiversity rich habitats such as forest, grass and scrub, agriculture and plantations, coastal wetlands (creeks, estuaries, and mangroves), freshwater wetlands (lakes, ponds, rivers) and urban parks/gardens/avenues are present in MMR harboring a variety of plant and animal species. The biodiversity in MMR includes 169 species of birds, 52 species and sub-species of mammals, 64 of herpeto-fauna (52 reptiles and at least 12 amphibians), Around 88 species of freshwater fish, 206 species of marine fish, 1484 floral species (*Trees, shrubs, herbs, climbers, grasses and so on*), 115 species of butterflies [34]:

Water Resource

The region is also blessed with, unique water resources including water bodies reservoirs and lakes. MMR falls in the Mumbai Hydrometric Area (MHA) which is spread across an area of 5756 sq.km encompassing four river basins namely Vaitarna, Ulhas, Patalganga, and Amba. Currently there are around 13 major rivers in MMR (Map No. 1-6). Although there is no appropriate definition of a wetland and categorization of lakes in the region, it is estimated that there are more than 431 lakes[35] in the region of varying size, some of which are used for domestic and recreational activities. Being close to the coastal front, the ground water table of MMR is also quiet high. It is estimated that around 293.35 million litres day (MLD)[36] of ground water is begin extracted presently in MMR.

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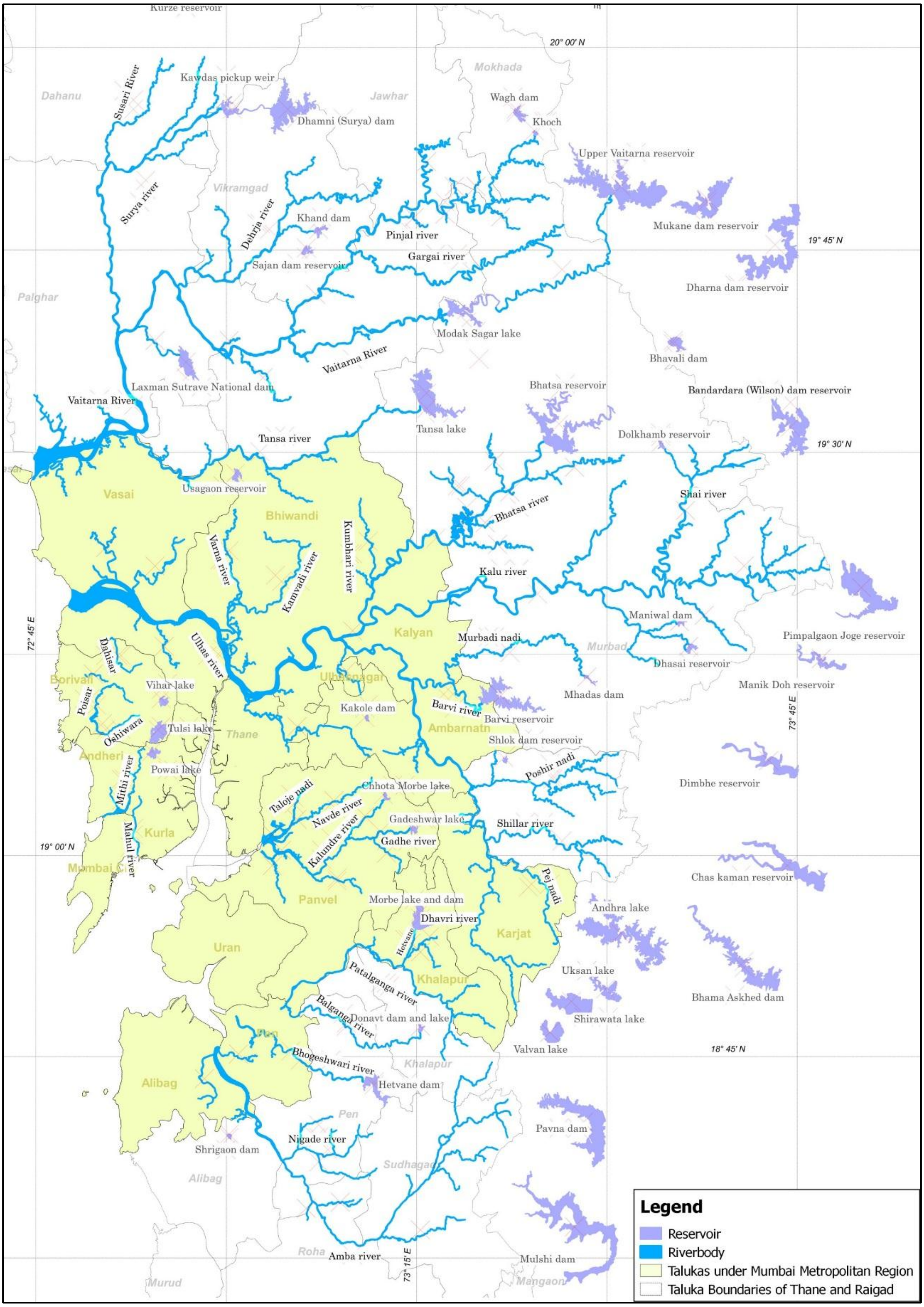
33 MRSAC (Maharashtra Remote Sensing Application Centre

34 MMR Biodiversity Project final report by Yuhina EcoMedia sponsored by MMR-EIS (November 2009-November-2012)

35 MRSAC data, latest ESRs and quesstionaires filled by Municipal Councils

36 Environmental Status Reports and Maharashtra Jeevan Pradhikaran



Map No. 1-6: Spatial representation of 13 west flowing rivers of MMR

Source: Map generated by TERI using data from MRSAC and Google Earth

1.2.5.3 Infrastructure---Ever expanding

In MMR, there are several intra-regional polarizations in terms of location of the economic activities and residential zones. The southern part of the city harbours most of the key offices, ports and markets. With this, the residential zones have been shifted northwards. As the city started growing financially, the local government had to strengthen the existing means of transport and build new infrastructure to shuttle the working population between different parts of the city. The varying aspects of the increasing infrastructure development have been discussed below.

1.2.5.4 Transport and connectivity

Even after being the most populous city of the country and the fourth most populous city in the entire world [37], getting in and around Mumbai is quite easy and affordable. Interconnectivity and intra-connectivity in the Mumbai city is excellent owing to variety of transport systems that provide shuttling of passengers across various parts of the city, state country and globe through its efficient transport network of roadways, railways and airways. This disciplined transportation arrangement makes travelling in Mumbai through public transport quite comfortable. Most of the Mumbaikars also prefer to travel by public transport over their own vehicle, which itself proves the efficiency and punctuality of the system.

Railways

The rail network in Mumbai which connects many parts of the MMR is known to be its lifeline. With the introduction of railways back in 1853, the population of MMR has always been dependent on railways to commute from one part of the city to another. This dependency has led the railway network to improve and thus has become the backbone of the transport system. As on date the suburban rail network in MMR is spread over 465 km, with almost 2,342 train services and carries more than 7.24 million commuters daily[38][39].

Furthermore, the Mass Rapid Transit System of Metro rail system is also in transit. It consists of a 146 kilometre-long metro system, of which 32 km would be underground. The system's first line connecting Versova, Andheri in the Western Suburbs to Ghatkopar in the Eastern Suburbs, covering a distance of 11.4 kilometres (7.1 mi) opened for service on 8 June 2014. While India's first Mono Rail operational between Wadala Depot and Chembur, was opened to the public on 2 February 2014. Implementation of these state of the art transport systems has eased pressure on the highly congested local trains as well as internal roads thus also proving to be an important driver for the development of the city.

Roadways

With increasing development of the region, the vehicular population has increased. Several new arterial roads, flyover, bridges and sea link have been constructed to de-congest the road traffic, especially during the peak travel hours. The Western and Eastern Express Highways have been instrumental in reducing the traffic jams in the western and eastern suburbs respectively. The Bandra-Worli Sea Link, built in 2009, directly connects the commuters from South Mumbai to Western Suburbs. Around 50 flyovers were planned by Maharashtra State

[37] http://www.worldpopulationstatistics.com/mumbai-population-2013/

[38] http://backoffice.phillipcapital.in/Backoffice/Researchfiles/PC_-_GZ_-_1st_June_Issue_low_res_20140602200921.pdf

[39] http://www.internations.org/mumbai-expats/guide/living-in-mumbai-15323/transportation-in-mumbai-2

Road Development Corporation (MSRDC), out of which around 37 have been completed by the year 2000[40]. The rickshaws and taxis equally support the road transport. The graph below gives an overview of the increase in the vehicular growth in MMR. Apart from this, the Mumbai Trans-Harbour Sea Link will connect the main island city to Navi Mumbai.

Bus services, catering to population of all the corners of the region, are provided by the Maharashtra State Road Transport Corporation which is the largest bus service provider of the state. Additionally, bus services are also provided by Brihanmumbai Electricity Supply and Transport (earlier Bombay Electric Supply & Tramways Company) and by transport departments of the respective municipal corporation. These buses travel between different cities to connect the respective corporations/ ULBs.

Airways

Mumbai being the economic capital of the country is an important trade destination. The international airport of the city is the second busiest airport in India in terms of passenger traffic. After the inauguration of the T2 airport in 2014 capacity of the airport has increased from 30.74 million to 40 million passengers annually[41]. The city also has a huge cargo terminal facilitating international trade.

Waterways

Two of the largest ports in India are in MMR, JNPT (Jawharlal Nehru Port Trust) and MbPT (Mumbai Port Trust).

Urban Services

The basic urban services include appropriate supply of electricity and water. With long term plan in place many water resources in the region were tapped and exploited for water supply. The existing sources of water supply for MMR are illustrated in the Table No. 1-5. Mumbai also houses one of the largest water treatment plants in Asia located at Bhandup. With further plan to augment the water resource and supply systems, MMR aspires to have abundant water supply to meet the growing water supply demands.

[40] https://www.msrdc.org/site/completedProjects/fiftyFlyover.aspx

[41] http://www.dnaindia.com/mumbai/report-with-maiden-air-india-flight-t2-opens-to-public-1961614

Table No. 1-5: Current sources of water supply in the region and quantity of water supplied

Sub-Region	Name of Dam / Source	Supply of water in MLD
Greater Mumbai	1. Tansa	445.0
	2. Modak Sagar	450.0
	3. Upper Vaitarna	630.0
	4. Bhatsa	1850.0
	5. Vihar	60.0
	6. Tulsi	15.0
	Sub-Total 1 (Out of this, 120 MLD is supplied to local villages)	**3450.0**
Rest of MMR	1. Barvi	600.0
	2. Morbe	360.0
	3. Hetawane	150.0
	4. Dehrang	11.0
	5. Amba (Nagothane)	168.0
	6.Ulhas River (Bhivpura Tailrace 710+80+10)	800.0
	7.Tansa River (Shirgaon Bandhara)	10.0
	8. Usgaon	10.0
	9. Pelhar	10.0
	Sub-Total 2	2119.0
	Total (Sub Total 1+2)	**5569**

Source: Presentation by MMRDA, Water Supply and Resources Cell (March 2013). Water Supply Resources: Planning and Development for MMR.

1.2.6 Indicators of Growth and Development

Natural resources, climatic conditions, access to markets, sound urban services, transport and human resources are some of the important parameters which drive the financial, economic, commercial and social growth of any region. In the case of MMR, these drivers play a very important role in making the region one of the important financial hubs of India.

Moreover, it is interesting to note a very strong interdependence of the parameters which further culminates into a complex web of assets and activities. However it also indicates that any imbalance induced in this network, may result in severe implications on several dependent entities and businesses. For instance, well developed transport network is regarded as strength of MMR. However the commonly occurring water logging in monsoon season often disrupts the road, rail and air traffic causing major congestions, delays, losses and inconvenience to millions of passengers who are the major work force of businesses.

Reclamation of low lying areas, clogging of sewer and storm water drains with plastic and other non-biodegradable waste, unplanned development along the river banks, and sensitive coastal zones are regarded as a major cause of the urban flooding. These are nothing but the pressures induced by development and urbanization which create imbalance in the infrastructural systems. Thus, resource availability and its responsible management drive the development in progressive manner whereas unregulated urbanization and industrialization leads to a sever imbalance in the ecosystem.

Given the commercial significance of the region and the subsequent demands it imposes on development, it may have been wrongly assumed in the past that protection of natural entities like wetlands, mangroves and forests may be given secondary importance. It is often accepted that development would be associated with degradation of natural resources and at the cost of reclaiming natural entities like forests, ponds and mangrove covered areas. However several incidences of water logging in urban pockets, extreme floods due to cloud burst in the year 2005, and frequently occurring man animal conflicts in the forest fringes time and again indicate a need to maintain a strong balance between development and protection of natural entities.

Hence the parameters which drive the development and the resources which provide the foundation for the development need to be critically assessed. A visual depicting the interrelation between the Driving forces and their interaction and impact with the resources is depicted in **Figure No. 1-2**. To support this increasing population, resource demand especially for water, food, clothing and energy (electricity & fuel), are simultaneously growing at an exorbitant and unprecedented rate. Based on a working report published by Asia Research Institute, Singapore; population density of the region has increased consistently from 4549/sq km in 2001 to 5403/sq km in 2011[42]. However considering the limited built up area of 14% (619.2 sq.km), the population density gets effectively concentrated to 38,000/sq km.

[42] Bhagat R. B. and Jones G. W. (May 2013). *Population Change and Migration in Mumbai Metropolitan Region: Implications for Planning and Governance*. Working Paper Series No. 201. Asia Research Institute, National University of Singapore, Singapore

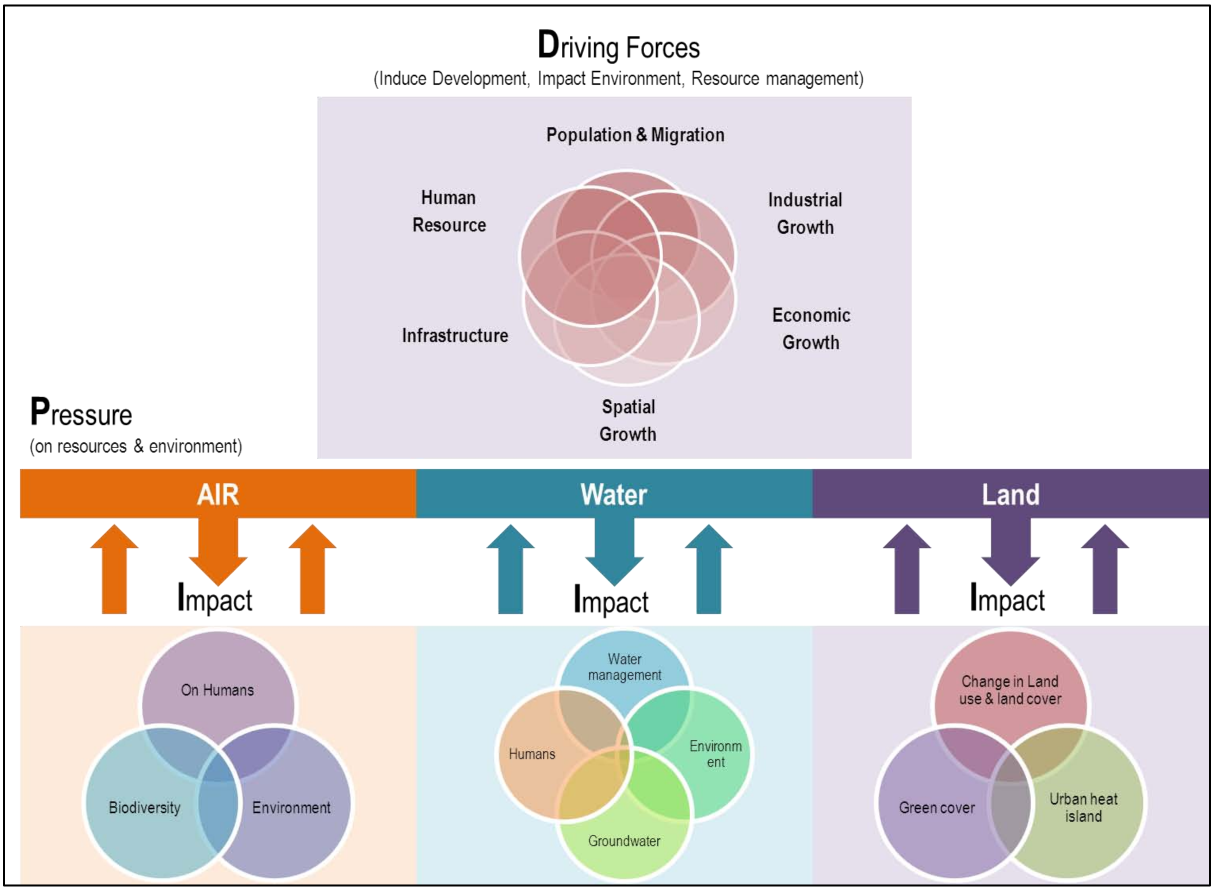


Figure No. 1-2: Dynamic interrelation between driving forces and the resources of MMR

The statistics indicates that there has been an increase in activities related to manufacturing units, corporate houses, trading centres, film industry, education centres, businesses and so on which in turn attracts population from other districts and states to MMR.

To further take advantage of these abundant human resources, more economic activities are induced. These economic activities further provide opportunities to people from other districts and states, stimulating migration. Thus it becomes a vicious cycle. In order to better manage this huge influx of economic activities and population; infrastructure development need to keep pace with these activities. Each of these activities, tend to consume resources on a large scale, thus overburdening them. Post consumption, these sectors have the tendency to produce more waste, effluents, emissions and pollutants impacting the environment and hence tending towards unsustainability.

1.2.6.1 Population Growth

The most crucial driver of urbanization is population growth of that region. To meet the growing demands imposed by the population, parallel development of allied business sectors catering to the needs of housing, businesses, and infrastructure required for transport, also takes place. This growth pattern makes the city denser. Mumbai city is one of the most densely populated cities in the world[43] whereas Thane district has registered population growth of almost 36% between 2001 and 2011 and the urban population of Raigad district has registered a decadal growth of almost 82% in the same period.

The city has always attracted migrant population since it presents a wide array of business and service opportunities ranging from corporate, industrial as well as public sector. With the spatial growth of the region, the rippling effect has also induced rapid growth in the satellite towns and peri-urban areas. The increase in population of MMR is presented below in **Table No. 1-6**. It is evident that in the span of 40 years (1971-2011) the population of MMR has increased by almost 197%.

Table No. 1-6: Increase in population of Mumbai Metropolitan Region

	1971	1981	1991	2001	2011*
Gr. Mumbai (MCGM region)	5,970,575	8,243,405	9,925,891	11,978,450	12,478,447
Rest of MMR#	1,821,013	2,848,387	4,608,473	6,914,609	10,654,977
Total MMR	**7,791,588**	**11,091,792**	**14,534,364**	**18,893,059**	**23,133,424**
Increase in population wrt 1971 (%)	---	42.35	86.53	142.48	196.90

Source: Census of India 1971, 1981, 1991, 2001 and Provisional Census Data 2011

**Population considered for MCGM, #Select talukas of Thane and Raigad which are under MMR*[44]

The total population of MMR is more than 23.13 million as per the provisional data of Census 2011. The population of MMR has increased almost three times in the past 40 years, with a CAGR (Compound Annual Growth Rate) of almost 2.75% and during the same period the population of Greater Mumbai has doubled with a CAGR of 1.85%. However, decadal growth rate between years 2001-2011, for Greater Mumbai was recorded to be 4% whereas for the rest of the region, apart from MCGM area, the population grew by almost 55%. As for the growth rate of the region there is a declining trend for the MCGM region and an increasing trend for the rest of the MMR. The absolute growth in MMR and the trend of growth rate in MCGM and the other regions in MMR have been depicted in Figure No. 1-3 and Figure No. 1-4 respectively. As seen in Figure No. 1-4, the overall population growth rate in MCGM area and MMR as a whole is decreasing; however it is increasing in the rest of MMR area. This increase could be due to natural growth rate in population due to birth rate but also mainly due to migration within the MMR (from southern parts to newly developed areas in suburban areas)

[43]http://www.forbes.com/2007/12/14/cities-pollution-asia-biz-logistics-cx_tvr_1214densecities_slide_2.html
[44]Ambernath, Bhiwandi, Kalyan, Thane, Ulhasnagar, Vasai talukas of Thane District and Alibaug, Karjat, Khalapur, Pen, Panvel and Uran talukas of Raigad district

as well as from other parts of the country. Although the population residing in the southern/ old Mumbai has decreased, the overall number of people using the natural resources within the area has not decreased which clearly gets revealed in the status of water supply as wellas generation of waste and sewage.

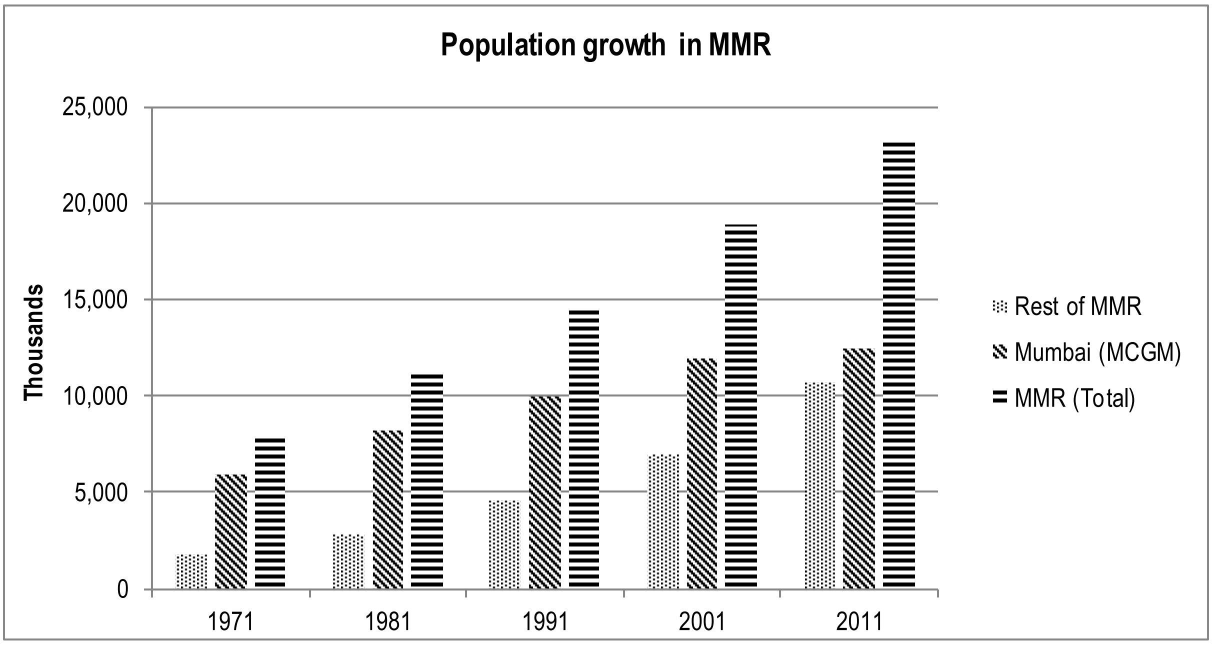


Figure No. 1-3: Population growth in MMR

Source: Census of India 1971, 1981, 1991, 2001 and Provisional Census Data 2011

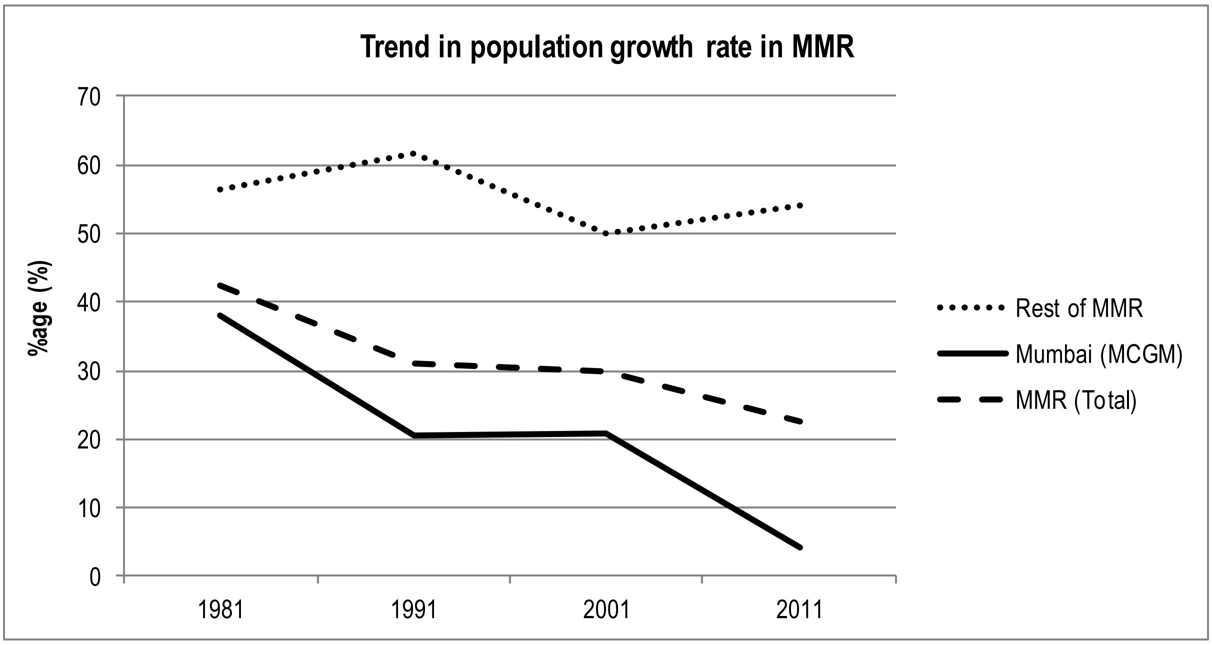


Figure No. 1-4: Trend in population growth rate in MMR

Source: Census of India 1971, 1981, 1991, 2001 and Provisional Census Data 2011 *

As per provisional data of Census 2011, almost 92% of the population in MMR is urban population. There are 10 A class cities (cities with population above one lakh) in MMR with independent ULB's. Apart from MGCM, Thane city has registered remarkable increase in its absolute population followed by Kalyan-Dombivali. Over a period of years, many ULB's in MMR have been transformed from councils to corporations either because of the population growth, or inclusion of villages. Vasai-Virar Municipal Corporation is the latest corporation which was formed in 2009. Of all the A class cities Ambernath and Panvel have municipal councils as a ULB. The city wise population trend in A class cities, except MGCM, is presented in Figure No. 1-5. It can be seen from the graph that the population of each of the respective administrative regions is also growing steadily.

MMR is spread across four districts and comprises of both rural and urban populace. The status of population distribution in urban centres and rural areas of the region and the district wise%age distribution is presented in Figure No. 1-6. The MMR region accounts for almost 34% of the urban population of Maharashtra and 20% of the total population of the state (Figure No. 1-7). While in terms of total population, MMR ranks 8th as compared to the top 20 metropolis globally (Figure No. 1-8).

In terms of migratory population there is very high flow of migration from other states like Uttar Pradesh, Andhra Pradesh, Gujarat, Bihar and Kerala to Mumbai. A summary of the migration from these states in presented in Table No. 1-8. Similarly, Table No. 1-9 gives the trend of rural and urban migrants and it clearly indicates that there has been the dominance of rural migrants over urban migrants in MMR.

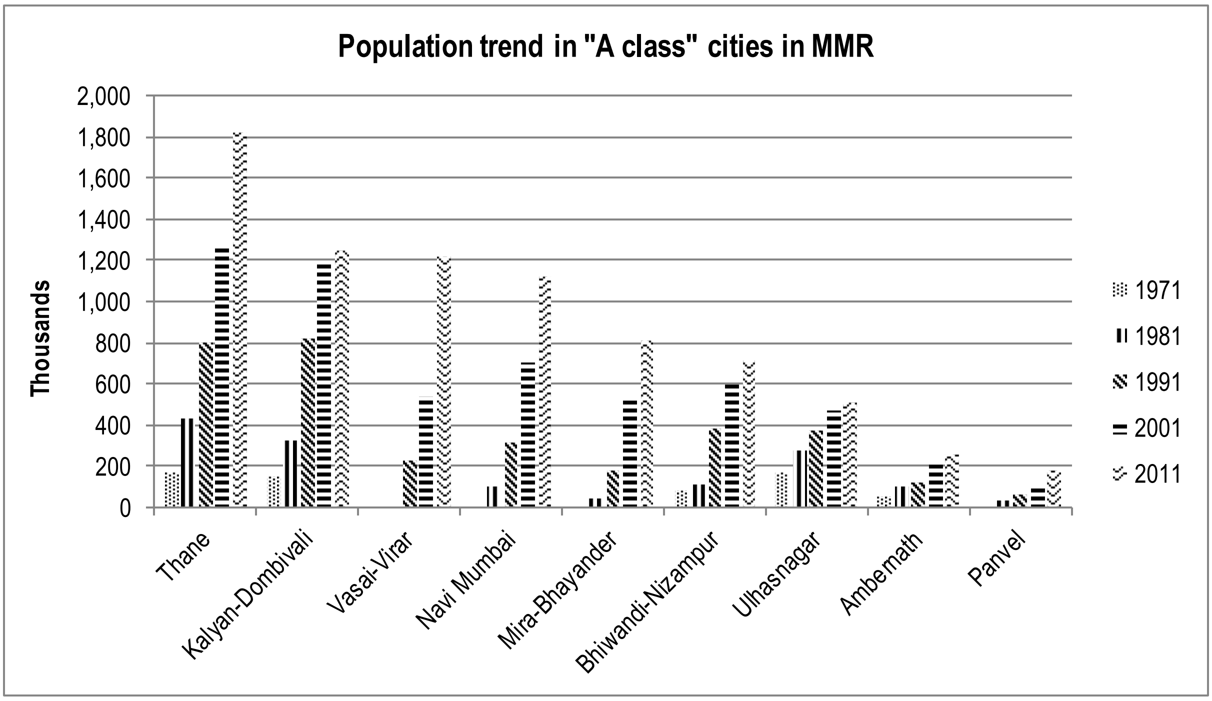


Figure No. 1-5: Population trend in "A class" cities in MMR

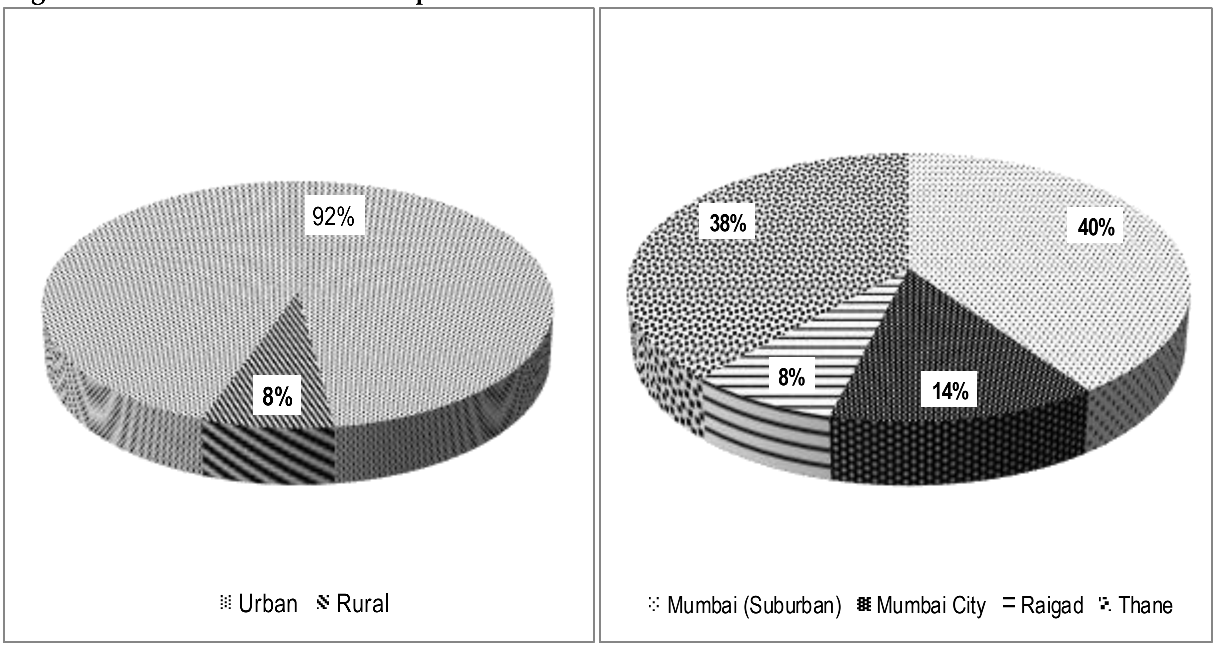
Source: Census of India 1971, 1981, 1991, 2001 and Provisional Census Data 2011

Table No. 1-7: Population status of "A" class cities within MMR in year 2011

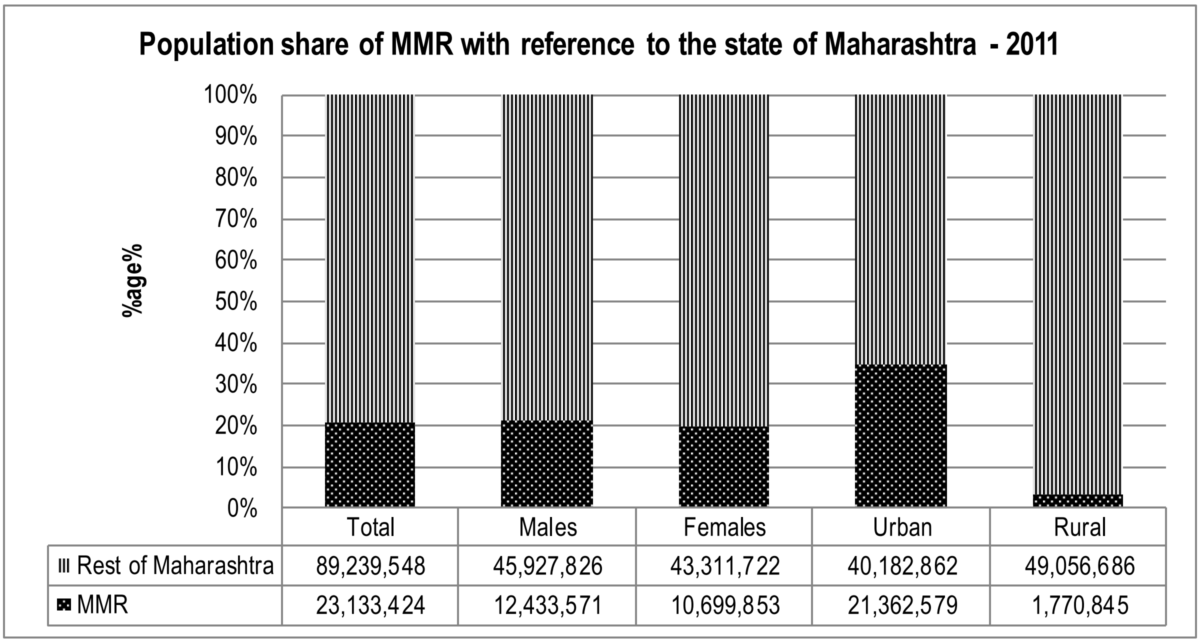
Sr No	City	ULB Type	Population	Male	Female
1	Mumbai	Municipal Corporation	12,478,447	6,736,815	5,741,632
2	Thane	Municipal Corporation	1,818,872	966,293	852,579
3	Kalyan-Dombivali	Municipal Corporation	1,246,381	650,075	596,306
4	Vasai-Virar	Municipal Corporation	1,221,233	649,535	571,698
5	Navi Mumbai	Municipal Corporation	1,119,477	611,501	507,976
6	Mira-Bhayander	Municipal Corporation	814,655	434,330	380,325
7	Bhiwandi-Nizampur	Municipal Corporation	711,329	418,478	292,851
8	Ulhasnagar	Municipal Corporation	506,937	270,373	236,564
9	Ambernath	Municipal Council	254,003	133,006	120,997
10	Panvel	Municipal Council	180,464	93,135	87,329

Source: Provisional Data Census of India 2011

Figure No. 1-6: Distribution of Population in MMR - 2011



Source: Provisional Census Data 2011



	Total	Males	Females	Urban	Rural
Rest of Maharashtra	89,239,548	45,927,826	43,311,722	40,182,862	49,056,686
MMR	23,133,424	12,433,571	10,699,853	21,362,579	1,770,845

Figure No. 1-7: Population share of MMR with reference to the state of Maharashtra

Source: Provisional Census Data 2011

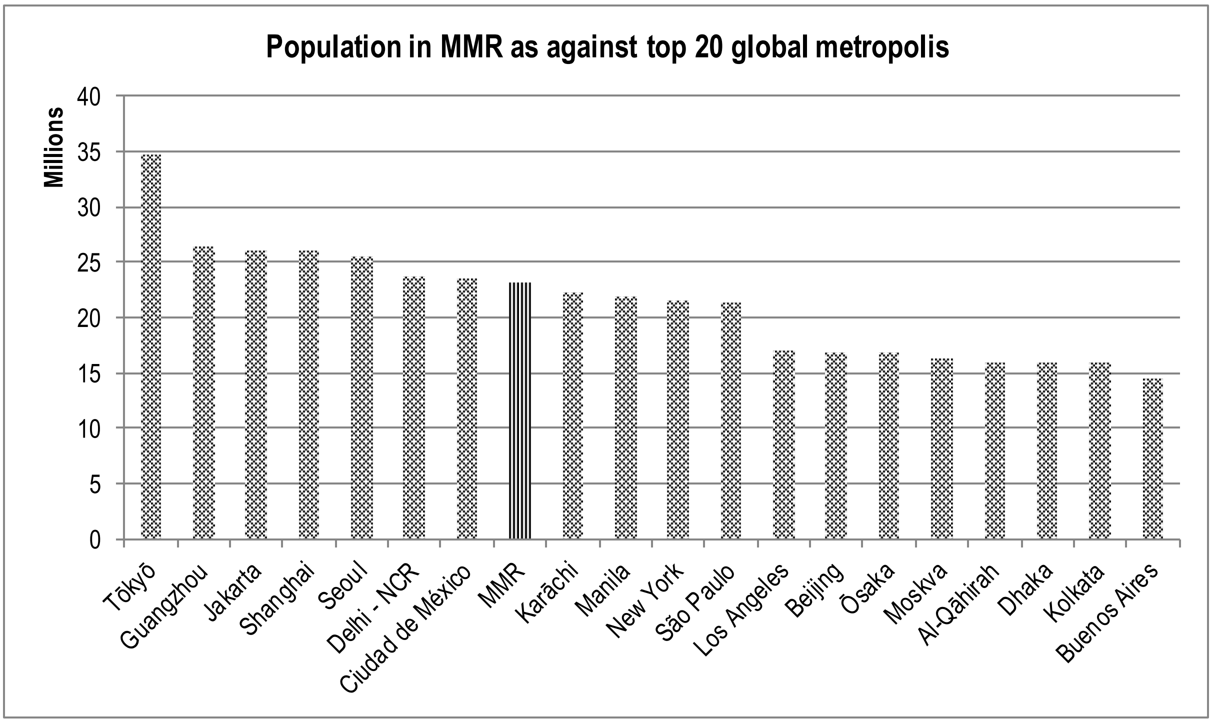


Figure No. 1-8: Population in MMR as against top 20 global metropolis

Source: City Population[45]

[45] http://www.citypopulation.de/world/Agglomerations.html

Table No. 1-8: Trend of migrant population in Greater Mumbai and their place of birth

	Census Years				
	1961	1971	1981	1991	2001
Total Population	4152056	5970575	8243405	9925891	11978450
Total No. of Migrants	2667130	3372384	4229276	3696764	5185429
States	%age of migrants to Greater Mumbai according to place of birth: 1961-2001				
Maharashtra	41.64	41.57	42.23	41.2	37.4
Andhra Pradesh	3.38	3.02	2.70	2.30	2.41
Bihar	0.22	0.41	0.80	1.40	3.50
Gujarat	16.9	14.85	13.46	11.89	9.58
Karnataka	6.44	7.34	7.19	6.55	5.83
Kerala	2.76	3.60	3.33	2.93	2.21
Rajasthan	1.94	2.59	2.68	3.26	3.87
Tamil Nadu	3.20	3.27	3.37	3.49	3.14
Uttar Pradesh	12.01	13.46	15.9	19.28	24.28

Source: Mumbai Human Development Report, 2009[46]

Table No. 1-9: Trend of migrants from rural and urban areas in %age

	1961	1971	1981	1991	2001
Total lifetime migrants	64.24	56.86	51.46	37.46	43.70
Rural	58.13	64.17	66.03	67.65	68.47
Urban	33.16	31.51	31.28	30.04	26.15

Source: Mumbai Human Development Report, 2009[47]

[46] MCGM 2009, *Mumbai Human Development Report 2009*, Table 2.5: Place of Birth of Migrants to Greater Mumbai 1961-2001, pps 20
[47] MCGM 2009, *Mumbai Human Development Report 2009*, Table 2.7:%age of Migrants from Rural and Urban areas to greater Mumbai, pps 22

1.2.6.2 Economic Growth

Being a natural harbour, Mumbai has been a key trading centre for ivory, precious stones, spices and cotton since the 8th century B.C. According to Kamath (2000[48]), even in those ages western India extensively practiced the art of spinning and weaving cotton which was exported to Babylonia and ancient Egypt. The first textile mill '*The Bombay Spinning Mill*' started in the year 1854 by Cowasji Nanabhai Davar[49].

The American Civil War was fought between the years 1861 to 1865, which gave impetus to cotton trade in India and during the same time the Suez Canal (1869) was made open for merchants which further enhanced the trade and maritime activities of the ports across Europe and Asia. This paved way for establishment of textile mills in Mumbai city which reached to a total of 83 mills by 1915. Communities from Marathi speaking districts of Maharashtra migrated to the city to be employed in the mills and this sector became one of the biggest employers in those days. The financial bubble created by cotton trade lasted until the late 20th century making the city one of the prominent financial centres across the world. As on date, Mumbai city is famously recognised as the financial capital of India and is regarded as the strongest powerhouse in terms of economic contribution. The city contributes more than 33% of share in the national tax collection, more than 60% custom duty collection, and 40% share of the foreign investment in India.

The MMR is also highly influenced with the economic growth of Mumbai city and the region has registered significant growth over the years. The GDDP (Gross District Domestic Product) of MMR has been increasing steadily at a CAGR (Compound Annual Growth Rate) of 14.92% of over the past 4 years. In 2011-12 the GDDP of MMR was recorded to be INR 4,49,697 crores which is almost 1.5 times that of the year 2008-09 (2,96,238 crores). The region wise growth in GDDP for last four years is presented below in Figure No. 1-9.

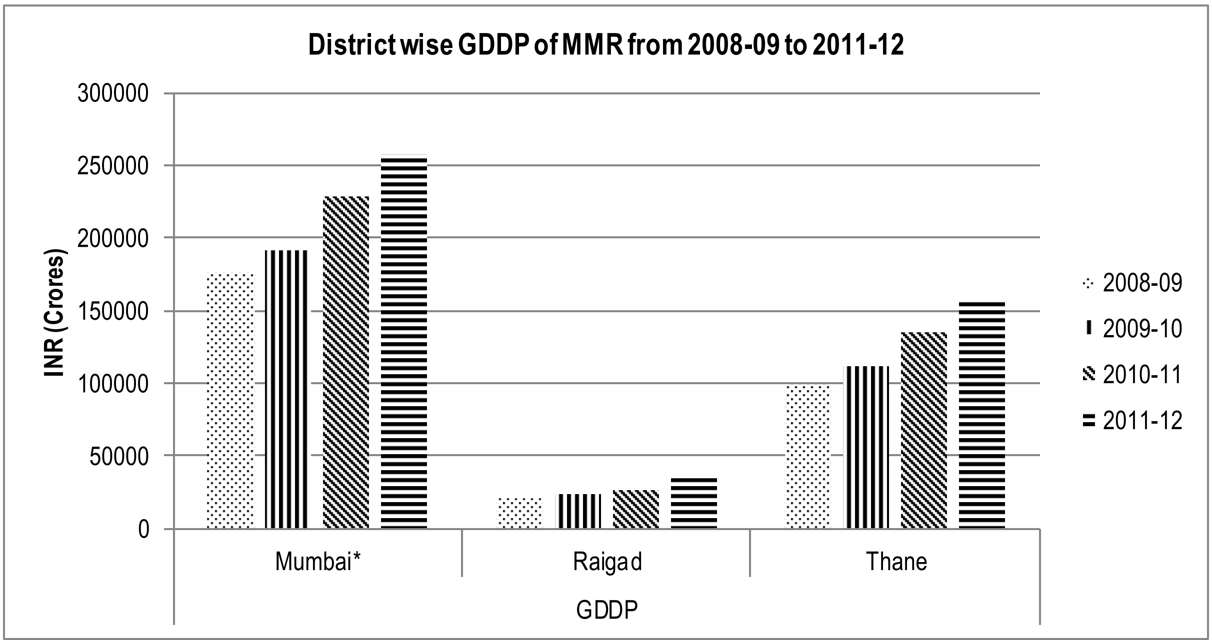


Figure No. 1-9: District wise GDDP of MMR from 2008-09 to 2011-12

Source: Economic Survey of Maharashtra 2010-11, 2011-12, 2012-13 GoM
*Note: * Mumbai includes Mumbai and Mumbai Suburban District*

[48] Kamath M. V. (2000). *Tides of Time*. Mumbai Port Trust
[49] http://theory.tifr.res.in/bombay/history/cotton.html

The economic growth of the region has also influenced the per capita economic growth of the population in MMR. In terms of PCNDDP (Per Capita Net District Domestic Product) the region has a steady growth at 13.31% CAGR. In the last four years the PCNDDP of the MMR has grown by almost 1.45 times from INR 2.82 Lakhs in the year 2008-09 to INR 4.11 Lakhs in 2011-12.

However upon having a region wise break-up one may note that the Raigad district has recorded the highest growth in the last two years, the PCNDDP in the region has increased 1.51 times in the same period with a CAGR of 14.81%. The district wise growth in PCNDDP is provided below in Figure No. 1-10. Although the GDDP of Mumbai is much higher than that of Thane and Raigad regions the PCDDP of the region is more or less comparable for all the districts in MMR. This could be attributed to higher population density in Mumbai and Mumbai suburban districts and also to the large floating population.

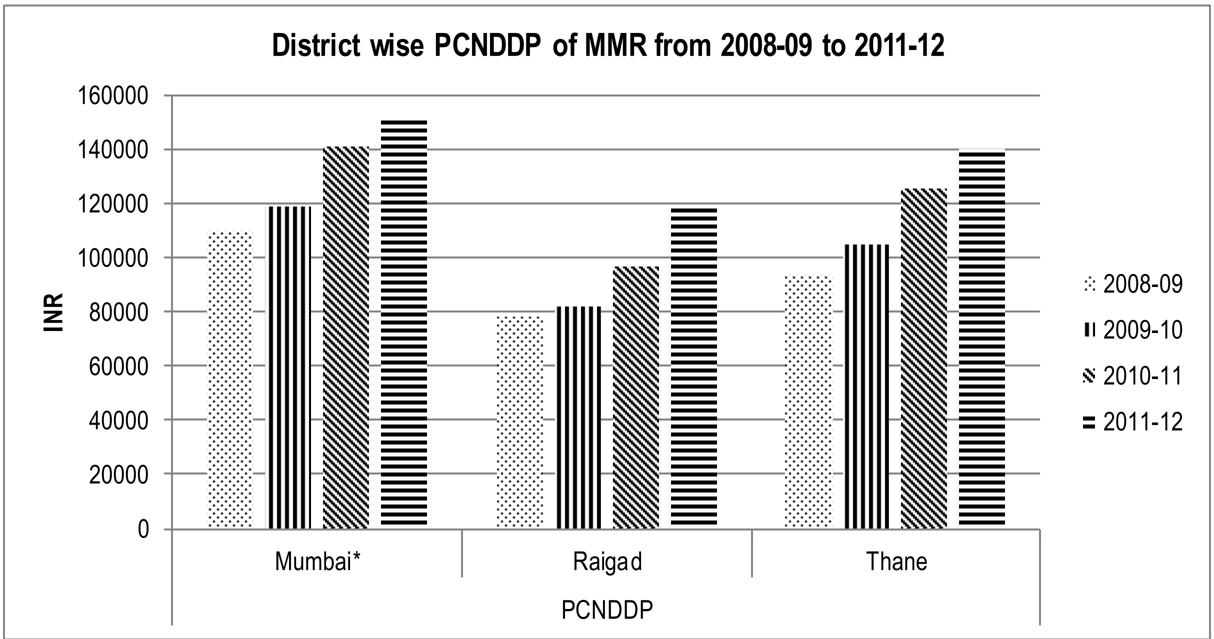


Figure No. 1-10: District wise PCNDDP of MMR from 2008-09 to 2011-12

Source: Economic Survey of Maharashtra 2010-11, 2011-12, 2012-13 GoM
*Note: * Mumbai includes Mumbai and Mumbai Suburban District*

In 1980s, a major strike started by the labour unions of these textile mills started crippling this sector and thus started the downfall of textile mills[50]. The closure of the mills coincided with the statement of the Industrial Policy of India released in July 1980, which provided special assistance to activities for improvement of environment and reducing the deleterious effects of air and water pollution (Department of Industrial Policy and Promotion, Ministry of Commerce and Industry, Government of India[51]). The majority of the over 80 mills in Central Mumbai closed during and after the strike, leaving more than 150,000 workers unemployed. Textile industry in Mumbai has largely disappeared, reducing labour migration after these strikes and implementation of Industrial policy (1980).

[50] Mumbai Human Development Report, 2009
[51] http://eaindustry.nic.in/handbk/chap001.pdf

1.2.6.3 Industrial growth

Industrial growth is one of the key driving forces for growth of a city. It helps create job opportunities and thus attracts population migration. The influx of population indirectly creates demand for resources and infrastructure thus leading to growth of city. MMR has strong presence of corporate, prominent industries, research institutions, government sector, entertainment & media, retail, construction, hotel industry and so on.

Trend in growth of industrial units

The major industrial belts in MMR area are spread across TTC (Trans-Thane Creek), Taloja, Waghale estate, Dombivali, Ambernath, Bhiwandi and so on. Figure No. 1-11 depicts the trend in number of industries within MMR[52].As reported by MPCB as on 2008-09[53] , there are almost 16058 industrial units including SSI (Small Scale Industry), MSI (Medium Scale Industry) & LSI (Large Scale Industries) across red, orange and green categories as specified by CPCB (Central Pollution Control Board)[54]. Although there is a dip in number of industries, between the years 2004-05 and 2006-07 one may notice that there is increase in number of industries by 8.38% between 2006–07 and 2008-09 (Figure No. 1-11).

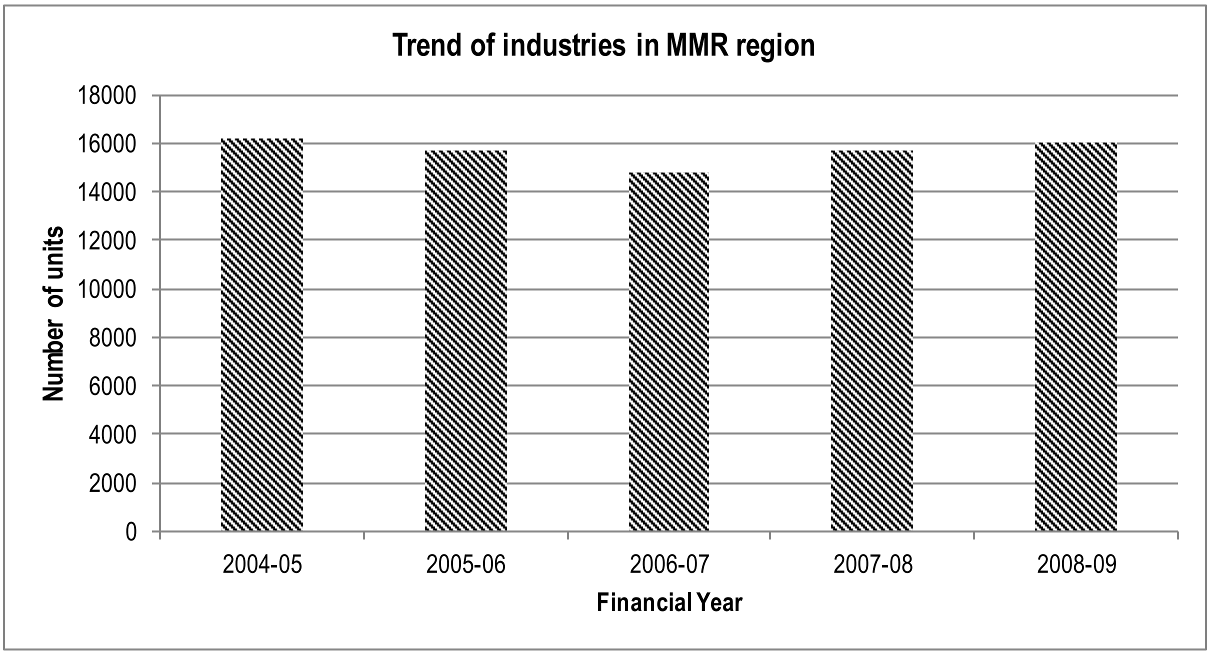


Figure No. 1-11: Trend of industries in MMR region

Source: MPCB 2012

52 The industries from Mumbai, Navi Mumbai, Thane, Kalyan and Raigad regions have been considered as classified by MPCB
53 http://mpcb.gov.in/indstat/indstats.php
54 http://gpcb.gov.in/pdf/rog.pdf

Region wise trend in industrial growth

Owing to space crunch and higher cost of operations many manufacturing units in Mumbai have shut down, especially the mills. It is worth noting from Figure No. 1-12 that the industrial units in Mumbai and Thane region have decreased by almost 32% and 17% respectively but there is a gradual increasing trend in number of industries in Navi Mumbai (17%) and Kalyan (38%) regions and a very sharp growth in the Raigad region of about 44% in the four years under consideration.

This could also justify as one of the reasons for increase of significant population growth in Thane district, which recorded a decadal growth rate of more than 35%[55] the highest among all districts in Maharashtra. The region of Kalyan and Navi Mumbai both fall under the Thane district.

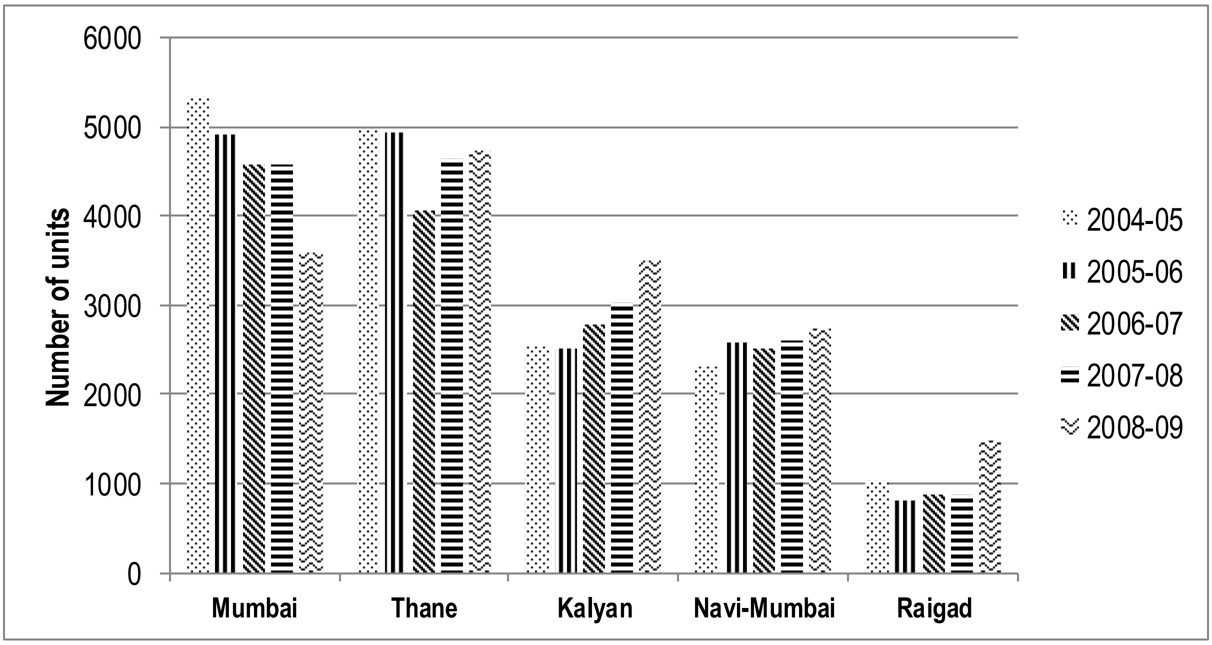


Figure No. 1-12: Region wise trend of growth in industrial units in MMR

Source: MPCB 2012

The driving forces of city, viz population, economic, industrial growth have all provided opportunities as well as created constraints in the growth of the city. Resource demands in terms of water, food, energy, clothing, housing and so on has modified the climatic, topographic and demographic pattern of the region. The resources in the region are many times over exploited to accommodate and meet the demands of the increasing population thus inducing a continual pressure on the resources like water, land and emissions from anthropogenic activities which have been described in the following section.

[55]http://www.censusindia.gov.in/2011-prov-results/paper2/data_files/mah/8-POP-11-26.pdf

1.2.7 Pressures on Finite Resources

Green areas such as forest, agricultural and other natural landscapes like wetlands, water bodies and wastelands too occupy a large part of the region. Owing to urbanization, there is a growing demand to convert these green and open spaces into built-up areas. Conversion of green land into built-up may further lead to environmental degradation. Hence it is crucial to retain these green and open spaces in order to maintain the natural balance. Besides these, the congestion of residential and commercial infrastructure in the main city is exceeding the carrying capacity of the land in that region making it vulnerable to natural disasters which was evident in the massive water logging/ flood of the year 2005.

1.2.7.1 Air Pollution

Similarly, increasing use of fossil fuels, construction activities, burning of waste, emissions from industries create immense pressure on the air resource inducing air pollution. MMR has four major industrial areas of the state such as the TTC industrial area, Taloja industrial belt, MIDC area in Dombivali and Ambernath. Also located in the close vicinity is the Patalganga industrial area in the south and Dahanu industrial area in the north. Major red category industries like TATA power plant, Rashtritya Chemical Fertilizers (RCF), refineries of BPCL (Bharat Petroleum Corporation Limited) and HPCL (Hindustan Petroleum Corporation Limited) all are well within the city limits. Almost 1200 vehicles[56] are added per day to the vehicular fleet in MMR, the region is experiencing exponential increase in the number of vehicles, thus also inducing demand and rapid growth in consumption of fossil fuels.

In the context of MMR, transition of the industrial activities has always been a unique feature of the region. For instance, the textile mills were established in 1854 and then onwards those flourished in the region until 1980s. The air quality of the industrial area was thus governed by the emissions from these mills. The redevelopment of Mumbai's cotton mills began in 1992, when efforts began to demolish the numerous cotton mills that once dotted the landscape of Mumbai, to make way for new residential and commercial buildings, as part of the wider modernization of Mumbai.

In this report, TERI has made an attempt to analyse the trend of air quality of this transition period where mills stopped functioning and demolition activities began vis a vis the current trends. The results are discussed in the technical report titled Air Quality in MMR.

[56] As per data from MVDM, a total of 388078 were vehicles registered in 2011-12 in Greater Mumbai, Thane, Raigad and Kalyan RTO which are in MMR. Considering 300 working days in year an average of 1293 vehicles got registered every day in 2011-12

1.2.7.2 Pressure on Water Resources

Water supply in MMR is majorly through dams and lakes for domestic and industrial use. Table No. 1-10 shows an increasing trend of water supplied from the different sources and the population that it catered to. In terms of the water resources, the city had to scale up their water supply resources and their capacity in order to cater to the increasing population. As the city expanded and included the surrounding regions, the individual ULBs owned and administered their respective sources of water supply.

Table No. 1-10: Trend in increasing water supply and the respective sources

Year	Sources of water supply	Water supplied in MLD	Population catered to (in million)
1948	Vihar, Tulsi, Powai and Tansa water schemes	494	1.80[57]
1967	Vaitarna cum Tansa and Ulhas in addition to the existing sources	984	4.15[57]
2013	Mumbai city: Tansa, Modak Sagar, Upper Vaitarna, Bhatsa, Vihar, Tulsi, Rest of MMR: Barvi, Morbe, Hetawane, Dehrang, Amba, Ulhas, Usgaon, Pelhar	5569[58]	23 (includes entire MMR)[59]

Source: Modified from report of the Expert Committee (Water Planning) on Bombay's Future Water Resources and Improvement in Present Water Supply Scheme. (December 1994)

Though, areas of Greater Mumbai have 24 hours water supply, parts of Thane and Raigad district have only 16 hours water supply. Thus it so happens that the overcrowded city is leading to unequal distribution of resources and thus social inequality. While on the other hand, release of waste water is a major issue. It is estimated that around 4753 MLD of waste water is generated in the region, out of which only 59% is treated to some extent (either primary or secondary). The waste water is released in the creeks and rivers, leading to severe water pollution. Extraction and withdrawal of water for consumption and release of huge amount of waste water into the rivers and creeks downstream creates tremendous pressure on the natural water bodies and allied ecosystem.

Construction of dams is found to be the key threat currently on the west flowing rivers in MMR. Currently there are 8 dams proposed and 2 are under construction. Dams under construction on the Middle Vaitarna and Balganga are Kalu, Shai, Gargai, Pinjal, Poshir and Barvi. Construction work for Kalu dam has stopped following a petition from local tribal organization. These dams in future will displace more than 30000 tribals and submerge more than 14000 hectares of primarily tribal land, including land in global biodiversity hotspot of

[57] Figures taken from report of the Expert Committee (Water Planning) on Bombay's Future Water Resources and Improvement in Present Water Supply Scheme (December 1994)
[58] Presentation by MMRDA, Water Supply and Resources Cell (March 2013). Water Supply Resources: Planning and Development for MMR
[59] Based on Provisional data of Census 2011

Western Ghats. The land which will be submerged is present in Eco sensitive zone 1 (ESZ1) as per Gadgil committee as well as Kasturirangan committee report[60]. As these dams are supplying water to industrial areas they are exempt from clearances, EIA's, public hearings and so on because of the omission of a clause in EIA notification 2006[61,62]. Sand dredging is also a serious issue faced by the rivers in MMR. Illegal sand mining is on an increase in MMR as good income is generated through labouring at sand mines[63,64]. High growth in population of MMR has resulted in reclamation in low lying areas of many rivers. This is the main cause of floods in monsoons[65]. Due to low storm water drainage capacity, Mithi river and several other rivers had completely flooded the region in 2005 which was regarded as the main reason for complete havoc and damage in the city[66,67].

1.2.7.3 Vertical growth

Thus with the growing economy, the Mumbai city and region has developed, but it is significant to understand the pattern of its growth. It can be seen that the built-up area is 14 per cent of the total area in the region. But considering the infrastructure constructed in the region, it can be summarised that the city is growing vertically. To give an example, statistics on usable floor space was obtained from Navi Mumbai Municipal Corporation. It indicates that though the total land area has remained the same (108.5 sq.km), the vertical growth has provided more usable floor space from 4.2 sq.km in 2007 to 5.3 sq.km in 2010. This is explained in detail in the land section of Volume 2 of this report.

Thus due to vertical growth more space is made available which demands for more resources in exponential quantities. Hence though the urban sprawl is not spatially spread, it impacts the resources in and around the region by exerting a pressure on it, which is explained in the following section.

1.2.7.4 Compounded impacts

Pressure on drainage network

Mumbai city is highly prone to flooding or better termed as water-logging. It is a consequence of mismanagement of the urban plan of the city, which makes it prone to water-logging. Back in 1782-84, the islands were transformed into one land mass by Governer Vellard with an aim to cease the flooding in the low-lying areas of the islands. But after two centuries, the city is still facing problems of water-logging during monsoon season. Several urban management factors are responsible for this such as high tide time overlapping with high intensity rainfall and inadequate size of outflow gates.

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60 http://paper.hindustantimes.com/epaper/viewer.aspx

61 http://www.indiaenvironmentportal.org.in/content/385637/dams-in-tribal-belt-of-western-ghats-for-the-mumbai-metropolitan-region-unjustified-projects-better-options-exist/

62 http://sandrp.in/rivers/Rivers_of_Maharashtra_Dec_2011.PDF

63 http://timesofindia.indiatimes.com/city/mumbai/Sand-mining-banned-in-Maharashtra-but-flourishes-on-Mumbais-outskirts/articleshow/21719160.cms

64 www.udri.org/udri/MumbaiReader10/33%20Aneerudha%20Paul%20&%20Sonal%20Sundararajan%20-%20Ecologies%20of%20the%20Periphery.pdf?phpMyAdmin=w6qdoDhnTY-UA44T6XZMtfF7FTd

65 http://dspace.library.iitb.ac.in/jspui/bitstream/10054/1615/1/6029.pdf

66 http://www.oecdilibrary.org/docserver/download/5km4hv6wb434.pdf?expires=1395323049&id=id&accname=guest&checksum=CA96F8EF1E2360250266369F94BE6508

67 http://www.oecdilibrary.org/docserver/download/5km4hv6b434.pdf?expires=1395323049&id=id&accname=guest&checksum=CA96F8EF1E2360250266369F94BE6508

Apart from this, one of the key factors is extensive impervious surface in built-up areas such as roads, pavements and building premises (residential and non-residential) which leaves little space for the surface runoff to percolate into the ground. The storm water drainage system of the city is also age old and needs urgent revamping[68]. The drainage system is deemed to be inadequate to the high%age of runoff witnessed in the city[69]. Other management issue is clogging of drainage system due to dumping of waste[70].

Emissions from transport of Food

A tremendous rise in the population of MMR is observed every decade. The expected rise in the population is up to 3.40 crores in next 2 decades which is nearly double the current population of MMR which will impact the food sector of MMR in terms of food demand and economy. Even to meet the basic demand for dietary requirements like eggs, milk & vegetables are also sourced from as far as 200 to 500 km in MMR. Serious increase in population poses a threat on these resources which leads to indirect emissions from transportation and inflate the price of basic commodities manifold. As per estimates 30 to 60 thousand tonnes of direct carbon-dioxide is emitted to only transport these commodities in MMR. As per the projected population, the demand for these food items will also double in the next few decades thus inducing severe inflation for even basic dietary requirements.

Thus, with such huge resources in MMR, it becomes essential to understand the interdependence and inter linkages between resources and the rate of its utilization. Moreover, considering its availability, it is significant to retain and conserve these resources without any further delay. The current section has thus described in detail the major driving forces (drivers) inducing pressure on the resources, their exploitation and environmental degradation in the region.

The following technical section of this report emphasizes on different resources such as water, air, land and biodiversity of MMR whereas the cross cutting impacts of climate variation in the region and on important resources has also been included. The report gives an overall environmental status of the region, which would provide basis for development of the regional plan of MMR.

[68] Chitale M. (March 2006). Final Report of Fact Finding Committee on Mumbai Floods: Volume 1. Published by Government of Maharashtra. pp. 32

[69] Ibid

[70] Ibid

Environmental Status Report of Mumbai Metropolitan Region

Section

2 Water Resources

How to use this report?

There are 3 major sections in the report focusing on **surface water resources, groundwater resources** and **water supply, sewerage & sanitation**. Before coming to the subject, general introduction is given on the following:

- Water, its global and local availability and the need for planning authority to document the status of the existing water resources in the region.
- Policy initiatives taken at central & state level and the various programs implemented across the nation.
- Organizational framework
- Approach and methodology followed for documenting the status of water resources in MMR.

Section I- Surface water resources

The section is sub divided into 4 parts focusing on rivers, coastal & marine ecosystem, lakes/ponds/wetlands/water bodies and reservoirs/dammed reservoirs.

Rivers: - The 13 west flowing rivers are explained in the following heads

- General information *(origin, tributaries, length of the river, water application and so on.)*
- Water quality information and assessment *(The status and observations for 7 critical water quality parameters for the past 5 years is explained in detail.)*
- Water quality index *(The water quality index is calculated for the year 2012-13)*
- Overall water quality of the river
- Conclusion and specific recommendations

Lakes/ponds/wetlands/water bodies: - The detail in this sub section is elaborated under two heads: (i) Greater Mumbai and (ii) rest of MMR

Greater Mumbai:

- Inventory of lakes present in Greater Mumbai and general information pertaining to classification, usage pattern, accessibility and visual status.
- Common issues and specific recommendations

Rest of MMR:

- The inventory of water bodies for the rest of the region was prepared with the help of the data published in the annual ESR/CSP (Environmental Status Report/City Sanitation Plan) of the respective municipal corporation. The water quality information and assessment, common issues and the initiatives to address these issues is highlighted in this sub section.

- Navi Mumbai (*ESR 2011-12*)
- Thane (*ESR 2010-11*)
- Kalyan Dombivali (*ESR 2011-12*)
- Bhiwandi Nizampur (*ESR 2010-12*)
- Vasai Virar (*ESR 2010-11*)
- Mira Bhayander (*CSP 2012*)
- Panvel (*ESR 2011-12*)

(The inventory is not holistic because the data of rural and peri urban areas of MMR was not available.)

Reservoirs/dammed reservoirs: -

- Inventory, general information and status
- Current issues and recommendations

Coastal and marine ecosystem: -

- Inventory and general information on coastal features existing in Greater Mumbai and rest of MMR.
- Creek/sea water quality information and assessment *(23 creek water quality monitoring stations)*
- Water quality index

Section II- Groundwater resources

The section elaborates the following:

- Status of groundwater resources
- Groundwater quality monitoring network- *Inventory and spatial representation*
- Groundwater quality index
- Conclusion and specific recommendations

Section III- Water supply, sewerage and sanitation

The section is sub divided into 2 parts focusing on water supply and sewerage & sanitation.

Water supply: -

- Inventory of existing water supply sources in MMR and their status.
- Demand & supply gap
- Projected water demand & proposed water resources for MMR
- Performance assessment comparison of ULBs (Urban Local Bodies) (*Comparing the key performance indicators developed by Ministry of Urban Development, Government of India*)
  - *Coverage of water supply connection*
  - *Per capita supply of water*
  - *Extent of metering of water connections*

- *Extent of non-revenue water*
- *Continuity of water supply*
- *Quality of water supplied*
- *Efficiency in redressal of consumer complaints*
- *Cost recovery in water supply services*
- *Efficiency in collection of water supply related charges*

<u>Sewerage and sanitation</u>:

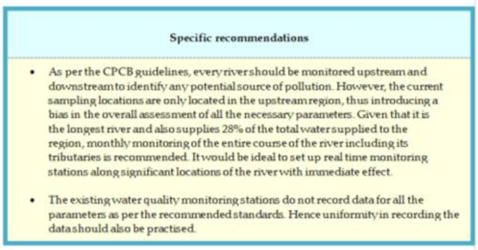
The sub section is further elaborated under two categories: (i) Residential sector and (ii) Industrial sector

Residential sector:

- Status of waste water generated by the residential sector
- Performance assessment comparison of ULBs
  - *Coverage of sewerage services and toilets*
  - *Collection efficiency of sewage network*
  - *Adequacy of sewage treatment capacity*
  - *Quality of sewage treatment*
  - *Extent of reuse and recycling of sewage*
  - *Efficiency in redressal of consumer complaints*
  - *Extent of cost recovery in sewage management*
  - *Efficiency in collection of sewage charges*

Industrial sector:

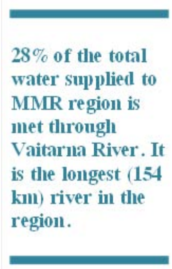
- Status of waste water generated by the industrial sector
- Inventory and spatial representation of the treatment facility (CETPs- Common Effluent Treatment Plant)
- Water quality information and assessment
- Conclusion and recommendations



Specific recommendations

- As per the CPCB guidelines, every river should be monitored upstream and downstream to identify any potential source of pollution. However, the current sampling locations are only located in the upstream region, thus introducing a bias in the overall assessment of all the necessary parameters. Given that it is the longest river and also supplies 28% of the total water supplied to the region, monthly monitoring of the entire course of the river including its tributaries is recommended. It would be ideal to set up real time monitoring stations along significant locations of the river with immediate effect.
- The existing water quality monitoring stations do not record data for all the parameters as per the recommended standards. Hence uniformity in recording the data should also be practised.

In addition, specific recommendations for each sub section have been enlisted & elaborated in blue color boxes.



Further, flow bars have been included in the running text to highlight the gist/key feature of the sub section.

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2.1 Introduction

2.1.1 Water and its status

Water is one of the most indispensable and vital natural resources for livelihood, food security and economic development. The total volume of water on Earth is about 1.4 billion km^3. The volume of freshwater resources is around 35 million km^3 (2.5% of the total volume). Of these freshwater resources, about 24 million km^3 i.e. 70% is in the form of ice and permanent snow cover in mountainous regions, the Antarctic and Arctic regions. Around 30% of the worlds freshwater is stored underground in the form of groundwater. This constitutes about 97% of all the freshwater that is potentially available for human use. Freshwater lakes and rivers contain an estimated 105 000 km^3 i.e. around 0.3 % of the world's freshwater. [1]

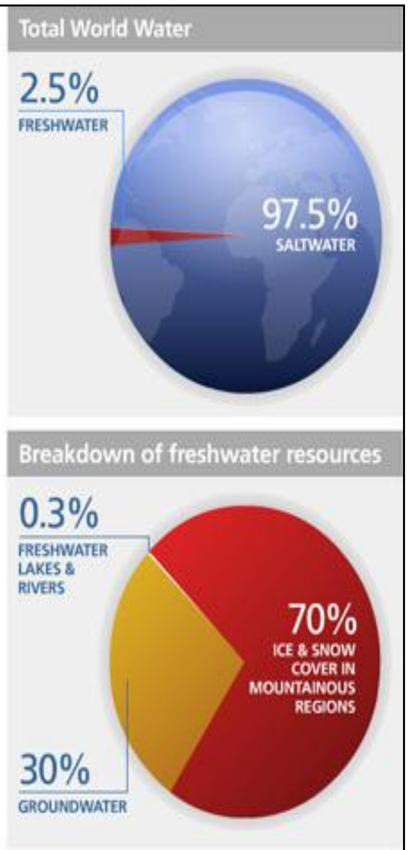


Figure No. 2-1: Breakdown of World water resources.

Source: UN water/statistics

Given the fact that the water resources are scarce and finite, its unplanned consumption driven by increased population and economic growth, is leading to water scarcity in cities across the globe and the prognosis for India is no different.

India's water crisis is often attributed to lack of holistic government planning and increased corporate privatization. Further, it is expected to worsen as the overall population of India is expected to increase to 1.6 billion by the year 2050. Moreover, according to the World Bank, 21% of the country's diseases are water releated as water resources are contaminated by both biological and chemical pollutants.

Keeping the global & local scenario in mind and with an objective of having equity in distribution and unified perspective in planning, management and efficient use of water resources, TERI had carried out a detailed quantitative and qualitative assessment of secondary data to get an overview of water resources in Mumbai Metropolitan Region (MMR). The water resources having environmental significance as well the one integrated in water supply chain were analysed using such parameters as water supply coverage, quantity supplied, per capita supply, norms for supply, indicators unaccounted for water, water treatment, waste water generation, adequacy of treatment facility and so on. The study was based on the secondary data collected from authentic sources, personal interactions with government officials, NGOs & research institutes and primary data collection by TERI for certain components.

[1] UN water/statistics

2.1.2 Policy initiatives

42nd Amendment Act, 1976, Article 51-A (g), Section 11 says "It shall be the duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures." Thus the Indian Constitution makes two fold provisions:

- On one hand, it gives directive to the state for the protection and improvement of environment.
- And on the other hand the citizens owe a constitutional duty to protect and improve natural environment.

At national and state level, there are several policies and regulation like National Water Policy, and Water (Prevention and Control of Pollution) Act, 1974 to regulate pollution discharges and restore water quality. Also, under this act, pollution control boards were created, who are responsible for implementation of the provisions mentioned in the Water act. One of the important provisions of the act is to maintain and restore the 'wholesomeness' of our aquatic resources. Therefore, "water use" has been classified into five categories to define the level of wholesomeness to be maintained or restored for a particular system and/or ecosystem.[2]

If a water body or its part is used for multiple purposes, then the use which demands highest quality of water is defined as 'designated best use' and accordingly water body or its part is designated (Table No. 2-1). Through regular water quality monitoring, the existing water quality is assessed and compared with the desired quality as recognized under designated best use class and gaps are identified. Based on the identified gaps the water body or its part is identified as polluted.

Table No. 2-1: Designated best use classification of surface water

Designated best use	Quality class	Primary water quality criteria
Drinking water source without conventional treatment but with chlorination	A	• Total coliform (TC) organisms (MPN/100 ml) shall be 50 or less • pH between 6.5 and 8.5 • Dissolved oxygen (DO) 6 mg/l or more and • Biochemical Oxygen demand (BOD) 2 mg/l or less
Outdoor bathing (organized)	B	• TC organisms (MPN/100 ml) shall be 500 or less • pH between 6.5 and 8.5 • DO 5 mg/l or more

2 http://www.cpcb.nic.in/upload/NewItems/NewItem_116_Guidelinesof%20waterqualitymonitoring_31.07.08.pdf

Designated best use	Quality class	Primary water quality criteria
		• BOD 3 mg/l or less
Drinking water source with conventional treatment	C	• TC organisms (MPN/100 ml) shall be 5000 or less • pH between 6 and 9 • DO 4 mg/l or more • BOD 3 mg/l or less
Propagation of wildlife and fisheries	D	• pH between 6.5 and 8.5 • DO 4 mg/l or more • Free ammonia (as N) 1.2mg/l or less
Irrigation, industrial cooling and controlled disposal	E	• pH between 6 and 8.5 • Electrical conductivity less than 2250 micro mhos/cm • Sodium absorption ratio less than 26 • Boron less than 2mg/l

Source: Central Pollution Control Board (CPCB), 1978

2.1.2.1 Policy documents on natural resource conservation

Policy Statement for Abatement of Pollution, 1992

The commitment of government on abatement of pollution for preventing deterioration of the environment is stated in this policy document. The document lays down steps to be taken to prevent pollution at source, encourages, develops and applies the best available practicable technical solutions. It also suggests developing different mechanisms like legislative and regulation, fiscal incentives, voluntary agreements, educational programmes and informative campaigns, while considering environmental perspective into decision making at all levels. Thus the objective is to develop a comprehensive approach to integrate environmental and economical aspects in planning, while stressing on preventive aspects for pollution abatement and promotion of technological inputs to reduce pollutants and through reliance upon public cooperation in securing a clean environment.[3]

The National Conservation Strategy and Policy Statement on Environment and Development, 1992

The primary purpose of the conservation strategy and the policy statement is to include & reinforce our traditional ethos and to build up a conservation society living in harmony with nature as well as making frugal and efficient use of resources guided by the best available scientific knowledge. Moverover, , the priorities mentioned in the document are preventing & controlling future deterioration of land, water and air; restoration of ecologically degraded areas; environmental improvement in rural and urban settlements, conserving and

[3] http://envfor.nic.in/sites/default/files/introduction-psap.pdf

nurturing the biological diversity and ensuring that the development of projects caused minimal adverse environmental consequences.[4]

The National Water Policy, 2002

The policy highlights the importance of water for human existence as well as for all economic and development related activities. While addressing the problem of water scarcity, the need to conserve the resource through optimal, economical, sustainable and equitable means is also emphasized. It presents a review and update of the National Water Policy in 1987 by making some additions and suggestions. The major provisions made in the policy are as follows:

- Establishing a standardized national information system with a network of data banks and data bases.
- Understanding the impact of developmental projects on human settlements and environment.
- Guidelines for the safety of storage dams and other water-related structures
- Controlling the exploitation of groundwater
- Setting water allocation priorities in the following order:
    - Drinking and domestic use
    - Sustaining livelihoods
    - Sustaining environment, maintaining river systems and aquatic life
    - Irrigation and hydro-power
    - Thermal power and industries
    - Recreation and religious uses
    - Navigation
- The water tariffs for surface water and groundwater should be rationalized with due regard to the interests of small and marginal farmers.

The policy also deals with participatory approach for management, development of institutional mechanism, water quality monitoring programmes, flood and drought management and so on.[5]

2.1.2.2 Indian laws and regulations on water quality management

The laws and regulations for conservation of water resources expressed in the constitution are embodied in the following regulations:

The Water (Prevention and Control of Pollution) Act, 1974

The act deals comprehensively with water related issues. It empowers the Government to constitute PCBs (Pollution Control Boards) to maintain the wholesomeness of water bodies. It also enables the Central and State Pollution Control Boards to prescribe standards and has

[4] http://envfor.nic.in/sites/default/files/introduction-csps.pdf [4] http://envfor.nic.in/sites/default/files/introduction-psap.pdf

[4] http://envfor.nic.in/sites/default/files/introduction-csps.pdf

[5] http://www.swaraup.gov.in/Downloads/nwp_2002.pdf

provisions for monitoring, compliance and penalty against the violators of the act. It offers the permit system i.e. 'Consent" procedure to prevent and control water pollution and also empowers the State Boards to issue directions to the defaulters.[6]

Water Cess Act, 1977

The water cess act was formulated to levy and collect cess/tax on water consumed by persons carrying on certain industries and by local authorities, with a view to augment the resources of the Central and the State Boards for the prevention and control of water pollution constituted under the Water (Prevention and Control of Pollution) Act, 1974.[7]

Environment (Protection) Act, 1986

The act has a broad coverage in which 'Environment' which includes water, air and land. It empowers the government to take measures in protecting and improving the quality of the environment through preventing, controlling and abating environmental pollution. The government is authorised to set national standards for environmental quality and discharge of environmental pollutants from various sources, prescribe procedures for hazardous substance management and to collect and disseminate information regarding environmental pollution. Also the act provides severe penalties for those who fail to comply with provisions of the act.[8]

2.1.3 Organizational Framework

2.1.3.1 Central Pollution Control Board (CPCB)

CPCB, a statutory organisation was constituted in September, 1974 under the Water (Prevention and Control of Pollution) Act, 1974. CPCB along with its counterparts, State Pollution Control Boards (SPCBs) are responsible for implementation of legislations relating to prevention and control of environmental pollution. The principal function of the CPCB, as spelt out in the Water (Prevention and Control of Pollution) Act, 1974, is to promote cleanliness of streams and wells in different areas of the States by prevention, control and abatement of water pollution. It also serves as a field formation and provides technical services to the Ministry of Environment and Forests of the provisions of the Environment (Protection) Act, 1986. One of the mandates of CPCB is to collect, collate and disseminate technical and statistical data relating to water pollution. Hence, Water Quality Monitoring (WQM) and surveillance are of utmost importance.

2.1.3.2 Maharashtra Pollution Control Board (MPCB)

The Water (Prevention & Control of Pollution) Act, 1974 was adopted by the state government in the year 1981 and accordingly MPCB was formed under the provisions of section 4 of the act. MPCB is bound to implement various environmental legislations in the

[6] http://hspcb.gov.in/Water%20Act,%201974%20Relevant%20provisions.pdf

[7] http://envfor.nic.in/legis/water/water7.html

[8] http://envfor.nic.in/legis/env/env1.html and http://www.moef.nic.in/sites/default/files/eprotect_act_1986.pdf

state, mainly including Water (Prevention and Control of Pollution) Act, 1974, Air (Prevention and Control of Pollution) Act, 1981, Water (Cess) Act, 1977 and some of the provisions under Environmental (Protection) Act, 1986 and the rules framed there under like, Biomedical Waste (M&H) Rules, 1998, Hazardous Waste (M&H) Rules, 2000, Municipal Solid Waste Rules, 2000 etc. MPCB functions under the administrative control of Environment Department of Government of Maharashtra. Some of the important functions of MPCB are:

- To plan comprehensive program for the prevention, control or abatement of pollution of natural resources and secure executions thereof,
- To collect and disseminate information relating to pollution and the prevention, control or abatement thereof,
- To inspect sewage or trade effluent treatment and disposal facilities, specification or any other data relating to the treatment plants, disposal systems and air pollution control systems in connection with the consent granted,
- Supporting and encouraging the developments in the fields of pollution control, waste recycle reuse, eco-friendly practices etc.
- To educate and guide the entrepreneurs in improving environment by suggesting appropriate pollution control technologies and techniques
- Creation of public awareness about the clean and healthy environment and attending the public complaints regarding pollution.

2.1.4 National water quality monitoring program

CPCB in collaboration with concerned SPCBs have established a nationwide network of water quality monitoring comprising 2500 stations in 28 States and 6 Union Territories. The monitoring is done on monthly or quarterly basis in case of surface waters and on half yearly basis in case of groundwater. Presently the inland water quality-monitoring network is operated under a three-tier programme i.e. Global Environment Monitoring System (GEMS), Monitoring of Indian National Aquatic Resources System (MINARS) and Yamuna Action Plan (YAP).

2.1.4.1 GEMS

The United Nations Global Environment Monitoring System Water Programme is dedicated to providing environmental water quality data and information of the highest integrity, accessibility and interoperability. [9]

2.1.4.2 MINARS

Parallel to GEMS, the national programme titled 'MINARS' was started in 1984 with a total of 113 stations spread over 10 river basins. The present network comprises of 870 stations on rivers, lentic water bodies and subsurface water. Water samples are being analysed for 28 parameters consisting of physico-chemical and bacteriological parameters for ambient water samples apart from field observations.

[9] http://www.unep.org/gemswater/

2.2 Approach and Methodology

MMR is bestowed with numerous water resources which are significant from environment as well as resource point of view. Given the fact that there is dearth of comprehensive information at the regional scale, a specific and customised methodology was developed since the focus of this report was to highlight the regional status (quantity and quality) of water resources integrated in the supply chain as well those that have environmental significance. The step wise methodology for the study is appended below:

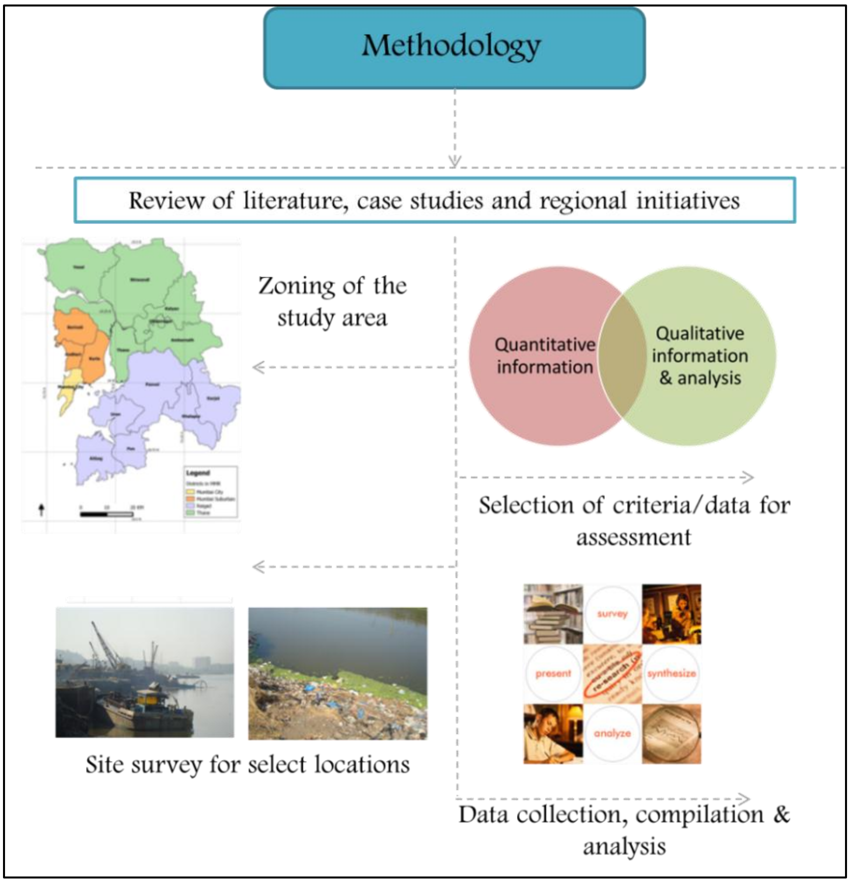


Figure No. 2-2: Methodology for preparing the environmental status report

Source: Conceptualized and prepared by TERI- WRC

2.2.1 Zoning of the study area

The water resources which are within MMR were identified with the help of remote sensing data procured from Maharashtra Remote Sensing Applications Centre (MRSAC). The quantitative data was acquired from various reports like environmental status report of Urban Local Bodies (ULBs), Water Resources Information System of India (India-WRIS) and so on, whereas for the qualitative assessment, the report titled 'Water Quality Status of Water Bodies in Maharashtra with the Recourde to Analytical/Statistical Tools' and the standards issued by Maharashtra Pollution Control Board (MPCB)[10] were referred. In totality, the water resources were studied, however, for the water resources integrated in the water supply chain, the focus was only on the 8 Municipal Corporations and 9 Municipal Councils of MMR, since the data for the rural area of MMR was not available.

2.2.2 Selection of criteria /data for assessment

The general information on the water resources is presented in the **First Section** of the report titled **'Surface water resources in MMR'**. For instance in case of rivers the general information about origin of the river, tributaries, course of the river, length of the river from origin, catchment area, gross storage capacity of the reservoir, water applications, dams/reservoirs on the river and so on. Similarly, the data for other water resources like lakes and dammed reservoirs are presented in this report.

Further, for water quality which refers to the chemical, physical and biological characteristics of water. It is most frequently referred to a set of standards against which compliance can be assessed. Across the world, major agencies like WHO (World Health Organization) and EPA (Environmental Protection Agency) whereas at national level CPCB (Central Pollution Control Board) provides the guidelines or common standards to assess water quality. WQAA (Water Quality Assessment Authority) created under Environment (Protection) Act, 1986 has notified a "Protocol for Water Quality Monitoring". Therefore, CPCB has published a document "Guidelines for Water Quality Monitoring' which brings out major considerations to design water quality monitoring network, procedures for sampling, laboratory analysis, data storage, data analysis, presentation, interpretation, reporting and quality assurance.

The designated standards may vary depending upon the usage of the water which may include drinking, industrial, fishing, recreational uses and so on. However the basic parameters considered for assessing water quality are standard across the globe. In the case of natural water bodies, they also make some reasonable estimate of pristine conditions. Different uses raise different concerns and therefore different standards are considered. Most commonly used physical, chemical and biological indicators include the following.

[10] http://mpcb.gov.in/envtdata/waterquality41.php

Physical indicators

- Water Temperature
- Specifics Conductance or EC, Electrical Conductance, Conductivity
- Total suspended solids (TSS)
- Transparency or Turbidity
- Total dissolved solids (TDS)
- Odour of water
- Colour of water
- Taste of water

Chemical indicators

- pH
- Biochemical oxygen demand (BOD)
- Chemical oxygen demand (COD)
- Dissolved oxygen (DO)
- Total hardness (TH)
- Heavy metals
- Nitrate
- Orthophosphates
- Pesticides
- Surfactants

Biological indicators

- Ephemeroptera
- Plecoptera
- Mollusca
- Trichoptera
- Escherichia coli (E. coli)
- Coliform bacteria

Thus for river water quality assessment, A-II category of MPCB for best designated usages (Annex-2- Table No. 6-1) was considered and for creek water quality assessment, SW-II category for coastal waters (Annex-3 Table No. 6-2 to 6-7) was considered.

The secondary data on the sources of groundwater and the potential water that is being extracted daily were assessed. Similarly to surface water resources, the water quality reports on the groundwater were assessed for the years 2007-11. This constitutes the **Second Section** of the report entitled **'Groundwater resources in MMR'**.

For water resources integrated in the supply chain and sewerage, the data was collected and analysed for the key performance indicators developed by Ministry of Urban Development (MoUD), Government of India[11]. This creates the **Third Section** of the report titled **'Water supply, sewerage and sanitation in MMR'**.

The key performance indicators are:

[11] http://moud.gov.in/sites/upload_files/moud/files/pdf/Handbook.pdf

Water supply services:

- Coverage of water supply connections
- Per capita supply of water
- Extent of metering of water connections
- Extent of non-revenue water (NRW)
- Continuity of water supply
- Quality of water supplied
- Efficiency in redressal of customer complaints
- Cost recovery in water supply services
- Efficiency in collection of water supply related charges

Sewerage and sanitation:

- Waste water generated
- Coverage of sewerage services and toilets
- Collection efficiency of sewage network
- Adequacy of sewage treatment capacity
- Quality of sewage treatment
- Extent of reuse and recycling of sewage
- Efficiency in redressal of consumer complaints
- Extent of cost recovery in sewage management
- Efficiency in collection of sewage charges

2.2.3 Data collection, compilation and analysis

As per the ToR (Term of Reference), it was agreed that TERI shall prepare the ESR for MMR based on the secondary data. Various government departments and private agencies were approached for sourcing the secondary data (Table No. 2-2). Primarily, the annual ESR of the ULBs was reviewed for atleast past 5 years. After assessing these ESRs, TERI had developed a data matrix which highlighted the data gaps. These data gaps were then filled up by having personal interactions with the concerned officials (Table No. 2-3) or by circulating customized questionnaires. Published and unpublished reports, papers and presentations were also reviewed and the key findings are incorporated in the report. The analysis of the data is presented either in graphical or spatial formats in this report.

Table No. 2-2: Agencies approached for data collection

Organization/Agency	Title of the Report/ data sets	Periodicity	Latest publication
Central Groundwater Board (CGWB), GoI	Water Quality Information given online for Thane and Raigad District	Annual	2012
Groundwater Survey and Development Agency (GSDA), GoM	Water Quality Information given online for Thane and Raigad District	Annual	2010
Maharashtra Industrial Development Corporation (MIDC), GoM	Water Supply (Industrial & Municipal)	Annual	Latest Year
MPCB, GoM	Water Quality for Station within MMR	Monthly	Latest Month
	Annual Water Quality Status under GEMS MINARS Project	Annual	2006 - 07
	Status of CETP's in Maharashtra	Annually	2008 - 09
	Annual Report on Implementation of MSW	Annual	2011 - 12
	Region wise Environmental Status Report	No more being prepared	2005
Maharashtra Jeevan Pradhikaran, GoM	Annual Report	Annual	2007-08
Municipal corporations in MMR	ESR of Navi Mumbai Municipal Corporation	Annual	2011-12
	ESR of Thane Municipal Corporation	Annual	2011-12
	ESR of Kalyan Dombivli Municipal Corporation	Annual	2011-12
	ESR of Municipal Corporation for Greater Mumbai	Annual	2011-12
	ESR of Bhiwandi Nizampur Municipal Corporation	Triennial	2010-12
	ESR of Vasai Virar Municipal Corporation	Annual	2010-11

Organization/Agency	Title of the Report/ data sets	Periodicity	Latest publication
	ESR of Mira Bhayandar Municipal Corporation	Annual	2009-10
9 Municipal councils	Data on Water Supply, Sanitation, service benchmark report and City development Plan	Annual	2010-11
2 Zilla Parishad (ZP)- Thane ZP and Raigad ZP	District Statistical Abstract, Water Supply, Sanitation	Annual	2010-11
Water Supply Resource Management Cell, MMRDA	Report of the Expert committee (Water planning)		1994 & 2005
Regional Centre for Urban and Environmental Studies (RCUES), All India Institute of Local Self-Government (AIILSG), Mumbai.	Performance Assessment System Indicator report		2008-12

Table No. 2-3: Stakeholder consultations

Organization/Agency	Mode of correspondence	Highlights of the meeting
Municipal Corporations	Letter and personal interactions.	The ESR in either hard or soft copy for minimum 3 years was shared. Ulhasnagar Municipal Corporation does not prepare an ESR; hence they shared their City Sanitation Plan.
Municipal councils	Letter and personal interactions. A letter as well a detailed questionnaire was prepared to get the requisite data especially from the Municipal Councils, since they do not publish an annual	The questionnaire was filled in to quite an extent. Panvel Municipal Council had shared their latest environment status report (2012-2013), whereas the Kulgaon Badlapur, Alibag, Pen, Karjat and Matheran MCs shared their service benchmark reports. Few municipal councils also mentioned about Performance Assessment System (PAS) project that aimed at collating data precisely on water and

Organization/Agency	Mode of correspondence	Highlights of the meeting
	environment status report.	sanitation from all the ULBs from the state of Gujarat and Maharashtra, which is been done in collaboration with All India Institute of Local Self- Government (AIILSG).
Maharashtra Pollution Control Board (MPCB)	Letter and personal interactions.	The monthly report on the water quality for stations within the MMR and the annual water quality status under GEMS and MINARS project was shared by MPCB.
Maharashtra Jeevan Pradhikaran, Government of Maharashtra Undertaking	Letter, email and personal interactions.	The Executive Engineer, CTDM informed that the latest information about the ULBs with respect to water is regularly updated on their website- http://www.mahaurban.org/Login.aspx and requested TERI to refer the same.
Groundwater Surveys & Development Agency, Government of Maharashtra	Letter, email and personal interactions.	In order to get access to the database of GSDA, one needs to take the membership. TERI has now been registered as a member of GSDA. The data request was sent in the month of May, 2013, however due non-availability of the personnel in-charge. Due to high price of the set of hard copies of the data and the need for digitizing, a task which requires vast time expenditure, the procurement of the data is put to hold.
Central Groundwater Board (CGWB)	Letter and personal interactions.	The data pertaining to groundwater quality, water table, groundwater management strategy and major groundwater problems and issues was sourced from the official. Website- http://cgwb.gov.in/
Maharashtra Industrial Development Corporation (MIDC)	Letter, email and personal interactions.	The latest annual report on the water supply (Industrial and Municipal) was shared.
Zilla Parishad, Thane	Letter, email and personal interactions.	An excel sheet detailing the water supply network, hours of supply, energy consumption, annual expenditure on operation and maintenance was shared.
Water Supply Resource Management Cell, MMRDA	Letter, email and personal interactions.	The report of expert committee (water planning) and a detailed presentation on the water supply resources planning and development for MMR was shared.
Regional Centre for Urban and	Letter, email and personal interactions.	Data was not shared with TERI, since they had signed an agreement with their project

Organization/Agency	Mode of correspondence	Highlights of the meeting
Environmental Studies (RCUES), All India Institute of Local Self-Government (AIILSG), Mumbai.		partners.

2.2.4 Site survey of selected locations

During the primary assessment of data, it was observed that for certain components or locations the data was missing. Hence, TERI decided to conduct primary survey to fill in the data gaps.Table No. 2-4 reveals the details of the site surveys.

Table No. 2-4: Site survey for select locations

Sr. No.	Survey location	Objective of the survey
1	Netaji Lake, Juchandra, Vasai	During the data analysis, it was observed that there is a record of 90 lakes in Vasai- Virar region, which is the highest among all the municipal corporations in MMR. However, there was no further information available. Hence, TERI decided to conduct primary survey to assess status of few prominent lakes of the region.
2	Pelhar Lake and Dam, Virar	
3	Shirgaon Lake, Virar	
4	Nirmal Lake, Vasai	
5	Chakreshwar Lake, Nalasopara	
6	Wagholi Lakes (2), Nalasopara	
7	Gauripada talav, Milind nagar	Similarly for Kalyan Dombivali region, the data pertaining to lakes was missing. Hence 7 lakes were studied to understand the dependence of communities, physical status and so on.
8	Bhoiwada lake, Bhoiwada	
9	Kala talav, Beturkar pada	
10	Apurva lake, Kalyan highway	
11	Nilaje lake, Shilphata	
12	Mauli Talav	
13	Khidkaleshwar talav	
14	Ulhas river	There are 10 water monitoring stations, out of which 6 stations could not be analysed due to lack of data. Hence few site visits were conducted at different locations to cover the course of the river and present the first-hand experience/status of the river.

Sr. No.	Survey location	Objective of the survey
15	Taloje river	The details pertaining to the river was missing. Hence a recce survey was conducted.

Source: ESR reports and TERI-WRC

2.2.5 Review of case studies and regional initiatives

Literature review was carried out to highlight the initiatives taken by individuals and ULBs to address the issue of water scarcity and water quality. The best water management practices adopted by the ULBs are explained in brief so that other ULBs could explore the possibility of implementing the same in their respective jurisdiction. These details are included in the following sections as and where applicable.

2.3 Water resources in MMR

Water resources are sources of water that are useful or potentially useful.[12] They are used for various purposes like direct consumption, irrigation, fisheries, hydropower, industrial production, recreation, navigation, environmental protection, disposal of sewage and industrial effluents and so on. Water has economic, social, and spatial dimensions which makes it a unique and challenging natural resource to manage.

In MMR, there are four major sources of surface water as mentioned below:

- Rivers
- Lakes/ponds
- wetlands
- Reservoirs/dammed reservoirs

Altogether, there are 13 west flowing rivers and 21 tributaries, more than 431 water bodies (lakes and ponds) and 22 reservoirs/dammed reservoirs within the municipal limits of the various ULBs.[13]

The groundwater sources are:

- Wells- Tube wells, dug wells and bore wells
- Stand posts/Hand pumps

In all there are 5660 dug wells, 7511 tube wells, 1906 bore wells and 3715 hand pumps (within the municipal limits), from which 293.35 million litres per day (MLD) of groundwater is being extracted presently. [14]

In the following sections, the general information and the water quality assessment of the surface and groundwater resources are explained in detail.

[12] http://en.wikipedia.org/wiki/Water_resources

[13] MRSAC data, latest ESRs and quesstionaires filled by Municipal Councils

[14] Environmental Status Reports and Maharashtra Jeevan Pradhikaran

Surface Water Resources

2.4 Surface water resources in MMR

Surface water is water in a river, lake or fresh water wetland. These water resources are naturally replenished by precipitation and naturally lost through discharge to the sea, evaporation and sub-surface seepage.

In MMR, there are 13 west flowing rivers, 21 tributaries, more than 431 water bodies (lakes & ponds) and 22 reservoirs with in the municipal limits.

2.4.1 Rivers[15]

As we are aware, water is continuously circulating between Earth's surface (land & oceans) and the atmosphere, in a never-ending manner comparable to a conveyor belt called the water cycle. Rivers form an important part of this cycle that carry water from the higher parts of Earth i.e. uplands- mountains & hills to the lower parts- lakes and seas (Box no. 1 explains the course of a river). Rivers are often called as drains or channels with fairly well defined banks that can be thin & shallow or very deep & wide. Powered by gravity, rivers are always flowing downhill even if they look absolutely flat; they flow down with a gentle incline. They are filled with freshwater on which the lives of many different creatures like insects, animals, and humans are dependent.

Box no: 1 Course of a river

Upper river course (Youthful stage)

A river originates from hills or mountains. In a cold region, a river may be created by melting snow or a glacier. In warmer places, rivers typically form when water drains from series of upland slopes known as a basin.

Water drains from each slope to form a small trickle called a rill. Rills from many slopes combine together to make creeks (small streams) and larger streams, before all these things eventually merge into a river.

The streams and creeks that form a river are called its tributaries. Flowing down from high hills and mountains, the upper course of a river is usually narrow, steep, and marked by sharp valleys and abrupt, zig-zag changes of direction. The steepness means the water flows quickly, often forming dramatic features such as waterfalls. Rapid flow of water means the water has high energy to cut through rocks, wearing away deposits in a process called erosion.

[15] http://www.explainthatstuff.com/rivers.html

<u>Middle river course (Mature stage)</u>

As the river leaves the hills and mountains from where they originate, they take on the classic pattern of a mature river that we see in the landscapes around us, which are wider, slower, less steep, and change course more gradually. During the course, the features they form are more significant like wider lakes, wandering S-shaped bends called meanders, and deeper, broader cuts in the landscape called valleys. (For example: Ulhas River)

Sometimes two rivers will join together at a point called a confluence. (For example: Mithi river is a confluence of tail water discharges of Powai and Vihar lakes). Further, when sediments carved from the upper reaches of the river are carried downstream can build banks called levees that keep the water level higher than the landscape around it. Also when the flow is high, water spills over the banks carrying mud and sediment with it and creating marshy floodplains. As rivers cross floodplains, they snake from side to side eroding the landscape in some places and building it up at other places through a process called deposition. Rivers are often surrounded by lush grassland areas called meadows.

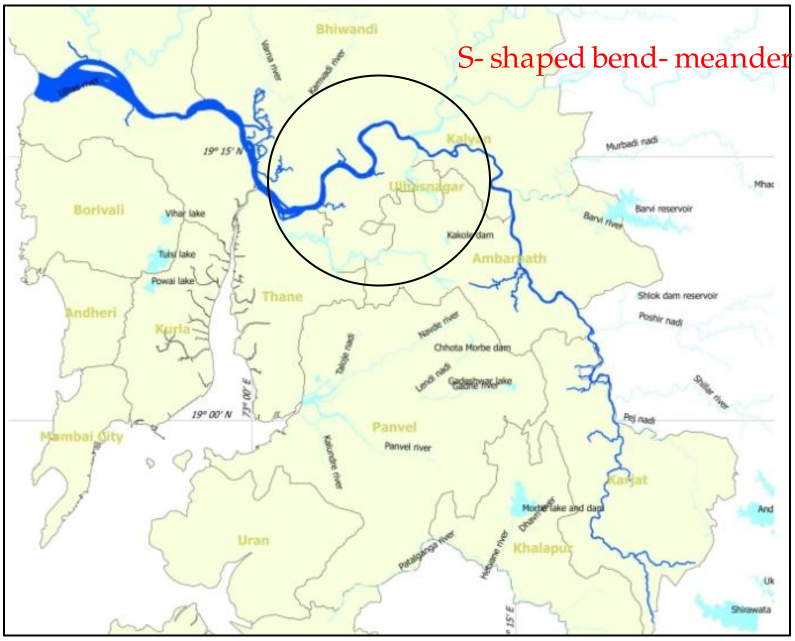


Figure No. 2-3: Spatial representation of Ulhas River highlighting meanders

Source: MRSAC and Google Earth

Lower river course (old age stage)

There are no strict boundaries between the upper, middle, and lower course of a river, the middle-course feature like meanders are also found in the lowest reaches of a river. But the lower course of a river is less steep than the middle course and the water runs even more slowly.

The river finally reaches the sea at estuaries (wide, deep, open river mouth) or triangular-shaped deltas where river deposits sediment at its mouth creating many narrower channels called distributaries instead of a single, wide mouth. (For example: Vaitarna river) Trophic states (mesotrophic, eutrophic and oligotrophic) are based on lake fertility. The root "trophy" means nutrients; therefore, lakes are classified based on the amount of available nutrients (Phosphorus and Nitrogen) for organisms. More fertile lakes have more nutrients and therefore more plants and algae. In the newly formed lakes, the edges and bottom are exposed rock, which doesn't erode very quickly, meaning there are not many nutrients available. As a lake ages, sediment from the watershed is washed off, filling in the bottom of the lake. This sediment is rich in nutrients, and therefore increases the fertility of the lake.

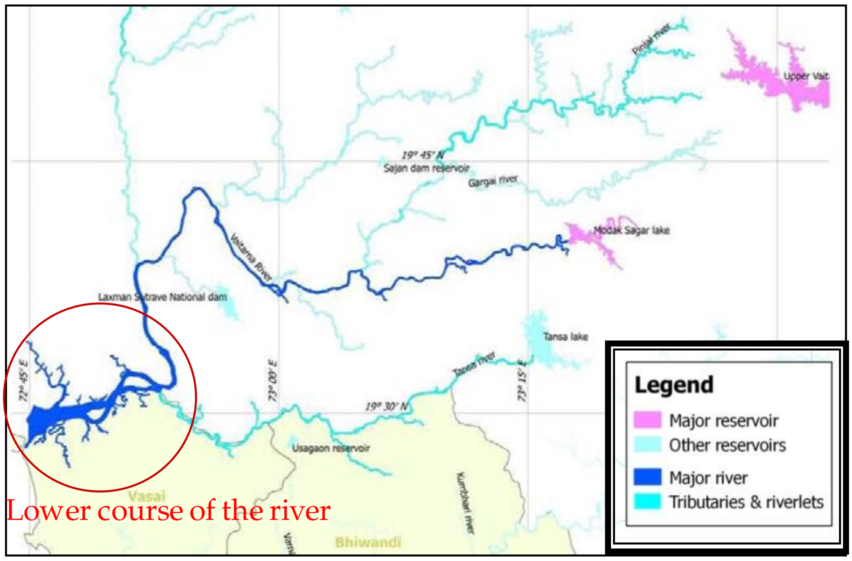


Figure No. 2-4: Spatial representation of Vaitarna River highlighting the lower course of the river

Source: MRSAC and Google Earth

Significance of rivers

Water from the rivers is a basic natural resource, essential for various human activities. Thus, river banks attracted settlers since antiquity. Rivers also played significant role in helping people travel across Earth, both for exploration and trade. In addition, people have been harnessing energy from rivers since ancient times and modern-day environmental issues like global warming have led to renewed interest in things like hydroelectric power (damming rivers and forcing them to flow at high-speed so as to rotate the turbines to generate electricity.)

Rivers are incredibly important for humans. However it has been over exploited for various activities like removing sand and gravel from river beds for building materials, irrigation, fishing and so on. Discharging untreated sewage and other wastewater into rivers has added to water pollution and thus deteriorated the quality of the water.

Rivers in MMR

In MMR there are 13 major west flowing rivers and drain into the Arabian Sea as tabulated in Table No. 2-5 and its spatial representation is given in Map No. 2-1.

Most of the westwards flowing rivers of Maharashtra originate from the Western Ghats like Damanganga, Surya, Vaitarna, Ulhas, Savitri, Kundalika, Patalganga, Vashisti, Shastri, Karli, Terekhol and so on[16]. The 13 west flowing rivers are an important source of water for drinking purposes, agriculture and also for industrial and domestic uses. Rivers like Vaitarna, Patalganga, Ulhas, Balganga and so on along with the tributaries such as Tansa, Bhasta and Barvi are used as sources of drinking water. While rivers like Panvel, Bhogeshwari and Amba & their tributaries are used for discharge of effluents by industries causing high water pollution[17]. The Ulhas and Patalganga rivers are also used for effluent discharge in the lower reaches. Due to this the water quality differs at various locations[18].

These rivers are also an important source of water for various industries clustered near Thane–Belapur belt, Kalyan–Ulhasnagar–Ambernath belt, western shore of Thane creek and around Patalganga River. These industries manufacture a wide range of products such as dyes, pharmaceuticals, fine chemicals, plastics, petro and agrochemical, fertilizers, and refined petroleum products release the waste water to Thane creek, Ulhas and Patalganga rivers which proves to be a reason for pollution in these rivers. Traces of lead are found at the Ulhas river basin due to waste released by these industries[19]. Thus majority of the rivers are polluted at various stages due to release of industrial effluents, solid waste and other waste from various sources[20][21].

[16] http://sandrp.in/rivers/Rivers_of_Maharashtra_Dec_2011.PDF

[17] http://www.dnaindia.com/mumbai/report-three-major-rivers-near-mumbai-polluted-mpcb-report-1417624

[18] http://moef.nic.in/soer/state/SoE%20report%20of%20Maharashtra.pdf

[19] http://dspace.library.iitb.ac.in/jspui/bitstream/10054/1615/1/6029.pdf

[20] http://timesofindia.indiatimes.com/city/mumbai/Mumbai-for-Me-After-leaving-park-Mumbais-rivers-get-polluted/articleshow/12510943.cms

[21] http://dspace.library.iitb.ac.in/jspui/bitstream/10054/1615/1/6029.pdf

Table No. 2-5: Details of rivers in MMR- River, tributary and course

Sr. No.	Rivers	Tributary	Origin	Joins/merges into	Admin. boundary	Length of the river from origin (Km)	Water application/significance	Number of WQMS (Quality)
1.	Vaitarna		Hilly terrain of Maharashtra at Trimbak in Nashik district	Arnala creek	Outside MMR	154	It supplies around 1525 MLD of water to the region. (28% of the total water requirement)	1 (Good to Excellent)
		Susari	Thane (Dahanu, Palghar)				It is estimated that 200 MLD of water shall be drawn for meeting the requirement of rest of MMR.	3 (Good to Excellent)
		Pinjal	Thane (Mokhada, Jawhar)				It is estimated that 697 MLD of water shall be drawn for Greater Mumbai and approximately 533 MLD for meeting the requirement of rest of MMR.	–
		Gargai	Thane (Mokhada, Wada)				It is estimated that 455 MLD of water shall be drawn for meeting the water requirement of Greater Mumbai.	–
		Tansa	Thane (Shahapur, Wada, Bhiwandi, Vasai)		Vasai Virar Municipal Corporation		It supplies 455 MLD of water to the region	1 (Good to Excellent)

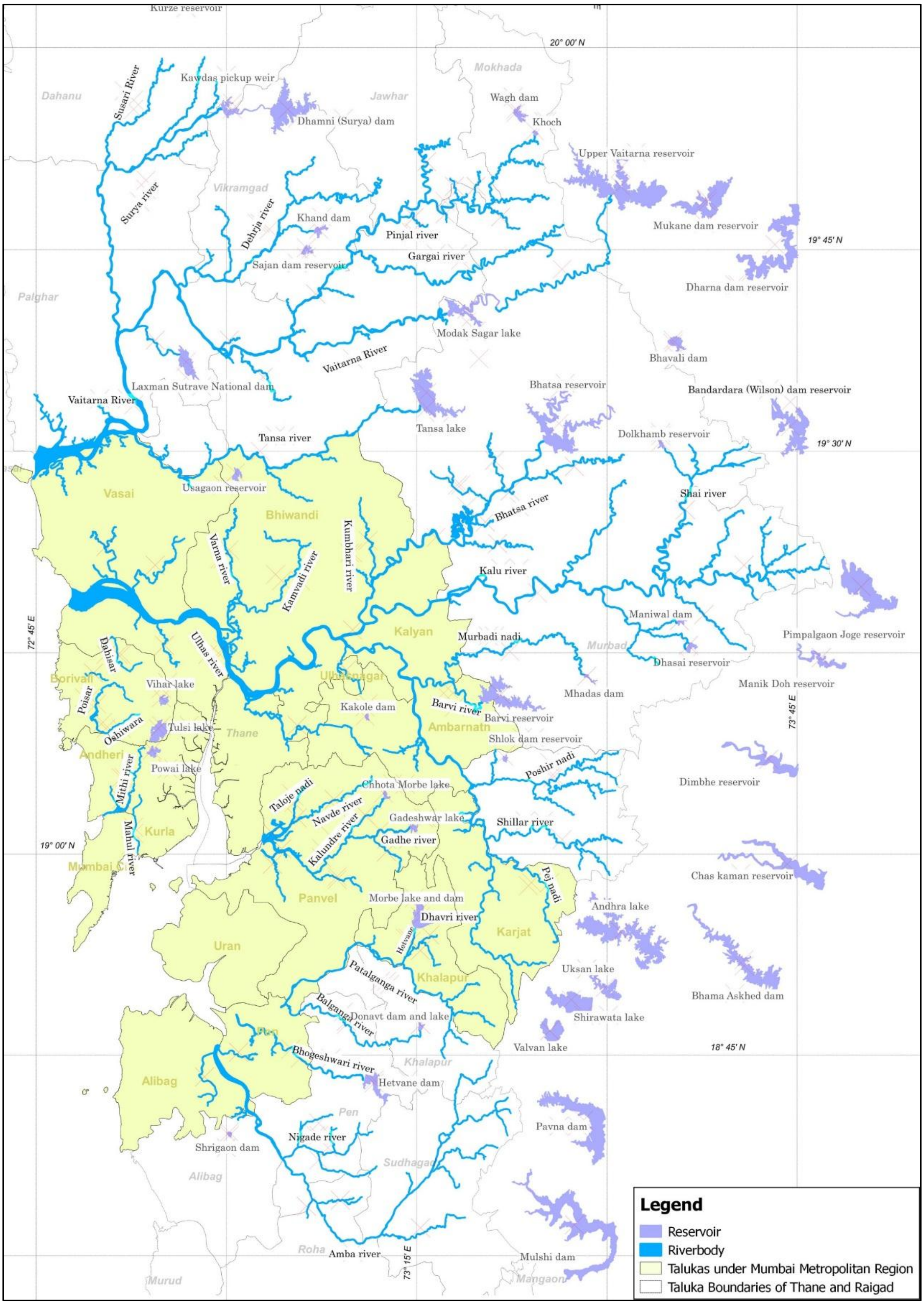
Sr. No.	Rivers	Tributary	Origin	Joins/merges into	Admin. boundary	Length of the river from origin (Km)	Water application/significance	Number of WQMS (Quality)
2.	**Ulhas**		Ravines of Sahyadari ranges to the north of Tungarli hills near Lonavala	Bassein creek	Kulgaon Badlapur Municipal Corporation (Creek- KDMC, TMC and MBMC)	122	Approximately 60% of the total water supplied to the region is met through ulhas river	3 on river (Good to Excellent) and 7 on creek (Medium to good)
		Varna	Thane (Bhiwandi)	ND- No Data				–
		Kamvadi						
		Kumbhari						
		Bhatsa	Thane		KDMC		Approximately 1850 MLD of water is drawn from the river to meet the water requirement of the region. It is the only tributary from where this huge quantum of water is drawn.	3 (Good to Excellent)
		Shai	Thane (Shahapur, Murbad)				It is estimated that 940 MLD of water shall be drawn for meeting the water requirement of rest of MMR.	–
		Kalu	Thane (Murbad)		KDMC		It is estimated that 1140 MLD of water shall be drawn for meeting the water requirement of rest of MMR.	1 (Medium to good)

Sr. No.	Rivers	Tributary	Origin	Joins/merges into	Admin. boundary	Length of the river from origin (Km)	Water application/significance	Number of WQMS (Quality)
		Murbadi	Thane (Murbad, Kalyan)	ND- No Data				–
		Barvi	Thane (Ambernath, Kalyan)				Approximately 600 MLD of water is drawn from the tributary to meet the water requirements of Greater Mumbai.	–
		Poshir	Raigad (Karjat)				It is estimated that 740 MLD of water shall be drawn for meeting the water requirement of rest of MMR.	–
		Shillar	Raigad (Karjat)	ND- No Data				–
		Pej						
3.	**Dahisar**		Spillway of the Tulsi Lake in the Sanjay Gandhi National Park		MCGM	14.5		–
4.	**Poisar**		Sanjay Gandhi National Park	Marve Creek	MCGM	11.5	Highly polluted and presently serves as a drain for the region	–
5.	**Malad**		Mumbai Suburban (Borivali)		MCGM	11		–
6.	**Oshiwara**		Mumbai Suburban (Borivali)	Malad creek	MCGM	9.63		–
7.	**Mithi**		At confluence of tail water discharges of	Mahim bay	MCGM	17.8	Washing of vessels, animals & oily drums.	1 (Bad)

Sr. No.	Rivers	Tributary	Origin	Joins/merges into	Admin. boundary	Length of the river from origin (Km)	Water application/significance	Number of WQMS (Quality)
			Powai and Vihar lake					
8.	**Mahul**		At confluence of Nehru Nagar Nala and Pratiksha Nagar Nala	Thane creek	MCGM	5.74	Water appears very polluted and black throughout the stretch. Hence not used.	–
9.	**Panvel**		Chotta Morbe Dam in North of Panvel	Thane creek	PMC	30	360 MLD of water is supplied to NMMC from Morbe dam	
		Taloje	Raigad (Panvel)	ND- No Data				–
		Navde						–
		Lendi						–
		Gadhe						–
10.	**Amba**		Borghat hill of the Sahyadri ranges near Khopoli-khandala	Dharamtar creek	Raigad	76	168 MLD of water is supplied to rest of the MMR region.	1 (Good to Excellent)
11.	**Bhogeshwari**		Western ghats near village Bhogeshwari	Dharamtar creek	Raigad	40		–
12.	**Patalganga**		Western scarps of the Matheran uplands	Dharamtar creek	Raigad	41	510 MLD is supplied to the region (360 MLD from Morbe dam & 150 MLD from Hetawane)	7 (Good to Excellent)
		Hetvan	Raigad	ND- No Data				–

Sr. No.	Rivers	Tributary	Origin	Joins/merges into	Admin. boundary	Length of the river from origin (Km)	Water application/significance	Number of WQMS (Quality)
		e	(Khalapur)					
		Dhavri	Raigad (Khalapur)					–
13.	**Balganga**		Tributary stream of the Patalganga	Dharamtar creek	Raigad	27	Balganga dam is proposed to be completed by 2014; on completion it shall supply 300 MLD to Navi Mumbai.	–

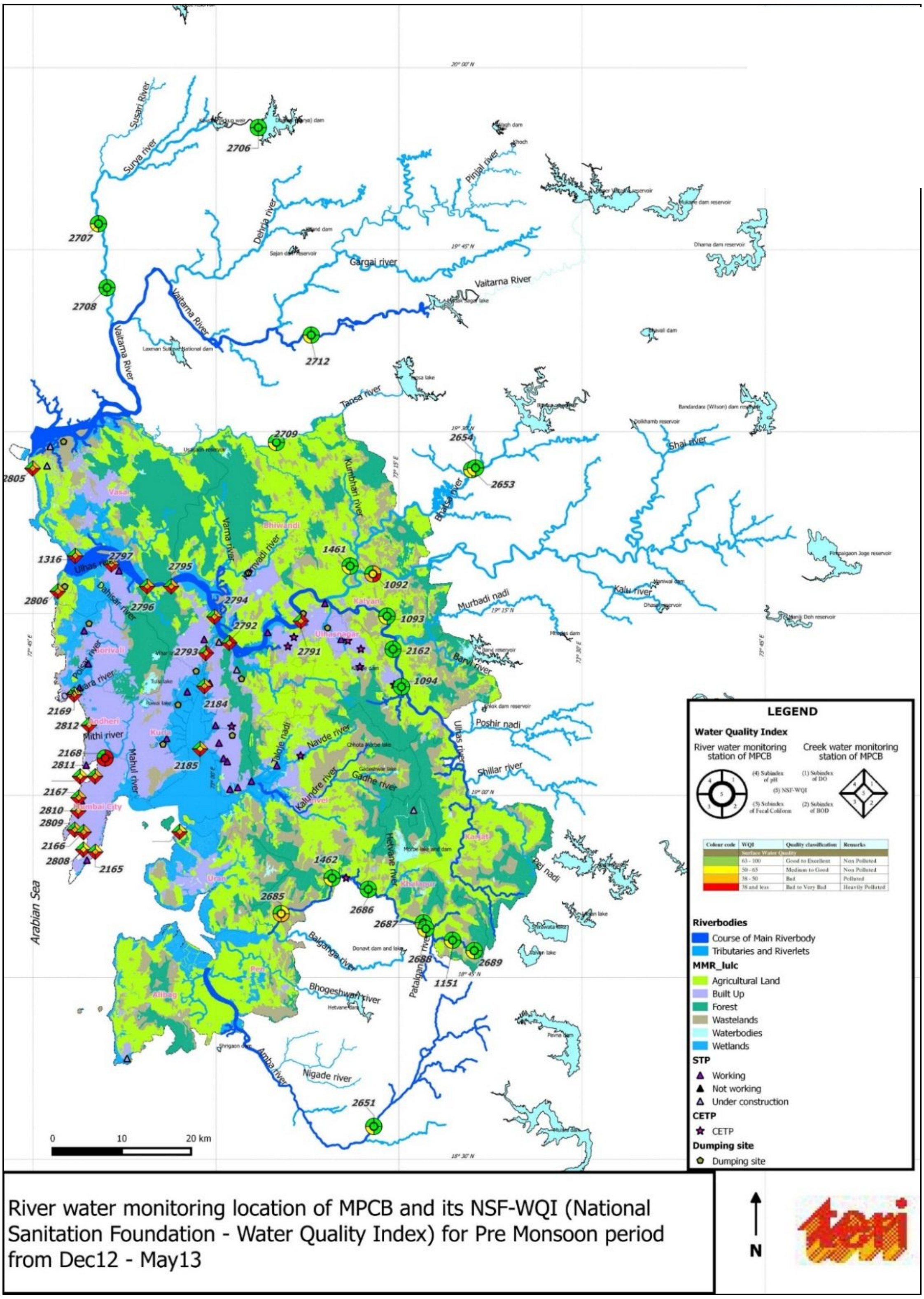
Source: MRSAC, Google Earth and Environment Status Reports



Map No. 2-1: Spatial representation of 13 west flowing rivers of MMR

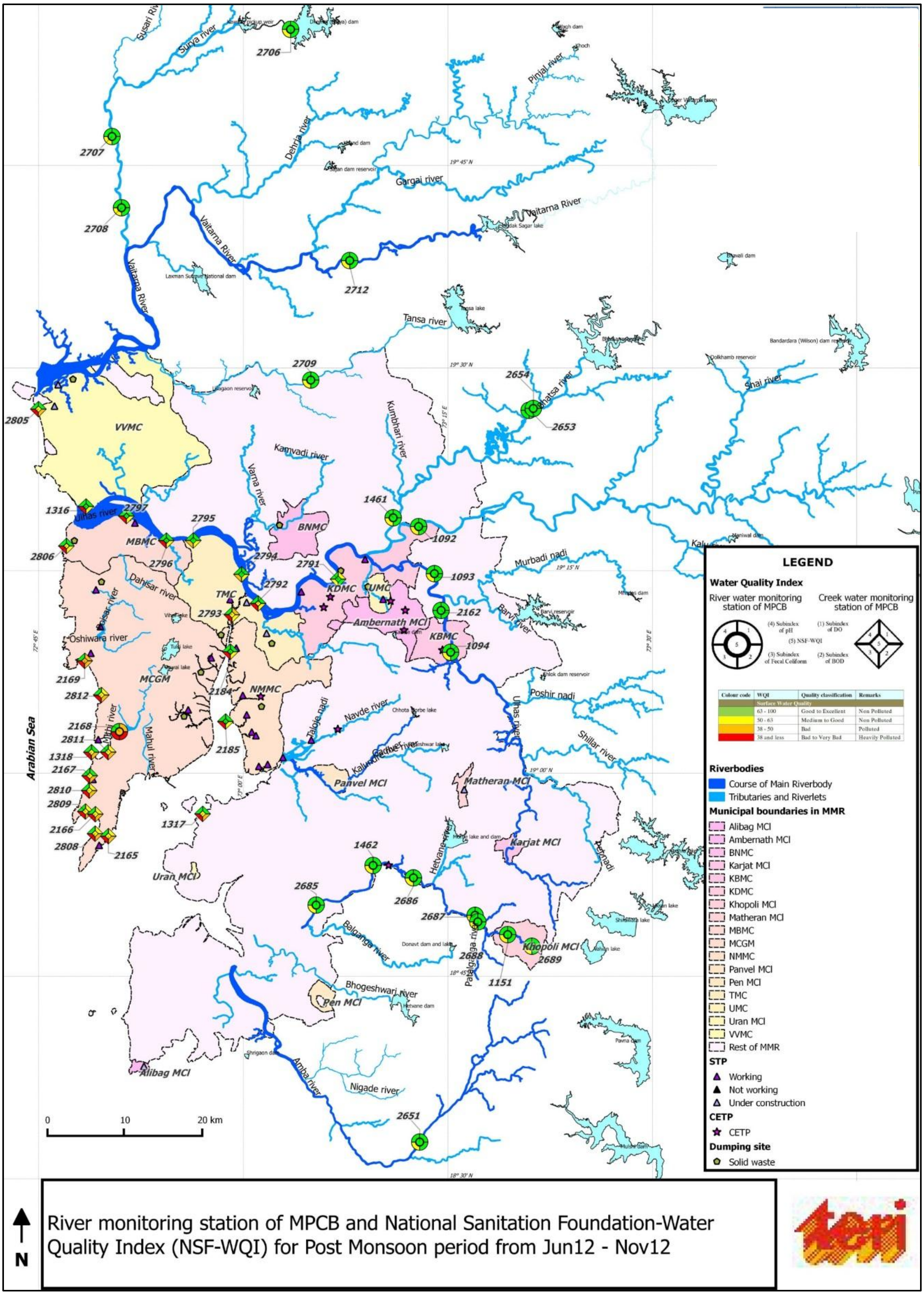
Source: MRSAC, Google Earth and Environment Status Reports (Refer Annex 18 for A3 size map)

Water Quality Index of rivers



Map No. 2-2: Water Quality Index of rivers for pre monsoon period

Source: MRSAC, MPCB and Environment Status Reports (Refer Annex 18 for A3 size map)



Map No. 2-3: Water Quality Index for rivers for post monsoon period

Source: MRSAC, MPCB and Environment Status Reports (Refer Annex 18 for A3 size map)

The WQI (Water Quality Index) was computed by TERI using modified NSF (National Sanitation Foundation) formula for pre and post monsoon period for the year 2012-13.

The parameters considered were DO, BOD, FC and pH. Other statistical methods were also applied to arrive at the trend of the results as presented Map No. 2-2 and Map No. 2-3. WQI classifications are based on the weightages for parameters and have been given subjective qualitative descriptions such as 'Bad', 'Good' and so on.

Observations: The total number of river water quality monitoring stations is 21. As seen in Table No. 2-6 , all the WQMS indicated 'Good to excellent' water quality during post monsoon period except at Mithi River. Whereas during pre-monsoon period, 2 locations *(WQMS no. 1092 on Ulhas and WQMS no. 2685 on Patalganga river)* indicated medium to good water quality and WQMS on Mithi River indicated 'Bad to Very Bad' water quality. The water quality was majorly affected due to increase in the fecal count which may be due to direct discharge of human sewage, fecal waste of mammals and birds, or from agricultural and storm runoff.

Table No. 2-6 WQI of rivers in MMR

	WQI-DO	WQI-BOD	WQI-FC	WQI-pH	WQI
Total number of river water quality monitoring station- 21 No.					
Post monsoon period (June, 2012 to November, 2012)					
Good to excellent *(Green)*	20	20	3	21	**20**
Medium to good *(Yellow)*	0	0	17	0	**0**
Bad *(Orange)*	1	0	0	0	**1**
Bad to very Bad *(Red)*	0	1	1	0	**0**
Pre monsoon period (December, 2012 to May 2013)					
Good to excellent *(Green)*	18	18	5	21	**18**
Medium to good *(Yellow)*	1	0	13	0	**2**
Bad *(Orange)*	1	1	2	0	**0**
Bad to very Bad *(Red)*	1	2	1	0	**1**

For each of the river, the general information and the water quality assessment done for the years 2008 to 2013 has been presented in the following section, under two heads namely:

1. General information
2. Water quality information and assessment

28% of the total water supplied to MMR region is met through Vaitarna River. It is the longest (154 km) river in the region.

2.4.1.1 Vaitarna River

General information

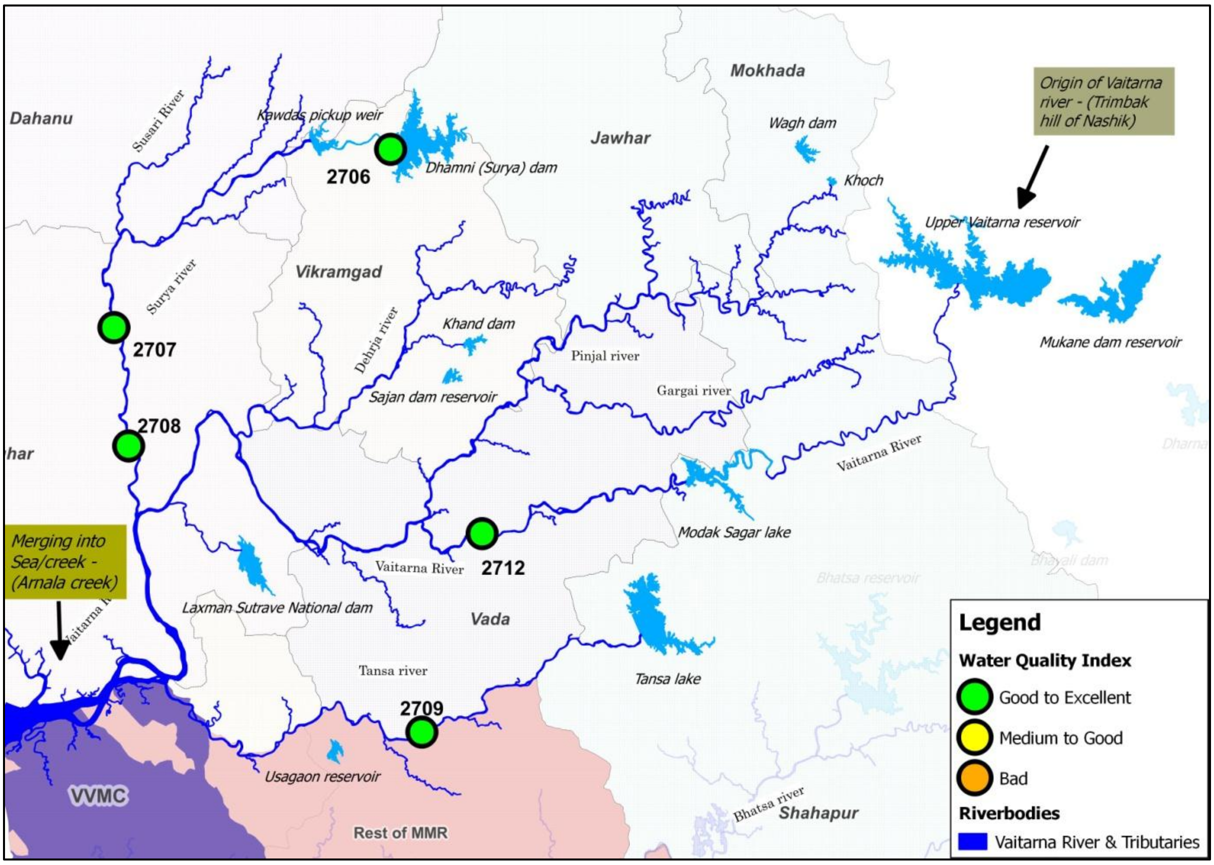
Vaitarana River originates from the hilly terrain of Maharashtra at Trimbak in Nashik district and flows nearly straight in south-west direction in the Thane district. The river flows on the state boundry of Gujarat and Maharashtra and meets the Arabian Sea at Arnala creek in Vasai Virar Municipal Corporation area. Major part of the river basin falls outside the MMR jurisdiction. However the river supplies water to the region and hence it is significant.

There are three dams constructed on the river - Upper, Middle and Lower Vaitarna dam, which are named according to their respective location along the flow of the river.[22] Lower Vaitarna Dam also known as Modaksagar, along with the other two dams, supplies around 1525 MLD of water to the region. As seen in Map No. 2-4, in the watershed of Vaitarna, there are other reservoirs like Surya and Pinjal which are proposed to supply water to the region. The other details about the river are tabulated below in Table No. 2-7.

Picture No. 2-1: Vaitarna Dam

Source: http://www.indianetzone.com/34/vaitarna_dam_maharashtra.htm

[22] http://www.indianetzone.com/34/vaitarna_dam_maharashtra.htm



Map No. 2-4: Spatial representation of Vaitarna River and its WQMS- Change the map

Source: MRSAC, MPCB and Environment Status Reports

Table No. 2-7: General information of Vaitarna River

Vaitarna River	
Origin	Trimbak in Nashik, Maharashtra
Tributaries	Susari, Pinjal, Gargai and Tansa
Length of the river from origin	154 km
Average rainfall in the basin	2293 mm
Catchment area (Thousand hectare)	Lower Vaitarna/Modak Sagar: 28.70 Upper Vaitarna: 16.08
Gross storage capacity of the reservoir	Modak Sagar: 204.98 MCM Upper Vaitarna: 331.63 MCM
Water application	Drinking/water supply

Source: Mumbai City Development Plan 2005-2025 and http://india-wris.nrsc.gov.in

Water quality information and assessment

The Central & State Government has initiated following programmes to install water quality monitoring stations (WQMS) along the river course.
There are in all 5 WQMS along Vaitarna River.

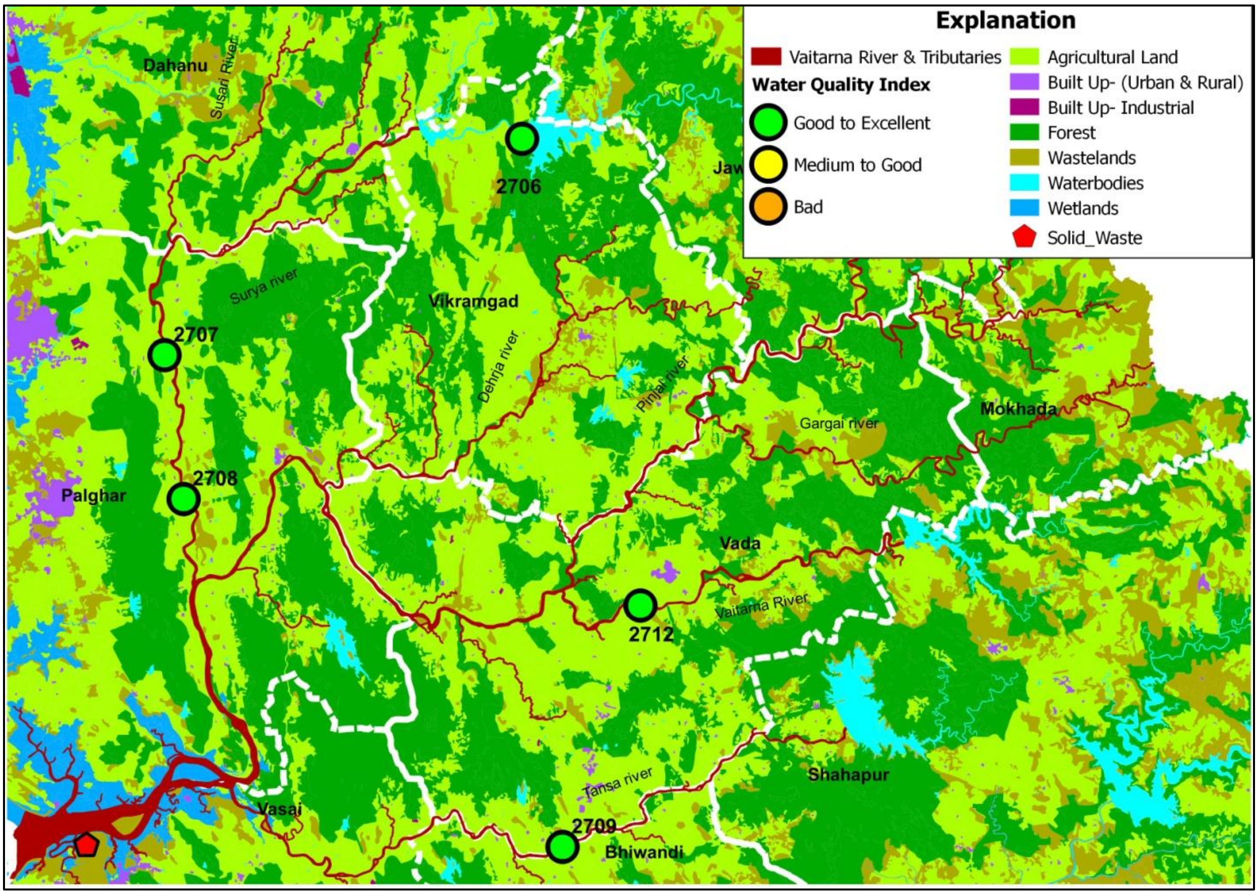
- National Water Quality Monitoring Programme (**NWMP**) or Monitoring of India National Aquatic Resources Series (**MINARS**) started by Central Pollution Control Board (CPCB).
- State Water Monitoring Programme (**SWMP**) started by Maharashtra Pollution Control Board (MPCB).
- **Hydrology project (HP)** sponsored by World Bank to Ministry of Water Resource Department, GoI.

The Vaitarna River has 4 tributaries, out of which only 2 are monitored for their water quality. In total there are 5 WQMS on the entire course of the river, out of which only 1 station is on the main river.

Table No. 2-8: WQMS details on Vaitarna River

Station code/ Program	Location	River/Tributary
2712/NWMP	Gandhare village, Wada taluka	Vaitarna River
2706/SWMP	Surya dam, Dhammi, Thane	Susari tributary
2707/SWMP	MIDC pumping station, Palghar, Thane	Susari tributary
2708/SWMP	Intake of Vasai-Virar w/s scheme, Palghar, Thane	Susari tributary
2709/SWMP	Dakewali Village, Wada taluka	Tansa tributary

Source: http://mpcb.gov.in/envtdata/envtwater.php



Map No. 2-5: Land use pattern around WQMS on Vaitarna River

Source: MRSAC and MPCB

The WQM station no. 2712 is on the upstream of the Vaitarna River and it is the only station on the river near Gandhare village, Wada taluka of Thane district. Further, there are 3 WQM stations on the Susari tributary; one on the Surya dam (WQMS no. 2706) and the other two (WQMS nos. 2707 and 2708) on the course of the tributary near Palghar in Thane district. The WQM station no. 2709 is on the Tansa tributary. The major land use pattern around these WQM stations is agricultural and forest land as seen in **Map No. 2-5** .

In order to assess the water quality of the river, MPCB has provided Water Quality Standards for Best Designated Usages[23]. Accordingly, the A- II category-"Public water supply with approved treatment equal to coagulate on, sedimentation & disinfection", is considered for the water quality assessment of the rivers.

In the following section, the river water quality data for the years 2008 to 2013 was assessed with respect to the MPCB water quality standards of A-II category. MPCB monitors only seven parameters namely pH, Dissolved oxygen (DO), Biochemical Oxygen Demand (BOD), Fecal Coliform (FC), Total Coliform (TC), ammonia and nitrate. Hence only these parameters were analyzed and compared with the standards to assess the overall quality of the river water.

[23] http://mpcb.gov.in/envtdata/envtwater.php

Parameter 1: pH

pH also known as power of Hydrogen is a measure of the acidity or basicity of an aqueous solution. Solutions with a pH less than 7 are said to be acidic and solutions with a pH greater than 7 are basic or alkaline. Pure water has a pH very close to 7. For most organisms, the optimal pH range is 6.5 to 8.2. Most organisms have adapted to life in water of a specific pH and may die if it changes even slightly.

Permissible MPCB standard: Between 6 and 8.5.

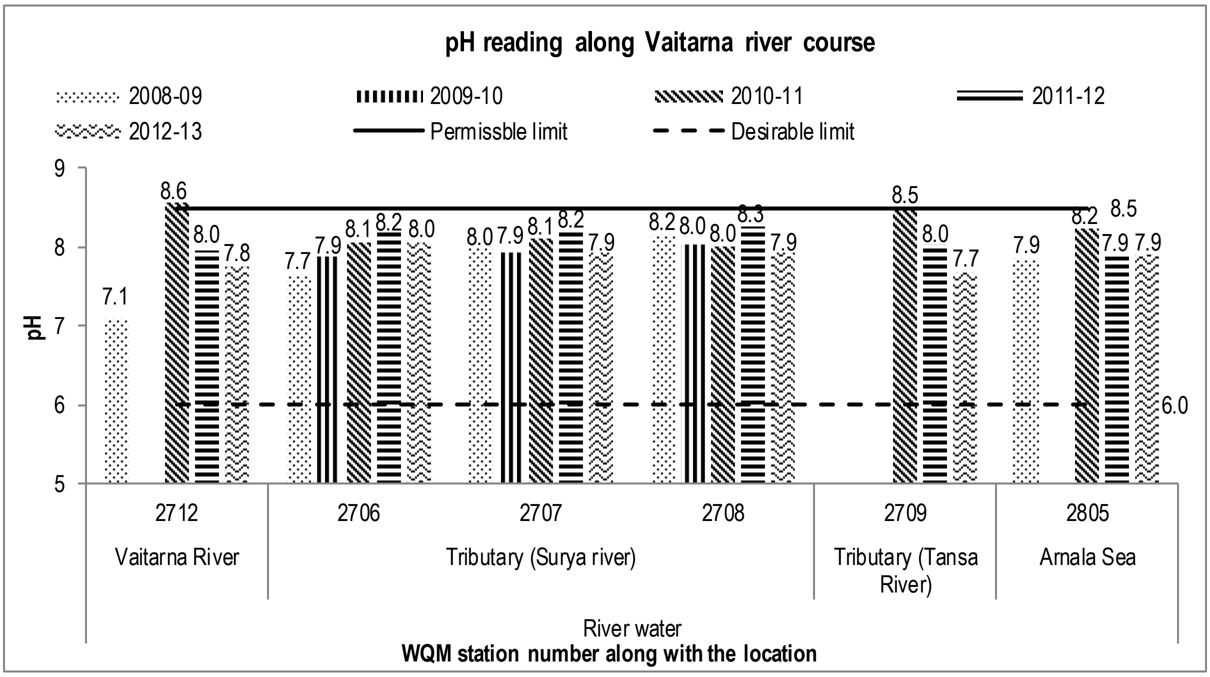


Figure No. 2-5: pH value at the WQMS of Vaitarna River

Source: http://www.mpcb.gov.in/envtdata/envtwater.php

Note: The data for the year 2009-10 and 2008-10 was not available for WQM station nos. 2712 and 2709 respectively.

Observation: It was observed that at all the water quality monitoring stations along the river the pH was within the permissible limit of MPCB, however in the year 2010-11, at WQM station no. 2712, the pH value was 8.6. This slight increase may be due to agricultural runoff from the surrounding fields and wastewater discharge from the villages of Wada block (Vada) of Thane district as seen Map No. 2-5. However in the following years the pH value was seen to be within the optimal pH range.

Parameter 2: Dissolved Oxygen (DO)

Like human beings need air to breathe, aquatic organisms need dissolved oxygen to respire. It is very essential for the survival of aquatic life, bacteria and underwater plants. Also it is equally needed for the decomposition of organic matter. When the dissolved oxygen levels in water drop below 5.0 mg/l, aquatic life is put under stress. Lower the concentration of DO, greater is the stress. If the Oxygen levels remain below 1-2 mg/l for few hours, it can result in large fish kills.[24]

Desirable MPCB standard: 4 mg/l (minimum desirable standard)

Observation: It was observed that at all the water quality monitoring stations the DO was above the minimum desirable MPCB limit indicating that the water quality is good and the possibility of pollution is minimal.

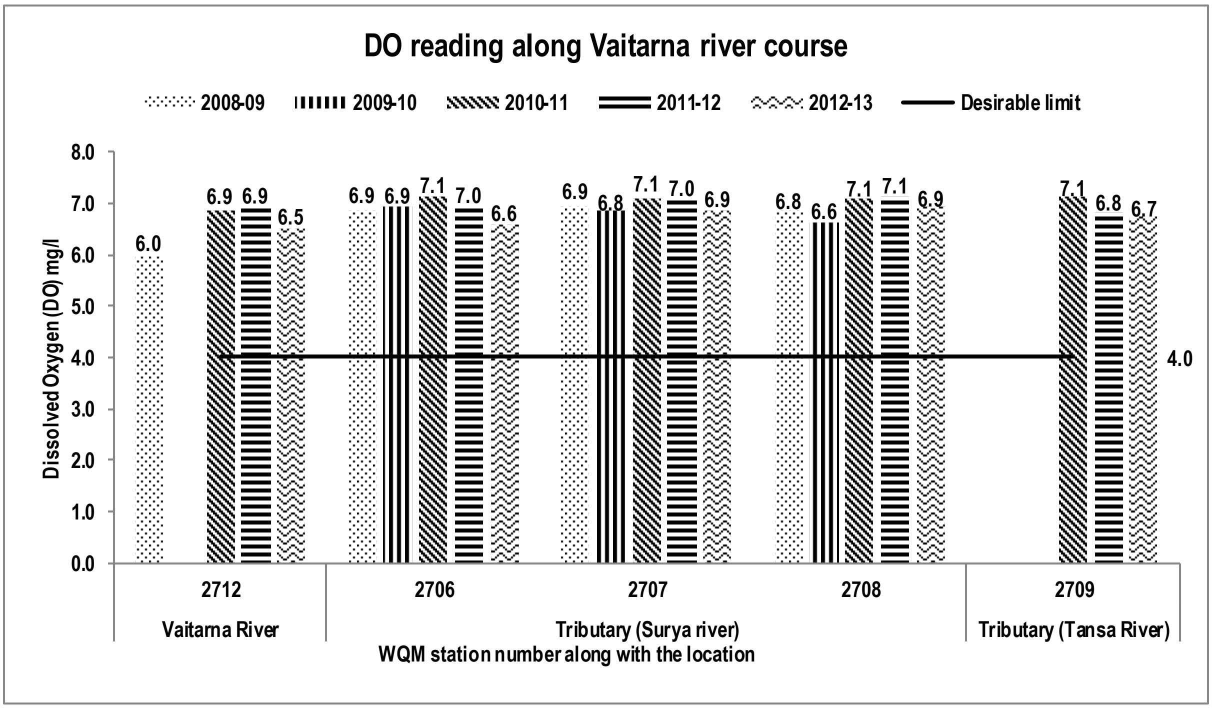


Figure No. 2-6: DO value at the WQMS of Vaitarna River

Source: http://www.mpcb.gov.in/envtdata/envtwater.php

Note: *The data for the WQM stations nos. 2712 and 2709 for the respective years 2009-10 and 2008-10 was not available for assessment.*

Parameter 3: Biochemical Oxygen Demand (BOD)

BOD is the amount of dissolved oxygen needed by aerobic biological organisms to break down organic material present in a given water sample at certain temperature over a specific time period. The term also refers to a chemical procedure for determining this amount. This is not a precise quantitative test, although it is widely used as an indication of the organic quality of water. The BOD value is most commonly expressed in milligrams of oxygen

[24] http://www.unc.edu/~shashi/TablePages/dissolvedoxygen.html

consumed per liter of sample during 5 days of incubation at 20 °C and is often used as a robust surrogate of the degree of organic pollution of water.[25]

Permissible MPCB standard: 5 mg/l

Observation: It was observed that BOD at all the WQMS was within the permissible limit, except in the year 2008-009 at the Vaitarna River monitoring station no. 2712. The possible reason for the exceedance of BOD may be due to significant organic matter content in water introduced as a result of domestic and human activities from adjacent villages of Wada block, Thane district.

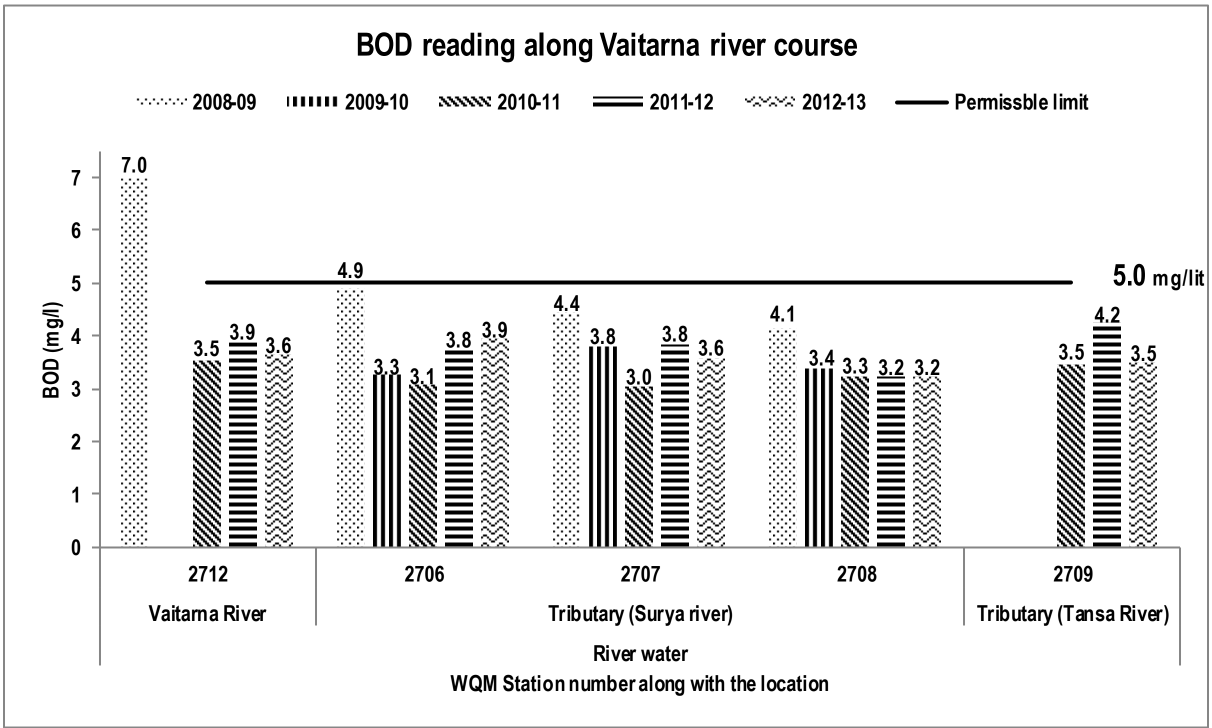


Figure No. 2-7: BOD value at the WQMS of Vaitarna River

Source: http://www.mpcb.gov.in/envtdata/envtwater.php

Note: The data for the WQM stations nos. 2712 and 2709 for the respective years 2009-10 and 2008-10 was not available for assessment.

Parameter 4 & 5: Fecal Coliform (FC) and Total Coliform (TC)

Coliform bacteria are described and grouped, based on their common origin or characteristics, as either Total or Fecal Coliform. The Total group includes Fecal Coliform bacteria such as Escherichia coli (E .coli), as well as other types of Coliform bacteria that are naturally found in the soil. Fecal Coliform bacteria exist in the intestines of warm blooded animals and humans, and are found in bodily waste, animal droppings, and naturally in

[25] http://en.wikipedia.org/wiki/Biochemical_oxygen_demand

soil.[26]. Fecal coliform bacteria can enter rivers through direct discharge of faecal waste of mammals and birds, from agricultural and storm runoff, and from human sewage.

Permissible MPCB standard: MPN (Most Probable Number) 5000 / 100 ml

Observation: It was observed that fecal coliform and total coliform was within the permissible limits of MPCB hence indicating that the water quality had permissible presence of human or animal waste.

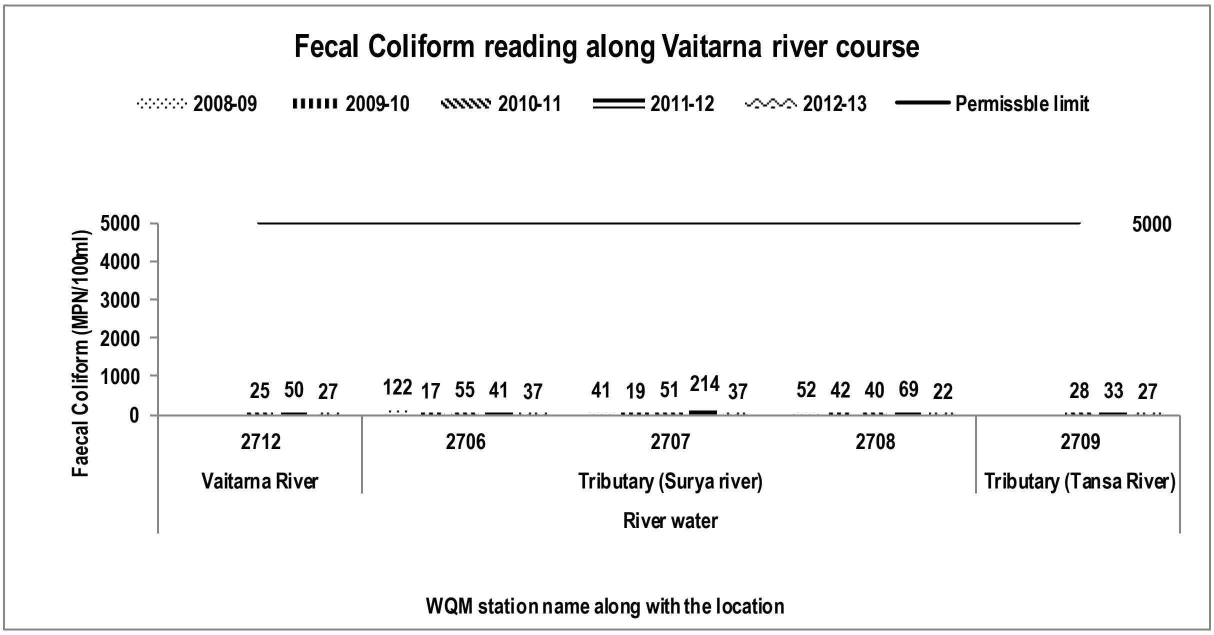


Figure No. 2-8: Fecal Coliform readings at the WQMS of Vaitarna River

Source: http://www.mpcb.gov.in/envtdata/envtwater.php

26 http://www.env.gov.bc.ca/wsd/plan_protect_sustain/groundwater/library/ground_fact_sheets/pdfs/coliform%28020715%29_fin2.pdf

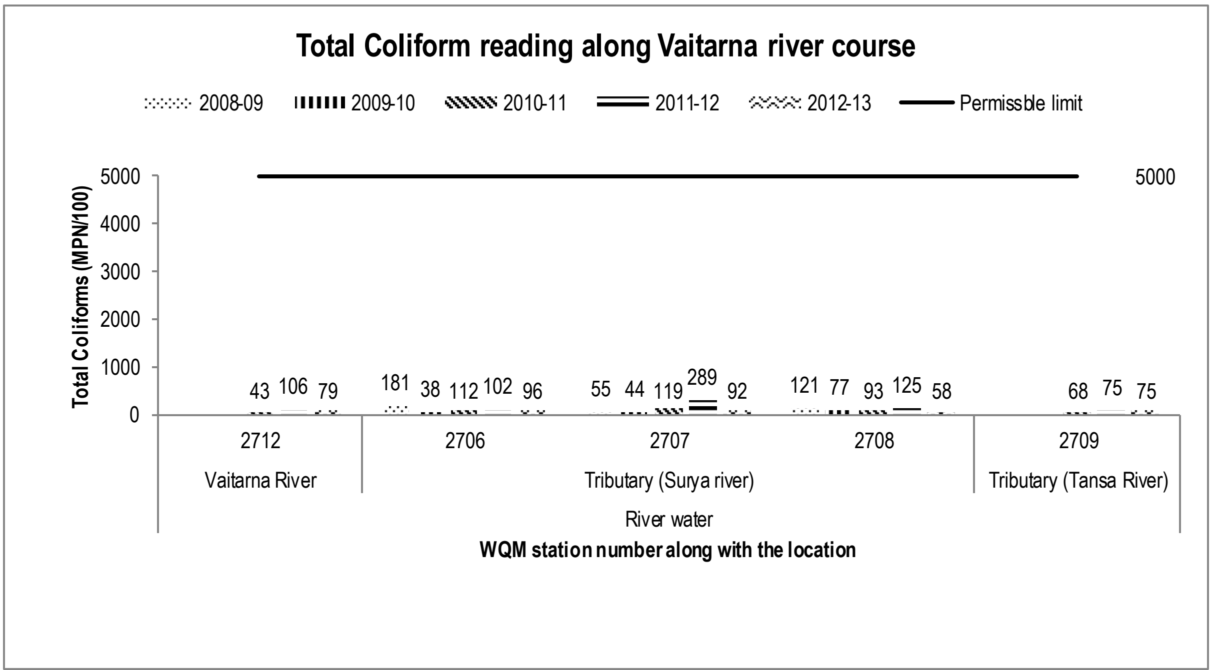


Figure No. 2-9: Total Coliform readings at the WQMS of Vaitarna River

Source: http://www.mpcb.gov.in/envtdata/envtwater.php

Note: The data for 2008-10 was not available for WQMS nos. 2712 and 2709.

Parameter 6 & 7: Ammonia and Nitrate

Ammonia is a nutrient that contains nitrogen and hydrogen. Its chemical formula is NH_3 in the un-ionized state and NH_4^+ in the ionized form. Total ammonia is the sum of both NH_3 and NH_4^+. Total ammonia is what is measured analytically in water. Ammonia is the preferred nitrogen-containing nutrient for plant growth. Ammonia can be converted to nitrite (NO_2^-) and nitrate (NO_3^-) by bacteria, and then used by plants.

Nitrate and ammonia are the most common forms of nitrogen in aquatic systems. Nitrate predominates in unpolluted waters. Nitrogen can be an important factor controlling algal growth when other nutrients, such as phosphate, are abundant. Ammonia is excreted by animals and produced during decomposition of plants and animals, thus returning nitrogen to the aquatic system. Ammonia is also one of the most important pollutants because it is relatively common but can be toxic, causing lower reproduction and growth, or death. The neutral, un-ionized form (NH_3) is highly toxic to fish and other aquatic life. Natural factors that can affect the concentration of ammonia include algal growth, decay of plant or animal material, and fecal matter. Ammonia can also come from domestic, industrial or agricultural pollution, primarily from fertilizers, organic matter or fecal matter.[27]

Permissible MPCB standard: Ammonia: - 1.5 mg/l Nitrate: - 45 mg/l

[27] http://www.waterboards.ca.gov/water_issues/programs/swamp/docs/cwt/guidance/3310en.pdf

Observation: It was observed that ammonia and nitrate readings at all the water quality monitoring stations are well within the permissible MPCB standards.

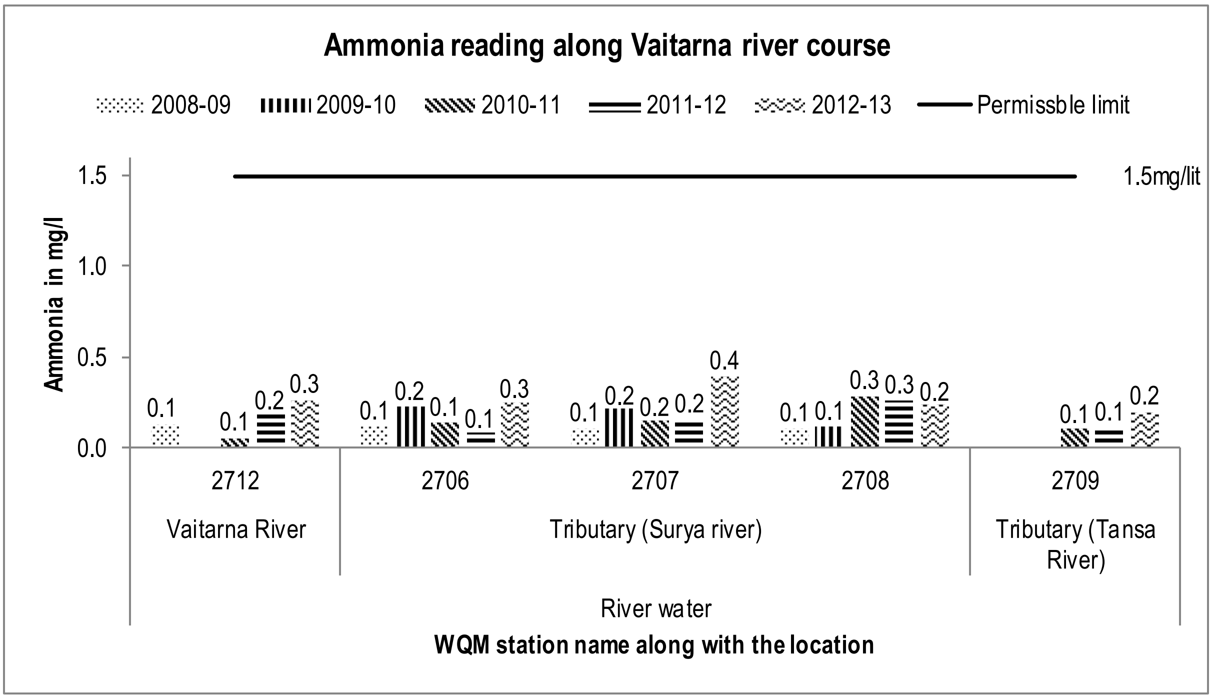


Figure No. 2-10: Ammonia value at the WQMS of Vaitarna River

Source: http://www.mpcb.gov.in/envtdata/envtwater.php

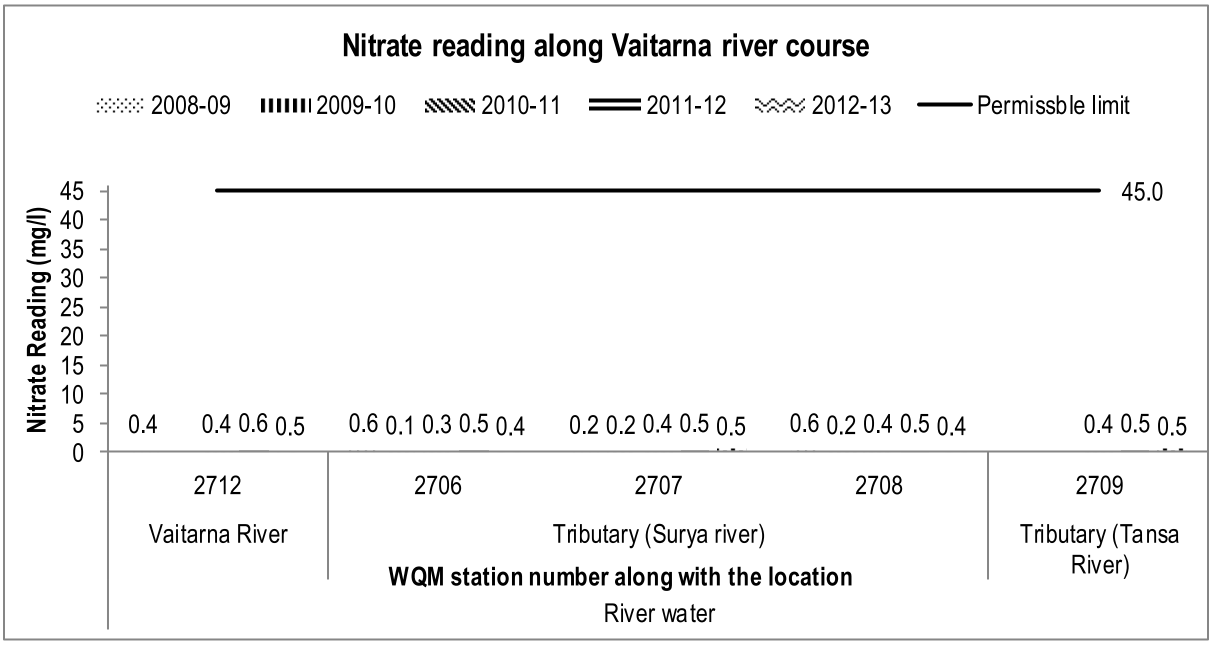


Figure No. 2-11: Nitrate value at the WQMS of Vaitarna River

Source: http://www.mpcb.gov.in/envtdata/envtwater.php

Note: The data for the WQM stations nos. 2712 and 2709 for the respective years 2009-10 and 2008-10 was not available for assessment.

Water Quality Index

Water quality evaluation was carried out by computing Water Quality Index (WQI) using modified National Sanitation Foundation (NSF) formula for drinking water which is referred below as **NSF WQI**[35]. The parameters considered were pH, DO, BOD and FC. Other statistical methods were also applied to arrive at the trend of the results. WQI classifications are based on the weightages for parameters and have been given subjective qualitative descriptions such as 'Bad', 'Good' and so on as seen in Table No. 2-9: Water quality classification based on WQI value.[28] The WQI for the year 2012-13 is presented for all the rivers in this report.

Vaitarna River meets the MPCB water quality standards of A-II category for best designated usage, except for the BOD & pH values at the WQMS no. 2712 for the years 2008-09 & 2010-11 respectively. The possible reason for the exceedance may be due to domestic waste discharge & agricultural runoff from Wada block of Thane district. Overall the river water quality falls in the 'Good to Excellent' category.

Table No. 2-9: Water quality classification based on WQI value

NSF WQI	Description of water quality	Class by CPCB	Remarks
63-100	Good to excellent	A	Non polluted
50-63	Medium to good	B	Non polluted
38-50	Bad	C	Polluted
38 & less	Bad to very bad	D,E	Heavily polluted

Source: *http://www.mpcb.gov.in/envtdata/envtwater.php*

As clearly seen in **Figure No. 2-12**, the WQI of Vaitarna River along with its tributaries ranges between 74 to 78, indicating 'Good to Excellent' water quality. A sample calculation of WQI for WQM station no. 2712 is given below for better understanding.

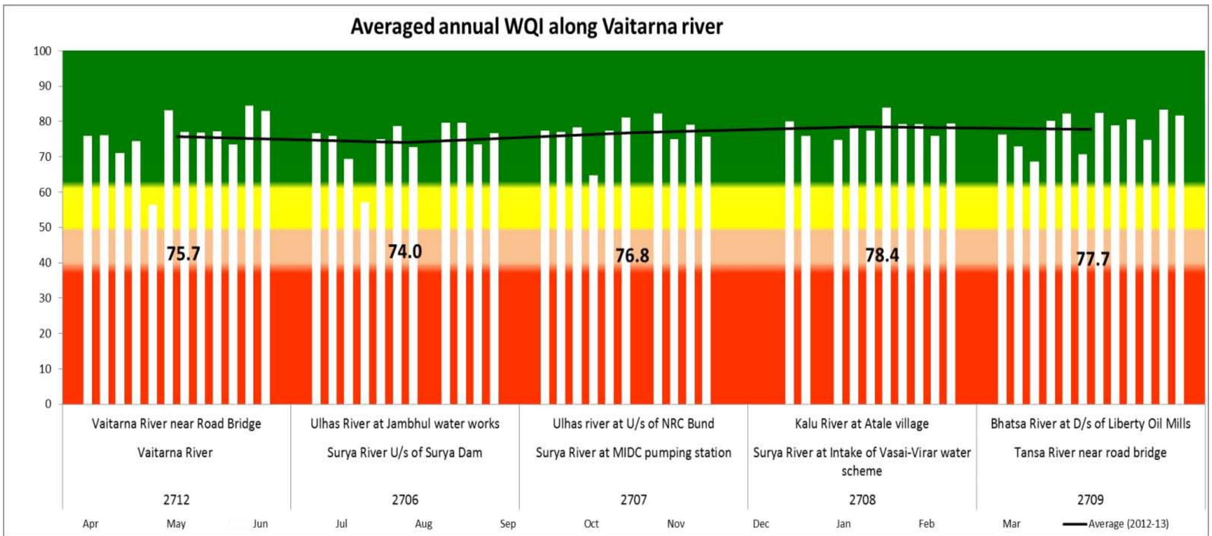


Figure No. 2-12 Overall WQI of Vaitarna river

[28] Water quality status of water bodies in Maharashtra with recourde to analytical/statistical tools – National Environmental Engineering Research Institute. April 2011

Step 1: Tabulating the monthly readings for pH, DO, BOD and FC parameters.

The monthly readings for WQM station no. 2712 is tabulated below in **Table No. 2-10**. Further, the DO values are in mg/l unit, however for calculating the index, the DO saturation percentage is required. Hence the DO value is converted into saturation percentage by using the below mentioned formula:

$$\frac{\textbf{Actual Dissolved Oxygen (mg/l)}}{\textbf{Max. Oxygen Concentration at water temperature}}$$

Example: For the month of April, 2012, the actual DO value observed was 7.0 mg/l, whereas, MPCB regards the Max Oxygen concentration at water temperature to be standard of value 6.5. Therefore substituting the values in the above equation,

$$\boldsymbol{DO\ Saturation}\ (\%) = \frac{\mathbf{7}}{\mathbf{6.5}} * \mathbf{100}$$

The DO saturation value comes to 108%. Similarly, for the rest of the months the saturation values were calculated.

Table No. 2-10: Monthly readings of water quality parameters at WQM station no. 2712

Month	DO (mg/l)	Temperature (degree Celcius)	DO saturation (%)	BOD (mg/l)	pH	FC (MPN /100ml
Apr	7.0	28	89.4	3.0	8.2	35.0
May	6.8	30	90.2	3.4	8.1	35.0
Jun	5.8	30	76.9	6.0	7.5	25.0
Jul	5.6	26	69.3	3.0	7.2	35.0
Aug	3.8	28	48.5	5.8	8.1	35.0
Sep	7.5	28	95.7	2.2	7.8	25.0
Oct	7.0	25	84.8	2.4	8.2	17.0
Nov	6.9	25	83.6	2.4	7.8	50.0
Dec	6.3	30	83.6	4.6	7.4	20.0
Jan	6.6	21	74.1	3.8	7.6	25.0
Feb	7.5	29	97.5	3.6	7.5	13.0
Mar	7.5	35	108.2	3.4	7.6	13.0

Source: *http://www.mpcb.gov.in/envtdata/envtwater.php*

Step 2: Calculating the sub index for each of the selected parameters

The below mentioned table is referred to calculate the sub index for each of the parameters. Depending on the monthly value observed for the parameter, the corresponding equation is used for calculating the sub index.

Table No. 2-11: Sub index equations for water quality parameters (NSF WQI)*

Water Quality Parameters	Range Applicable	Equation
DO (Precent saturation	0-40% saturation	IDO = 0.18+0.66 x (% Saturation DO)
	40-100% saturation	IDO = -13.55+1.17 x (% Saturation DO)
	100-140% saturation	IDO = 163.34-0.62 x (% Saturation DO)
B.O.D.(mg/l)	0-10	IBOD = 96.67-7 (BOD)
	10-30	IBOD = 38.9-1.23 (BOD)
	> 30	IBOD = 2
pH	2-5	IpH = 16.1+7.35 x (pH)
	5-7.3	IpH = -142.67+33.5 x (pH)
	7.3-10	IpH = 316.96-29.85 x (pH)
	10-12	IpH = 96.17-8.0 x(pH)
	<2 , >12	IpH=0
Fecal Coliform (MPN counts/100 ml)	$1\text{-}10^3$	IFC = 97.2-26.6 x log(FC)
	$10^3\text{-}10^5$	IFC = 42.33 -7.75 x log(FC)
	>105	IFC = 2

Source: Abbasi, 2002. Abbreviations:

Example: For the month of April, 2012, the DO value observed was 7.0 mg/l and the DO saturation value was 89.4%.

Hence, IDO = -13.55+1.17 x (% Saturation DO) equation shall be considered for calculation.

IDO = -13.55+1.17 x (89.4)

= 91.0

Similarly, sub index for other parameters was calculated using the corresponding equations in (**Table No. 2-12**).

Table No. 2-12: Sub index for water quality parameter

Month	DO (%)	BOD (mg/l)	pH	FC (MPN /100ml)
	Sub index for water quality parameter			
Apr	91.0	75.7	72.2	56.1
May	92.0	72.9	75.2	56.1
Jun	76.5	54.7	93.1	60.0
Jul	67.5	75.7	98.5	56.1
Aug	43.2	56.1	75.2	56.1
Sep	98.5	81.3	84.1	60.0
Oct	85.7	79.9	72.2	64.5
Nov	84.3	79.9	84.1	52.0
Dec	84.2	64.5	96.1	62.6
Jan	73.1	70.1	90.1	60.0

Month	DO (%)	BOD (mg/l)	pH	FC (MPN /100ml)
Feb	100.5	71.5	93.1	67.6
Mar	96.2	72.9	90.1	67.6

Source: *http://www.mpcb.gov.in/envtdata/envtwater.php*

Step 3: Assigning a weight to each of the selected parameters

Each of the parameters is then assigned with a weight for calculating the WQI. The CPCB modified weights (**Table No. 2-13**) are considered for the same.

Table No. 2-13: Original & modified weights for the computation of NSF WQI based on DO, Fecal Coliforms, pH and BOD*

Water Quality parameters	Original Weights from NSF WQI	Modified Weights by CPCB
DO	0.17	0.31
FC	0.15	0.28
pH	0.12	0.22
BOD	0.1	0.19
Total	0.54	1.00

Source: CPCB, 2001

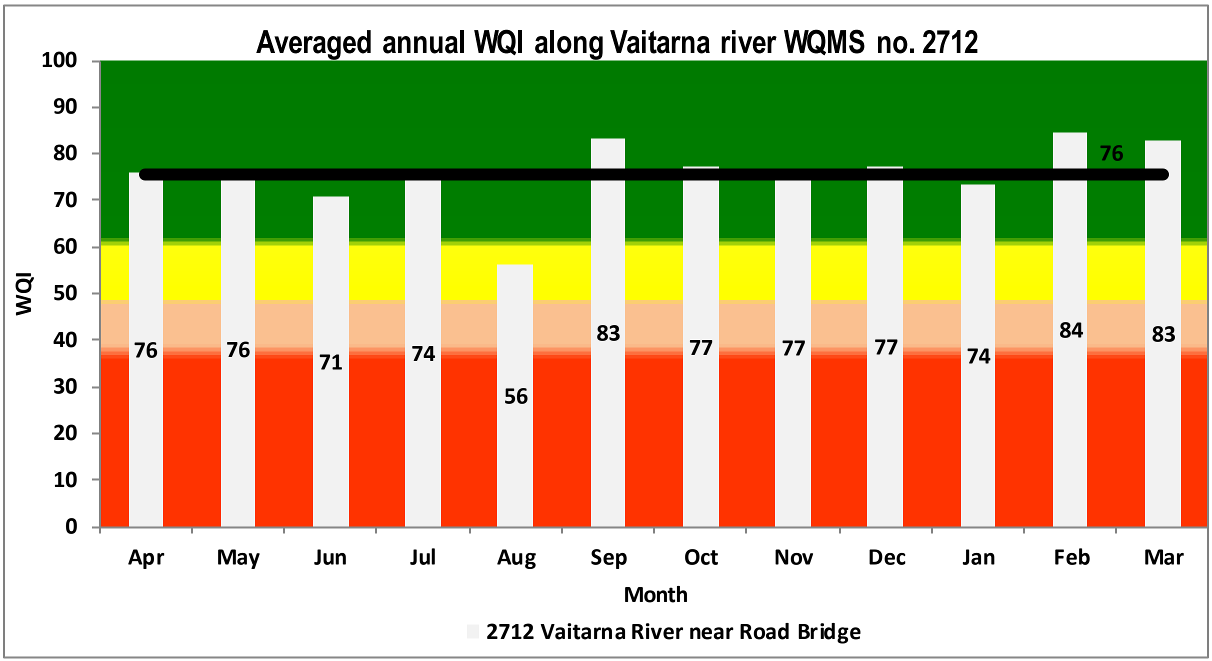
Example: For the month of April, 2012, the DO sub index was 96.6. This sub index is multiplied with the CPCB modified weights and the summation of sub index for all the 4 parameters gives the WQI for that particular month (**Table No. 2-14**).

Table No. 2-14: Monthly water quality index

Month	DO (%)	BOD (mg/l)	pH	FC (MPN/100ml)	WQI
Apr	29.9	21.2	15.9	10.7	77.7
May	30.5	20.4	16.5	10.7	78.1
Jun	28.2	15.3	20.5	11.4	75.4
Jul	27.0	21.2	21.7	10.7	80.6
Aug	17.0	15.7	16.5	10.7	59.9
Sep	28.5	22.8	18.5	11.4	81.1
Oct	29.9	22.4	15.9	12.2	80.4
Nov	30.2	22.4	18.5	9.9	81.0
Dec	31.0	18.1	21.1	11.9	82.0
Jan	31.1	19.6	19.8	11.4	82.0
Feb	28.5	20.0	20.5	12.8	81.8
Mar	28.5	20.4	19.8	12.8	81.5

Source: *http://www.mpcb.gov.in/envtdata/envtwater.php*

Further, to calculate the annual WQI, the average of all the monthly WQI was taken. Thus for WQM station no. 2712, the annual WQI was calculated to 78.5 (Figure No. 2-13).



Colour code	WQI	Quality classification	Remarks
	Surface Water Quality		
	63 - 100	Good to Excellent	Non Polluted
	50 - 63	Medium to Good	Non Polluted
	38 - 50	Bad	Polluted
	38 and less	Bad to Very Bad	Heavily Polluted

Figure No. 2-13: WQI of WQM station no. 2712

Source: ***http://www.mpcb.gov.in/envtdata/envtwater.php***

Overall water quality of Vaitarna River

The water quality assessment of Vaitarna river indicated that it meets the MPCB water quality standards of A-II for best designated usage, except for the fact that the BOD and pH at WQM station no. 2712 exceeded the limit (7 mg/l and 8.6) for the year 2008-09 and 2010-11 respectively. The possible reason for the exceedance may be due to domestic waste discharge from Wada block of Thane district and agricultural runoff. The WQI index of the river along with its tributaries also indicated the water quality to be in 'Good to Excellent' category.

Conclusion and recommendations

Vaitarna River is one of the most significant river basins of Mumbai hydrometric area. It is important from resource point of view as there are three important dams supplying water to MMR which include ModakSagar dam (450 MLD), Upper Vaitarna dam (630 MLD) and Tansa tributary (445 MLD) . The Susari tributary (200 MLD) and Middle Vaitarna dam (477 MLD) are considered for augmentation of water resources for Mumbai city.

Given the significance of the river, it is critical to examine the quality of the river on regular basis. Also it was observed that the Vaitarna River is monitored only at the upstream region and there are no monitoring stations on the downstream part of the river. Further, out of 4 tributaries, only two tributaries are monitored, which clearly highlights the infrastructural gap in terms of number of monitoring stations. Thus the following two recommendations are given at policy and implementation level:

Specific recommendations

- As per the CPCB guidelines, every river should be monitored upstream and downstream to identify any potential source of pollution. However, the current sampling locations are only located in the upstream region, thus introducing a bias in the overall assessment of all the necessary parameters. Given that it is the longest river and also supplies 28% of the total water supplied to the region, monthly monitoring of the entire course of the river including its tributaries is recommended. It would be ideal to set up real time monitoring stations along significant locations of the river with immediate effect.

- The existing water quality monitoring stations do not record data for all the parameters as per the recommended standards. Hence uniformity in recording the data should also be practised.

2.4.1.2 Ulhas River

General information

Ulhas River is an important westbound river flowing mainly through Thane district of Maharashtra. It rises in the ravines of Sahyadari ranges to the north of Tungarli hills near Lonavala (400mts above sea level). After a north-west course for about 122 km, it meets the Arabian Sea.

Approximately 60% of the total water supplied to the region is met through Ulhas River. It is the second longest (122km) river in the region.

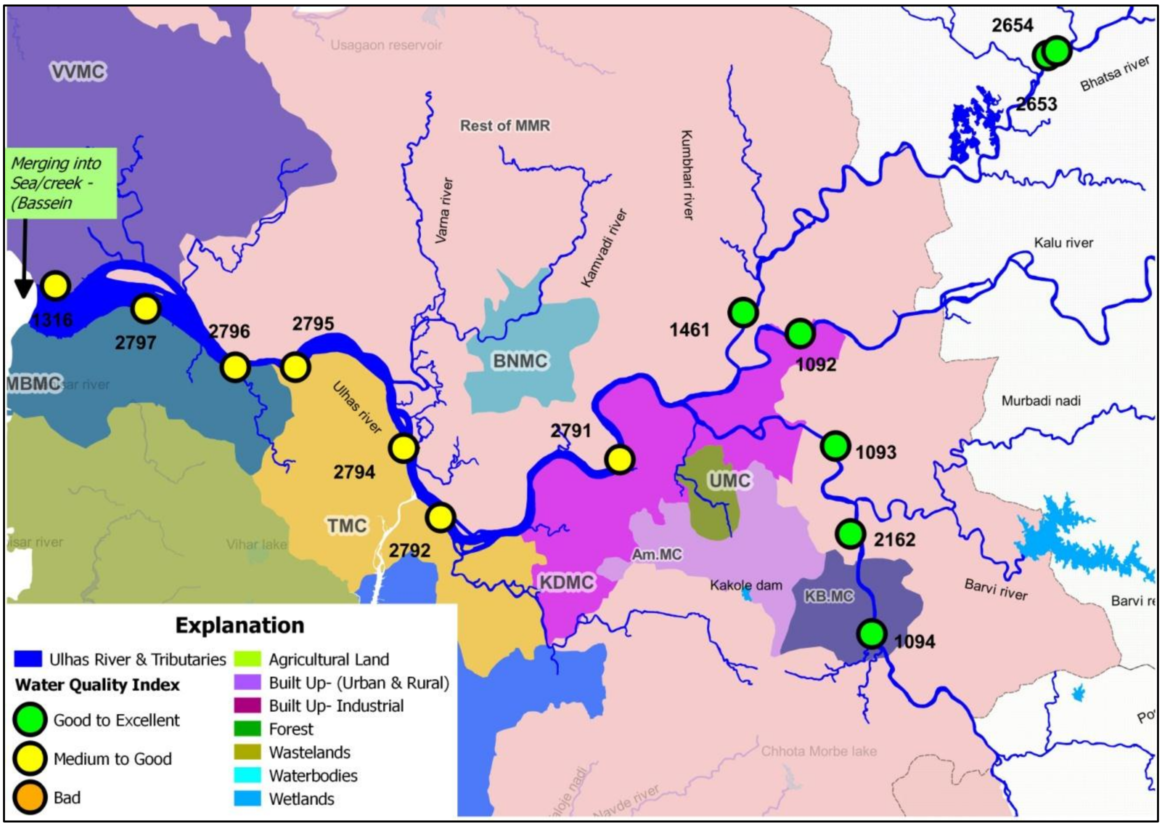
As seen in, the river enters Thane district at the southern border near Vangani railway station. In Thane district the river has a northerly course skirting the Matheran ridge initially through Ulhasnagar taluka until near Kalyan and then it is joined by combined flow of Kalu and Bhatsa and the river bifurcates into two branches, one turns west to enter through a gap to the north of Parsik range into the Thane creek and the other branch with the bulk flow turns to the north of Salsette island and broadens into an estuary which falls into the sea near Vasai[29]. The important tributaries of the Ulhas River are Pej, Barvi, Bhivapuri, Murbari, Kalu, Shari, Bhasta, Salpe, Poshir and Shilar. The Kalu and Bhasta are the major right bank tributaries which together accounts for 55.7% of the total catchment area of Ulhas.

The other details about the river are tabulated below in Table No. 2-15.

Picture No. 2-2: Ulhas River at Kalyan near KDMC dumping ground.

Photo credit: TERI

[29] Online International Interdisciplinary Research Journal, {Bi-Monthly}, ISSN2249-9598, Volume-III, Issue-II, Mar-Apr 2013



Map No. 2-6: Spatial representation of Ulhas River

Source: MRSAC, ESR and MPCB

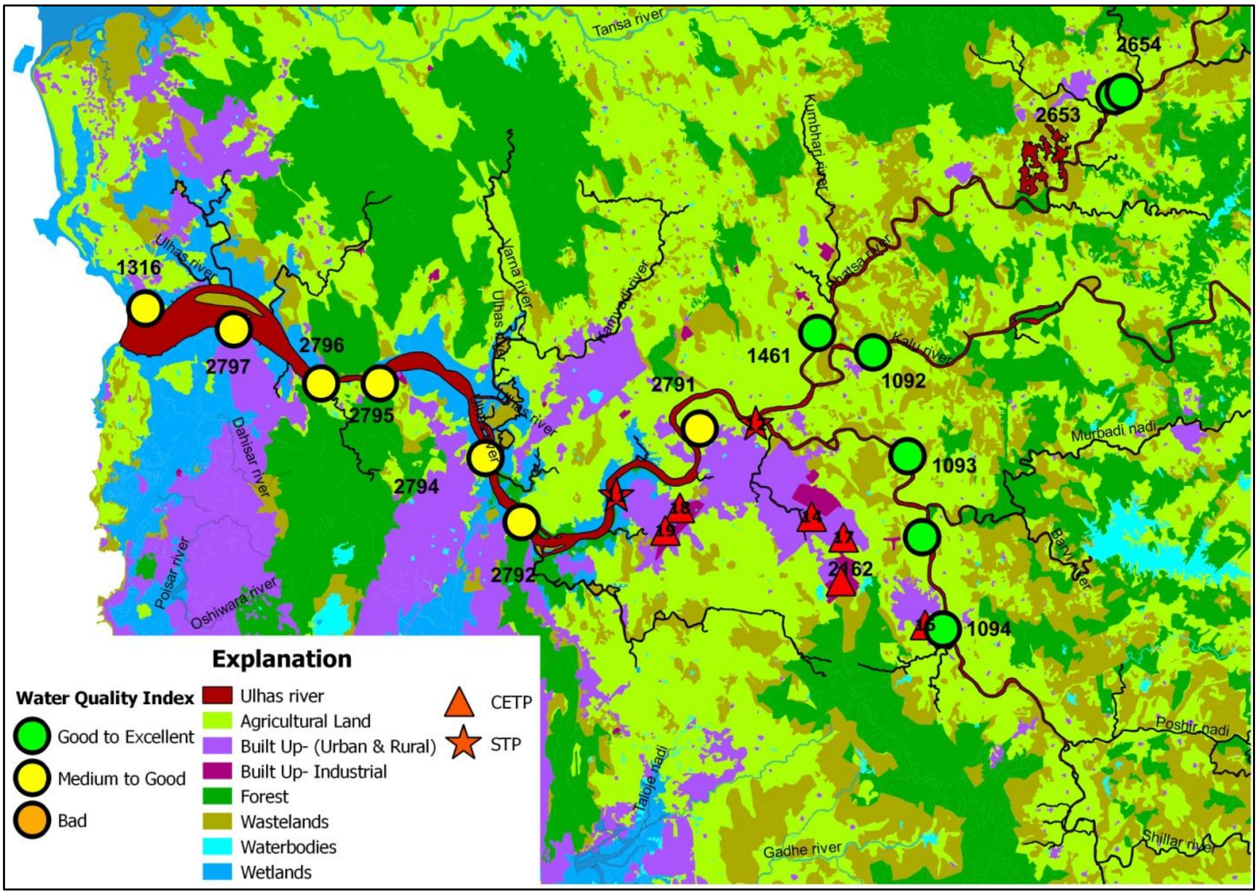
Table No. 2-15: General information of Ulhas River

Ulhas River	
Origin	Ravines of Sahyadari ranges to the north of Tungarli hills near Lonavala
Length of the river from origin	122 km
Average rainfall in the basin	2943 mm
Catchment area (sq.km)	3205
Gross storage capacity of the reservoir	6194 MCM
Water application	Drinking/water supply
Dam/reservoir on the river	Near Raw water pump house of MIDC Jambhul the river meets Barvi Dam & the discharge water also called as Barvi River.

Source:
http://kgbocwc.ap.nic.in/About%20Basins/West%20Flowing%20Rivers%20Basin%20Write%20-2008-09.pdf

Water quality information and assessment

Along the course of the Ulhas River, there are 7 river WQMS and 7 creek WQMS as tabulated in Map No. 2-7: Land use pattern around water quality monitoring stations on Ulhas River.



Map No. 2-7: Land use pattern around water quality monitoring stations on Ulhas River

Source: MRSAC and MPCB

*(**Legend: 11**- Motagaon STP; **12:** Aadharwadi STP; **14**: ACMA CETP Co-operative society limited; **15:** Additional ambernath CETP; **16:** Badlapur CETP association; **17:** Chikholi- Morivali effluent treatment plant; **18:** Dombivali better environment system association; **19:** Dombivali CETP)*

Table No. 2-16: WQMS details on Ulhas River

Station code/program	Location	River/Tributary
River water quality monitoring stations		
1461/NWMP	Bhatsa river at D/s of Pise Dam	Bhatsa river
1093	Ulhas river at U/s of NRC Bund;	Ulhas river
1094	Ulhas river at U/s of Badlapur water works	Ulhas river
1092/SWMP	Kalu river at Atale village	Kalu river
2162	Ulhas River at Jambhul water works	Ulhas river

Station code/program	Location	River/Tributary
2653/SWMP	Bhatsa river at D/s of Liberty Oil Mills	Bhatsa river
2654/SWMP	Bhatsa river at U/s of Liberty Oil Mills	Bhatsa river
Creek water quality monitoring stations		
2791	Ulhas Creek at Reti Bunder, D/s of Kalyan-Bhiwandi Bridge	
2792	Ulhas Creek at Mumbra Reti Bunder	
2794	Ulhas Creek at Kolshet Reti Bunder	Ulhas creek
2795	Ulhas Creek at Gaimukh at Nagla Bunder on Ghod Bunder Road	
2796	Ulhas Creek at Versova Bridge	
2797	Bhayander Creek at D/s. of Railway Bridge at Jasal Park Choupathy	Bhayander Creek
1316	Bassein creek at Vasai Fort, Thane	Bassein creek

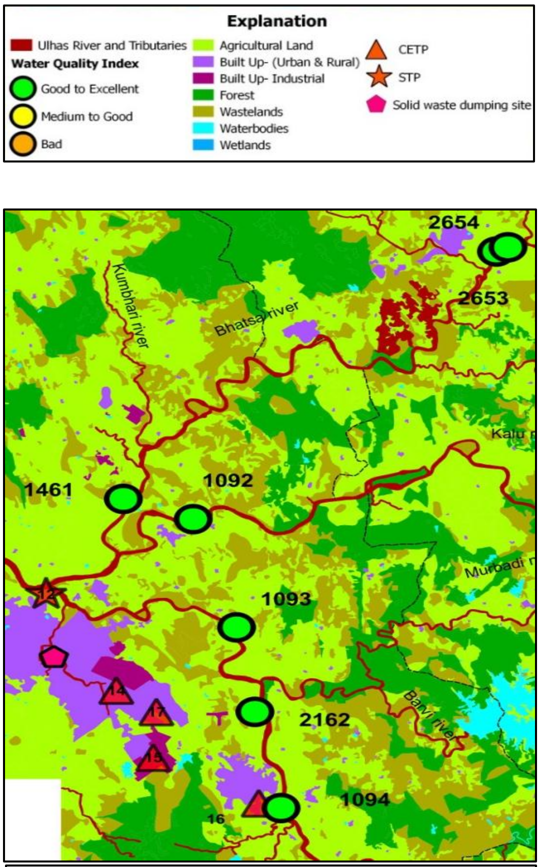
Source: http://mpcb.gov.in/envtdata/envtwater.php

Assessment of WQMS with respect to their surrounding land use pattern:

River WQMS:

As seen in Map No. 2-8, on the Ulhas River there are 3 WQM stations (1094, 2162 and 1093 station), which are located relatively at the upstream region of the river near Ulhasnagar area. The Badlapur CETP (Common Effluent Treatment Plant) (*Kulgaon Badlapur Municipal Council*) is located close to the WQMS no. 1094. Morever, when the 'Statistical Report' of MPCB for the year 2011-12 was assessed it revealed that the CETP exceeded the permissible CPCB standards for COD and BOD parameters (838 and 349 mg/l respectively). The major land use pattern around these WQM stations is agricultural land and built up area of the municipal council.

On the other hand, out of the 10 important tributaries of Ulhas River, only Kalu and Bhatsa are monitored by MPCB for their water quality parameters.. On Kalu tributary, there is one WQMS (1092 station)



Map No. 2-8: Spatial representation of WQMS on Ulhas River

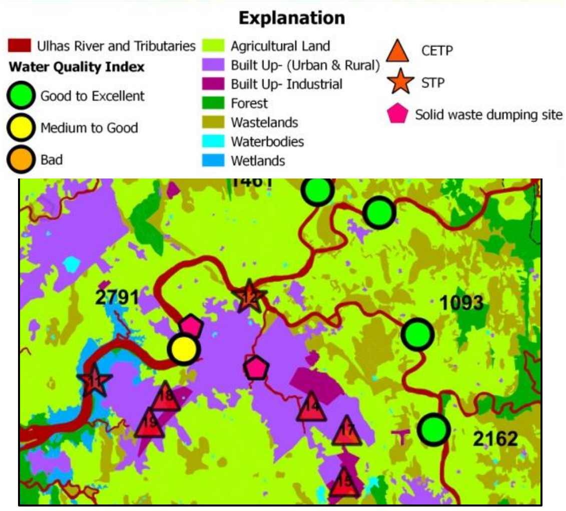
Source: MRSAC and MPCB

(***Legend: 12:*** *Aadharwadi STP;* ***14:*** *ACMA CETP Co-operative society limited;* ***15:*** *Additional ambernath CETP;* ***16:*** *Badlapur CETP association;* ***17:*** *Chikholi-Morivali* and on Bhatsa tributary there are 3 WQMS (2654, 2653 and 1461 station). And the major land use pattern around these WQM stations is agricultural and waste land with small patches of built up area (urban & rural).

Creek WQMS:

The Ulhas creek is also monitored by MPCB. Altogether, there are 7 creek WQM stations, out of which, five WQM stations (2791, 2792, 2794, 2795 and 2796 station) are on the course of the Ulhas creek, one WQMS (2797 station) on the Bhayander creek and one WQMS (1316 station) on the Bassein creek.

At the upstream of the WQMS no. 2791, there is Aadharwadi STP (16 MLD treatment capacity) and two solid waste dumping grounds of Kalyan Dombivali Municipal Corporation and Ulhasnagar Municipal Corporation each. Also the Additional Ambernath CETP, Chikhloli-Morivali Effluent Treatment plant and ACMA CETP are located in the vicinity of the station and thus influence the water quality of the creek (Yellow dot in **Map No. 2-9**). The statistical report of MPCB for the year 2011-12 revealed that BOD and SS values (26 and 38 mg/l respectively) observed at the above mentioned STP exceeded the permissible limit of MPCB.Also, all the three CETPs exceeded the permissible CPCB standards for COD and BOD as seen in **Figure No. 2-14.** But, it is to be noted that the BOD value at ACMA CETP met the CPCB standards.



Map No. 2-9: Spatial representation of WQMS no. 2791

Source: MRSAC and MPCB

*(**Legend: 12:** Aadharwadi STP; **14**: ACMA CETP Co-operative society limited; **15:** Additional ambernath CETP; **17:** Chikholi-Morivali effluent treatment plant; **18:** Dombivali better environment system association; **19:** Dombivali CETP)*

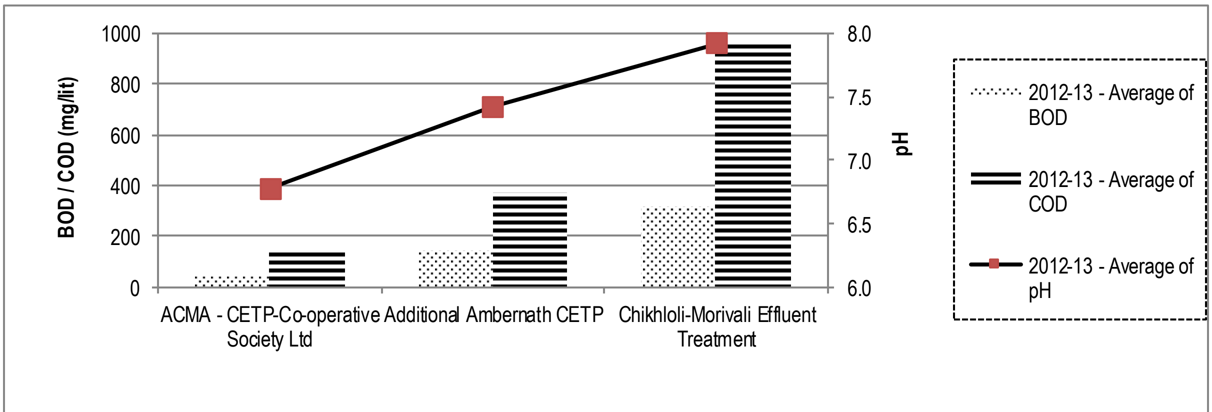
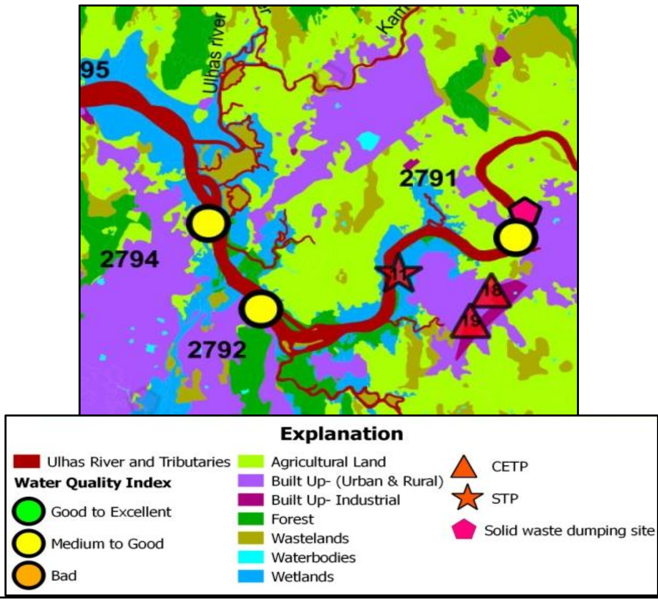


Figure No. 2-14: CETP performance for the year 2011-12

Source: MPCB

(Maximum permissible CPCB limits: BOD- 100 mg/l, COD- 250mg/l and pH between 5.5 and 9)

As seen in Map No. 2-10, at the upstream of the WQMS no. 2792, Motagaon STP (14 MLD treatment capacity), Dombivali CETP and Dombivali better environment system association's CETP are located. The Motagaon STP's, waste water quality report of MPCB for the year 2011-12 revealed that all the parameters (pH, COD, BOD, TAN, O&G and SS) were within the permissible standards of MPCB. However, the CETPs exceeded the CPCB standards for COD and BOD parameter as seen in Figure No. 2-14.



Map No. 2-10: Spatial representation of WQMS no. 2792

Source: MRSAC and MPCB

(***Legend: 11***- *Motagaon STP;* ***18:*** *Dombivali better environment system association;* ***19:*** *Dombivali CETP*)

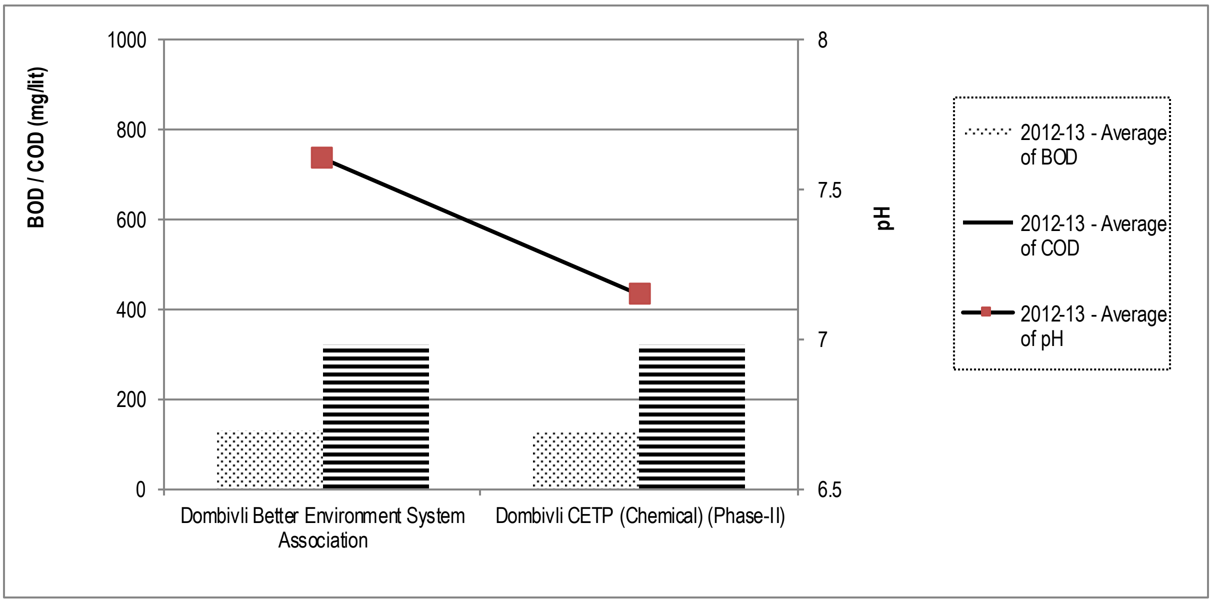


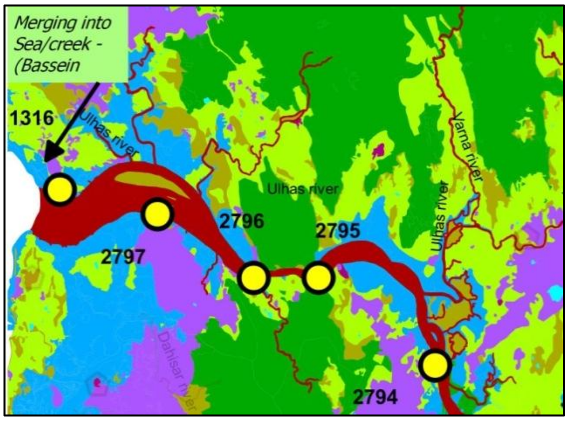
Figure No. 2-15: CETP performance for the year 2011-12

Source: MPCB

(Maximum permissible CPCB limits: BOD- 100 mg/l, COD- 250mg/l and pH between 5.5 and 9)

As seen in Map No. 2-11, the WQMS nos. 2794 and 2795 are located in Thane Municipal Corporation area and the major land use pattern around these WQMS is built up area (urban & rural) with patches of agricultural & forest land. In Thane, about 17% of the TMC notified area is covered by underground sewage network. The remaining sewage (216 MLD) is treated through septic tank and collected by nallhas running across the city and finally drained into the creek[30].

The WQMS nos. 2796 & 2797 are located in Mira Bhayander Municipal Corporation (MBMC) area and the land use pattern around these stations is wetlands, agricultural land, forest land and built up area (urban & rural) . In MBMC, only 16% of waste water generated is treated whereas the rest of the sewage (57 MLD) [31]is released into the creek after providing a primary treatment in the septic tank. Lastly, the WQMS no. 1316 is located near the wetland – Bassein creek.



Map No. 2-11: Spatial representation of WQMS on Ulhas creek

Source: MPCB, MRSAC

Parameter 1: pH

Permissible MPCB standard:

River water: between 6 and 8.5 Creek water: between 6.5 and 8.5

Observation:

River water:

It was observed that at all the WQMS of Ulhas River the pH was within the permissible limit of MPCB as seen in Figure No. 2-16.

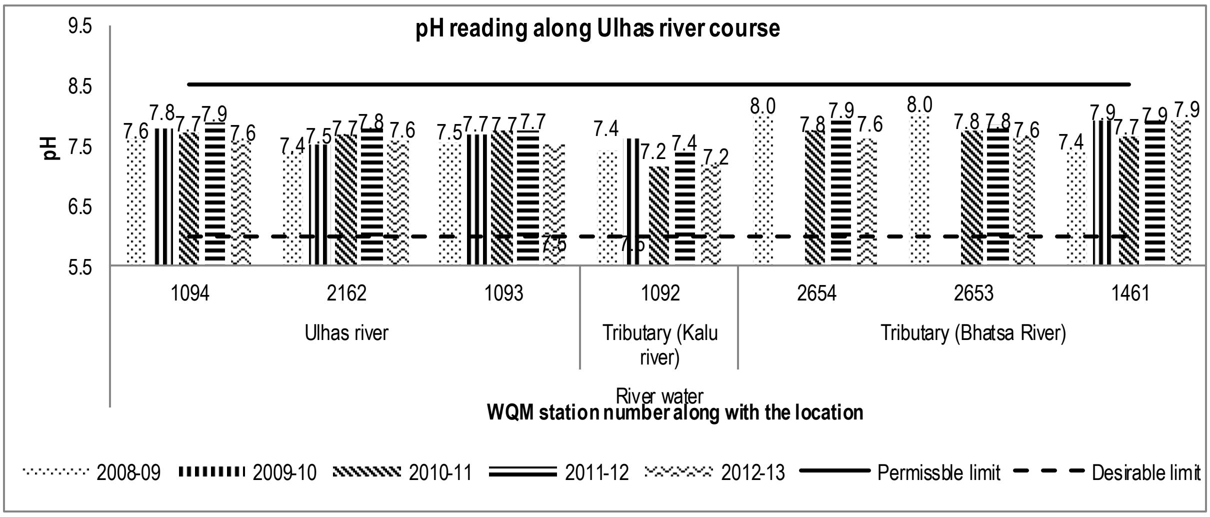


Figure No. 2-16: pH value at the WQMS of Ulhas River (river water)

Source: http://www.mpcb.gov.in/envtdata/envtwater.php

Note: The data was not available for WQMS nos. 2654 and 2653 for the year 2009-10

30 CSP of TMC, 2011

31 ESR and CSP of MBMC, April 2011

Creek water:

To assess the water quality of the creek, MPCB has provided Water Quality Standards for Coastal Waters[32]. As per the standards, the SW- II category is meant for water used for Bathing, Contact Water Sports and Commercial fishing. Hence, this category was considered for carrying out the assessment for the years 2008 to 2013. From the parameters mentioned below (Table No. 2-17). MPCB monitors only four parameters namely pH, Dissolved oxygen (DO), Biochemical Oxygen Demand (BOD) and Fecal Coliform (FC). Hence only these parameters were analyzed and compared with the MPCB standards to assess the overall quality of the creek water.

Table No. 2-17: Primary Water Quality Criteria for Class SW-II Waters (For Bathing, Contact Water Sports and Commercial Fishing)

Sr.no.	Parameter	Standards	Rationale/Remarks
1	pH range	6.5-8.5	Range does not cause skin or eye irritation and is also conducive for propagation of aquatic life
2	Dissolved Oxygen	4.0 mg/l or 50 percent saturation value, which ever is higher.	Not less than 3.5 mg/l at any time of the year for protection of aquatic lives.
3	Colour and Odour	No noticeable colour or offensive odour.	Specially caused by chemical compounds like creosols, phenols, naptha, pyridine, benzene, toluene etc. causing visible colouration of salt crystal and tainting of fish flesh.
4	Floating Matters	Nothing obnoxious or detrimental for use purpose.	None in concentration that would impair usages specially assigned to this class.
5	Turbidity	30 NTU (Nephelo Tur- bidity Unit)	Measured at 0.9 depths.
6	Fecal Coliform	100/100 ml (MPN)	The average value not exceeding 200/100 ml. in 20 percent of samples in the year and in 3 consecutive samples in monsoon months.
7	Biochemical Oxygen Demand (BOD) (3 days at 27°C)	3 mg/l	Restricted for bathing (Aesthetic quality of water). Also prescribed by IS:2296 1974..

Source: *http://mpcb.gov.in/images/pdf/CoastalwaterStandards.pdf*

[32] http://mpcb.gov.in/envtdata/envtwater.php

As seen in Figure No. 2-17, the pH value at all the WQMS of Ulhas creek was also observed to be within the permissible limits of SW-II category of MPCB, except in the year 2008-09 where the pH value was 6.3 at WQMS no. 2791 (Kalyan Bhiwandi bridge). The possible reason for the creek water to be acidic may be due to discharge of untreated sewage, inefficiency of the Aadharwadi STP and industrial effluent discharged from Additional Ambernath CETP, Chikhloli-Morivali effluent treatment plant and ACMA CETP.

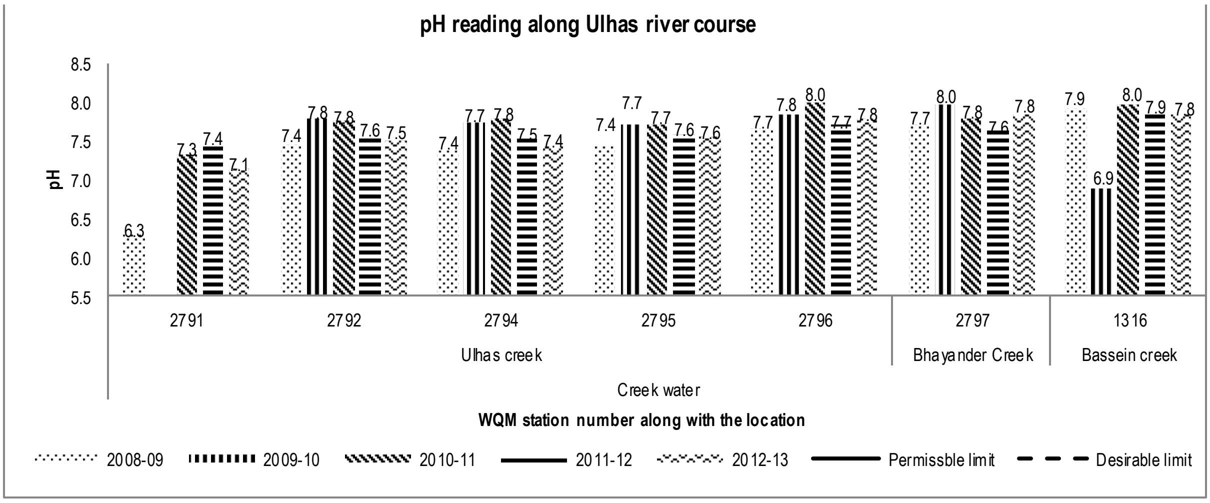


Figure No. 2-17: pH value at the WQMS of Ulhas creek (Creek water)

Source: http://www.mpcb.gov.in/envtdata/envtwater.php

Note: The data was not available for WQMS no. 2791 for the year 2009-10.

Parameter 2: Dissolved Oxygen (DO)

Desirable MPCB standard: 4 mg/l (minimum desirable standard) for river as well as creek water

Observation:

River water:

As seen in **Figure No. 2-18**, it was observed that at all the river WQMS the DO was above the minimum desirable MPCB standards, except at WQMS no. 1092 which was around 3.2 mg/l in the year 2010-11. Even the BOD at this particular station in the same year was recorded to be the highest (11.5 mg/l) and high levels of BOD cause the DO content of the water to drop.

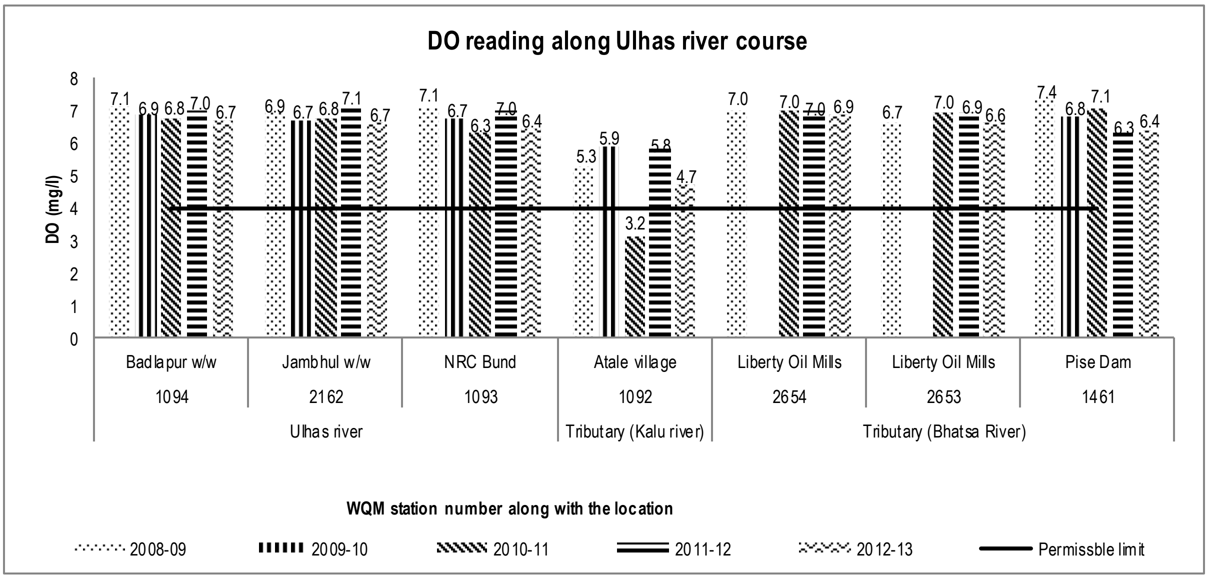


Figure No. 2-18: DO values at the WQMS of Ulhas River

Source: *http://www.mpcb.gov.in/envtdata/envtwater.php*

Note: The data was not available for WQMS no. 2654 for the year 2009-10.

Creek water:

For creek water, the DO value at WQMS no. 2791 (Kalyan-Bhiwandi bridge) was below the minimum desirable standard i.e 2.5 and 3.6 mg/l in the year 2010-11 and 2012-13 respectively and also at WQMS no. 2796 (Versova bridge) the DO value was 3.9 mg/l in the year 2009-10 as seen in figure no 2-15.

The possible reasons for low DO at certain locations along the creek may be due to the increase in the organic waste and run-off from surrounding agricultural fields containing phosphates and nitrates (the ingredients in fertilizers) and higher BOD value. The land use pattern around these WQM stations is majorly wetlands, agricultural &forest land and built up area of KDMC.

(Nitrates and phosphates can contribute to high BOD levels in the water body. Nitrates and phosphates are plant nutrients, causing plant life and algae to grow quickly. When plants grow quickly, they also die rapidly. This contributes to the organic waste in the water body, which is then decomposed by bacteria. The decomposition process requires lot of oxygen.)

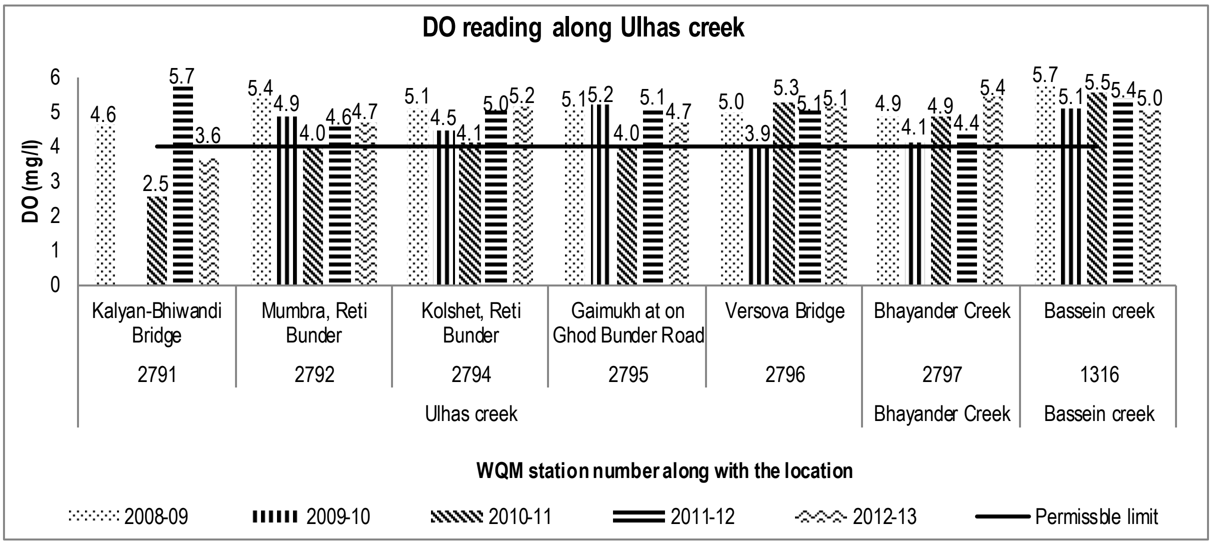


Figure No. 2-19: DO values at the WQMS of Ulhas creek

Source: *http://www.mpcb.gov.in/envtdata/envtwater.php*

Note: The data was not available for WQMS no. 2791 for the year 2009-10.

Parameter 3: Biochemical Oxygen Demand (BOD)

Permissible MPCB standard: River water: 5 mg/l Creek water: 3 mg/l

Observation:

River water:

As seen in Figure No. 2-20, it was observed that the BOD values for most (5 out of 7) of the stations were within permissible limits. However, BOD values at only two stations WQMS nos. 1092 (Atale village) on Kalu tributary and WQMS no. 1461 (Pise dam) exceeded the permissible limit of MPCB. Therefore, the monthly data pertaining to these two stations was critically assessed as explained below.

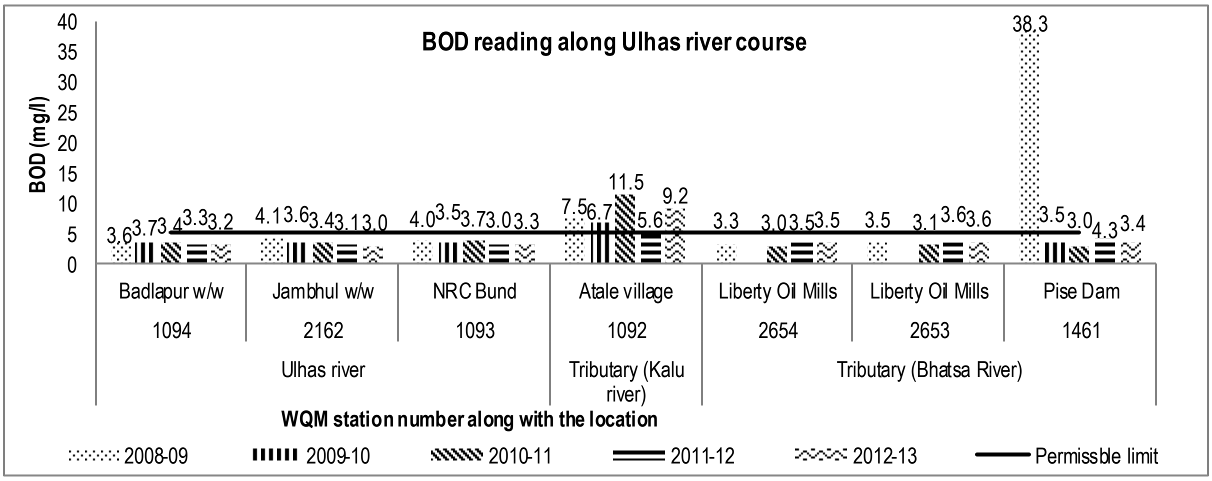


Figure No. 2-20: BOD value at the WQMS of Ulhas River

Source: *http://www.mpcb.gov.in/envtdata/envtwater.php*

Note: The data was not available for WQMS no. 2653 for the year 2009-10.

At WQMS no.1092 the BOD values were not monitored regularly across the study period. For instance, in the year 2010-11, only two readings corresponding to months of January and March were recorded. Hence given that BOD is an important parameter, MPCB averaged out the values to get annual readings. This inappropriate method tends to give incorrect inferences. Also as seen in Figure No. 2-21, in the year 2009-10 the readings were taken quarterly and BOD value exceeded the permissible limit only once i.e.in the quarter of April,2009 where it was 14 mg/l but for the rest of the quarters it was between 4 and 5 mg/ l (within the permissible limit). However, when it was averaged out for the annual BOD reading, the value was 6.7 mg/l which indicated violation of MPCB standards.

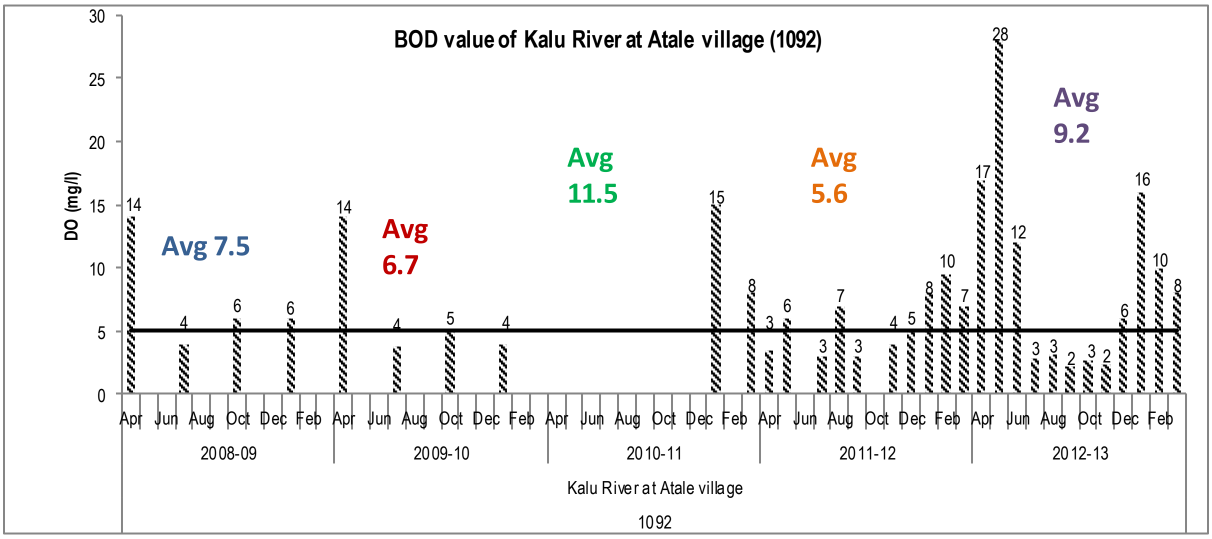


Figure No. 2-21: Monthly BOD value at Kalu River at Atale village station (WQMS no. 1092)

Source*: http://www.mpcb.gov.in/envtdata/envtwater.php*

Furthermore, as the monthly readings were available for the same station only for the year 2012-13, this data was considered for further assessment. It was observed that, higher BOD values were recorded in the non-monsoon season ranging from 6 to 28 mg/l. The possible reason for the exceedance may be due to discharge of organic matter from nearby villages of Titwala area of Kalyan Dombivali Municipal Corporation and run-off from surrounding agricultural fields containing phosphates and nitrates.

The WQMS no. 1461 is located at the Bhatsa River and downstream of Pise dam. There are no monthly readings available for this station and hence MPCB has averaged out quarterly readings for the year 2008-09. Further, the reading value of 143 mg/l, taken in the month of July was found to be much higher than the normal recorded trend at the station and hence regarded as an outlier (Figure No. 2-22). Therefore no further investigation was carried out for this station. Whereas, for the rest of the years (2009-13) the BOD values were within the permissible limit as seen in Figure No. 2-20.

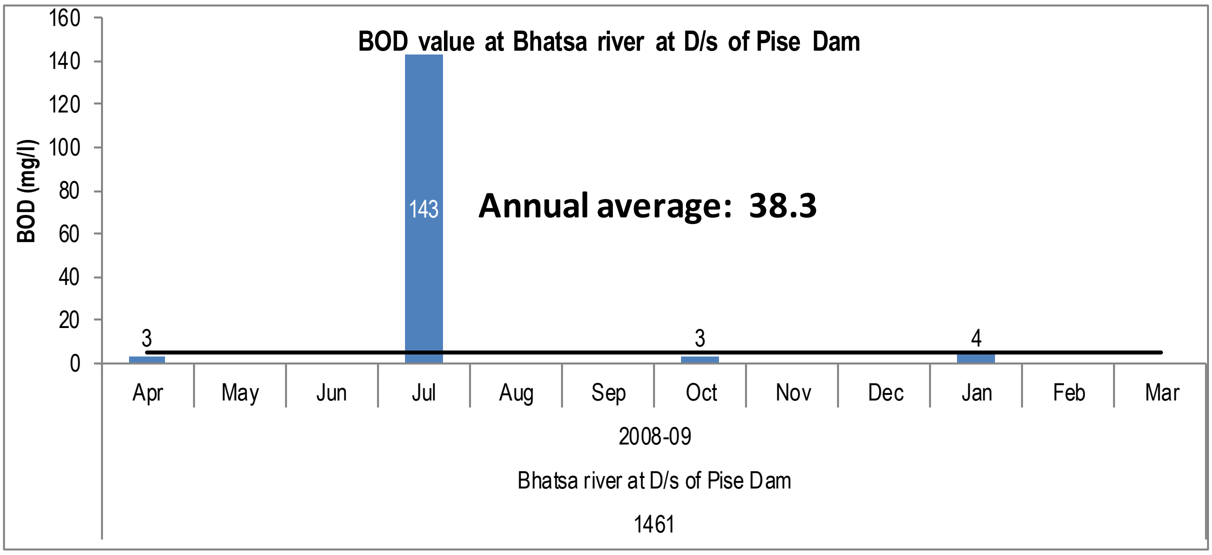


Figure No. 2-22: Monthly BOD value at Bhatsa river at downstream of Pise dam (WQMS no. 1461)

Source: *http://www.mpcb.gov.in/envtdata/envtwater.php*

Creek water:

For the creek water assessment, it was observed that at all the WQMS the value exceeded the permissible limit of 3mg/l as seen in Figure No. 2-23. The BOD values ranged between 6.8 to 18.3 mg/l. The possible reason for the exceedance could be untreated sewage discharge from Thane district and the inefficiency of the STPs present near the Ulhas creek (higher BOD {65 & 60 mg/l} and SS values {104 & 64 mg/l} were observed at the Motagaon and Aadharwadi STP respectively). Hence the entire downstream region of the Ulhas River was observed to be highly polluted with the organic waste.

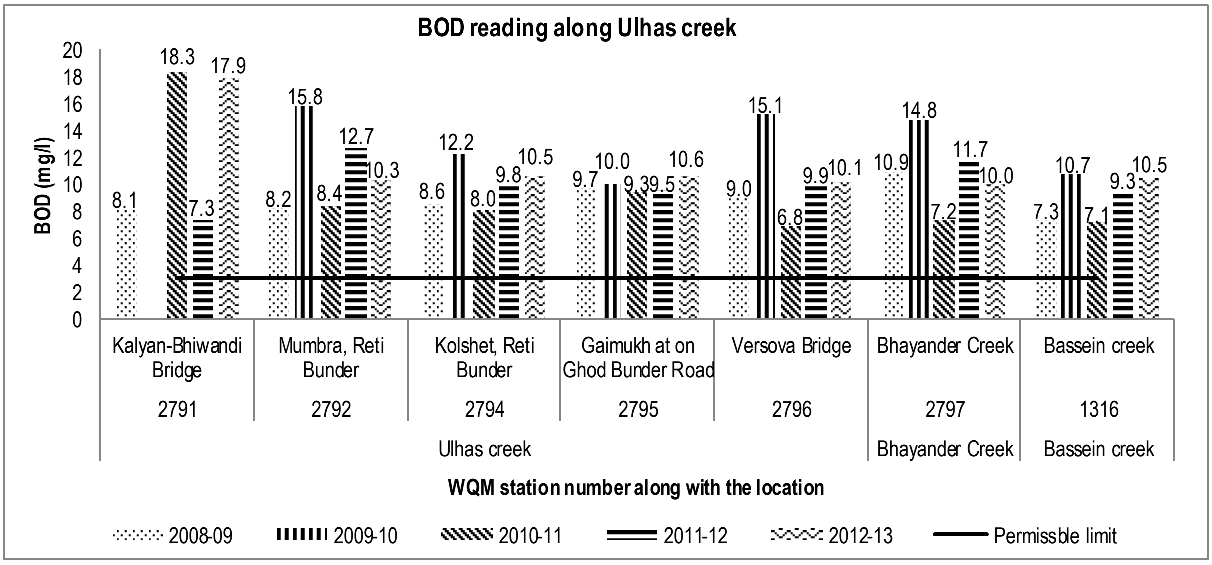


Figure No. 2-23: BOD value at the WQMS of Ulhas creek

Source: *http://www.mpcb.gov.in/envtdata/envtwater.php*

Note: The data was not available for WQMS no. 2791 for the year 2009-10.

Parameter 4 & 5: Fecal Coliform (FC) and Total Coliform (TC)

Permissible MPCB standard:

River water: 5000/100 ml (MPN) Creek water: 100/100 ml (MPN)

Observation:

River water:

It was observed that fecal & total coliform for the river water was within the permissible limit of MPCB standards, as seen in Figure No. 2-24, indicating permissible presence of human or animal waste.

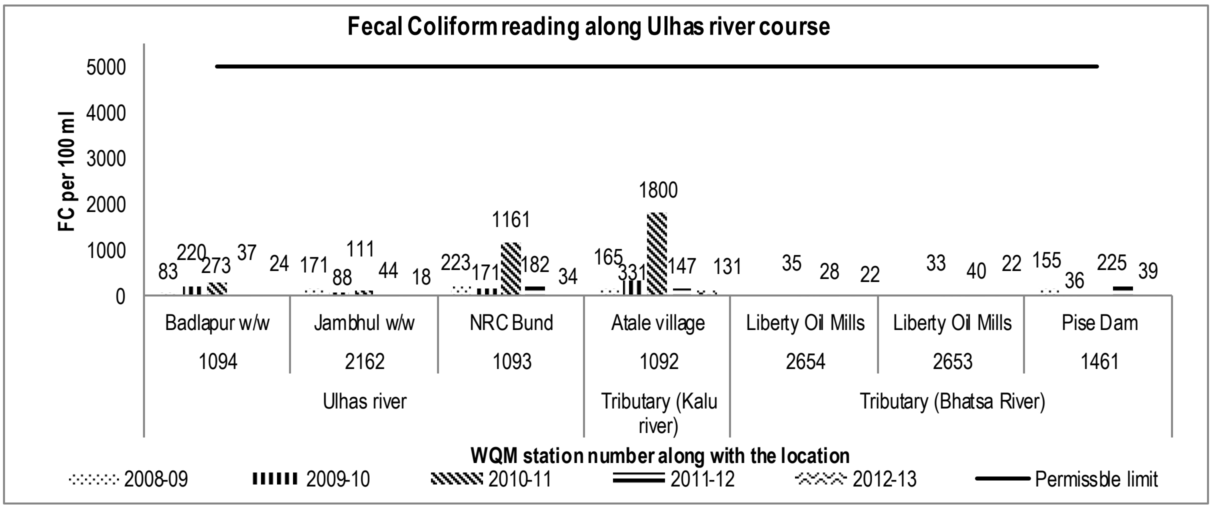


Figure No. 2-24: FC value at the WQMS of Ulhas River

Source: *http://www.mpcb.gov.in/envtdata/envtwater.php*

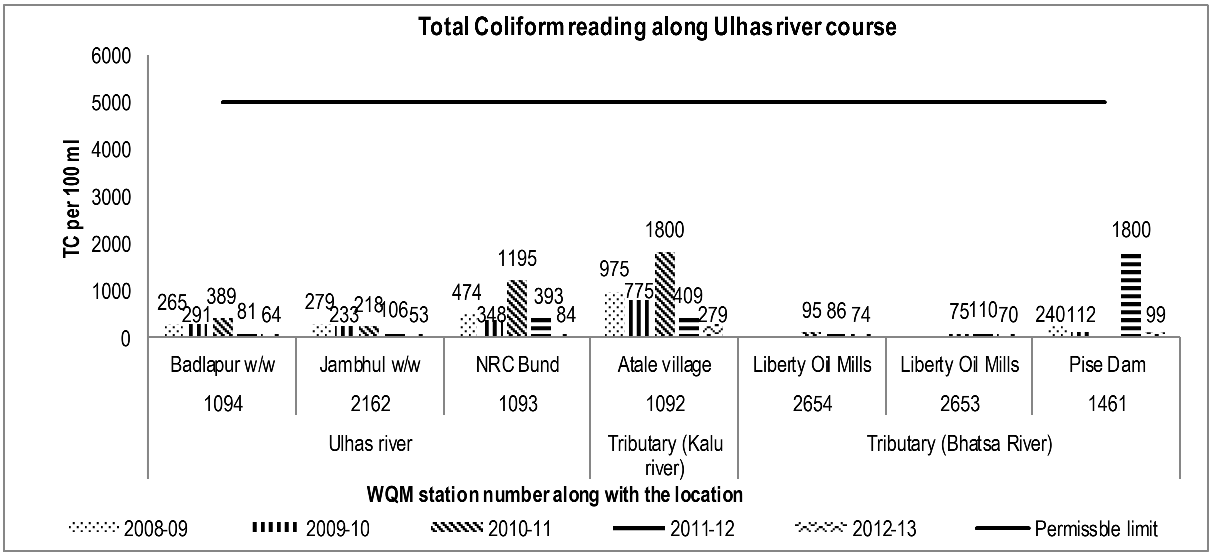


Figure No. 2-25: TC value at the WQMS of Ulhas River

Source: *http://www.mpcb.gov.in/envtdata/envtwater.php*

Note: The fecal & total coliform data was not available for WQMS nos. 2654 & 2653 for the years 2008 to 2010 and 2010-11 data for WQMS no. 1461.

Creek water:

As per the SW-II category of MPCB, only FC parameter is considered for creek water analysis. Hence the assessment was done only for recorded FC values. It was observed that fecal coliform at creek WQMS was above the permissible limit of 100/100 ml (MPN), it ranged between 112 to 1800 /100 ml (MPN) as seen in Figure No. 2-26. The possible reason for the exceedance may be untreated sewage discharge from Thane district and the inefficiency of the STPs located near the Ulhas River.

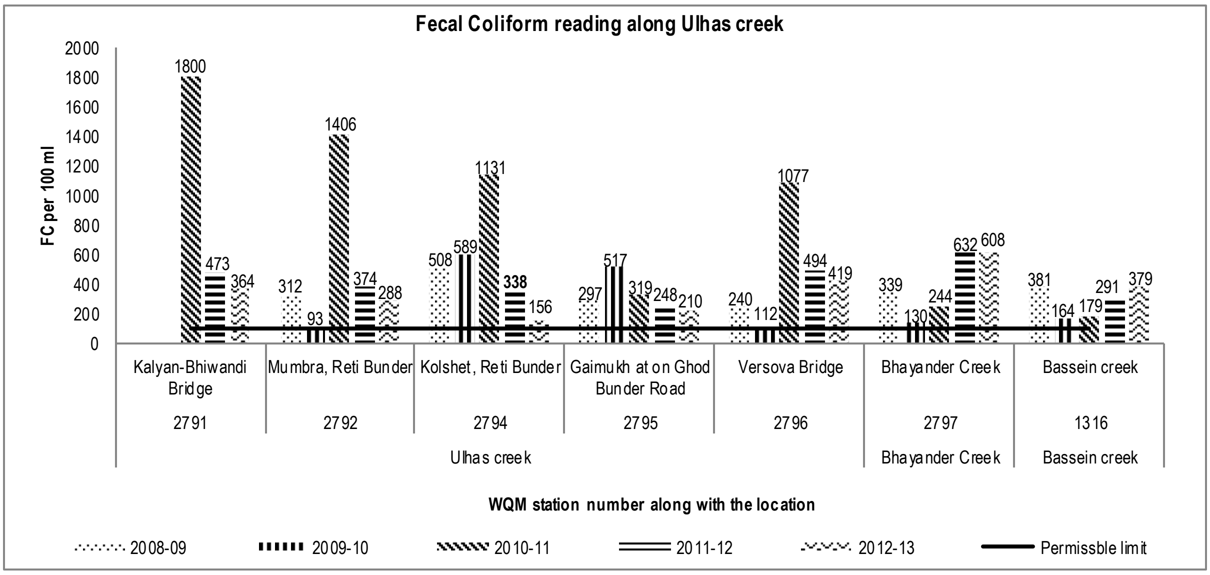


Figure No. 2-26: FC value at the WQMS of Ulhas creek

Source: *http://www.mpcb.gov.in/envtdata/envtwater.php*

Note: The FC data for WQMS no. 2791 for the year 2008-10 was not available for assessment.

Parameter 6 & 7: Ammonia and Nitrate

Permissible MPCB standard: Ammonia: - 1.5 mg/l Nitrate: - 45 mg/l for river water

Observation: River water:

It was observed that ammonia value at WQMS no. 2162 was 9.6 mg/l in the year 2010-11 and at WQMS no. 1092 it was3.5 and 3.3 mg/l for the year 2009-10 and 2010-11 respectively, which clearly indicated violation of the standards.

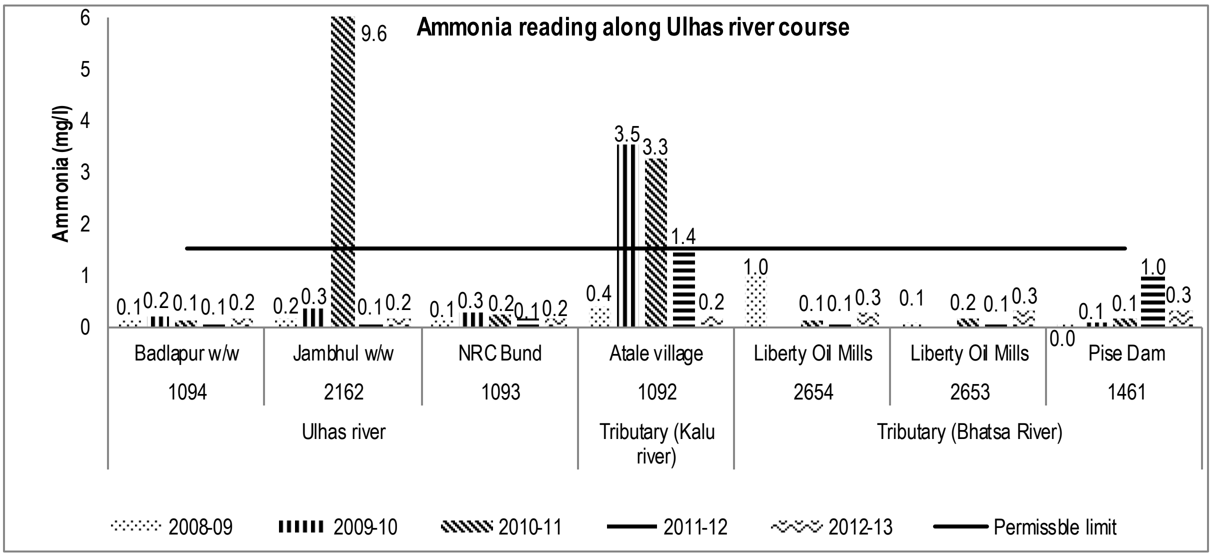


Figure No. 2-27: Ammonia value at the WQMS of Ulhas River

Source: *http://www.mpcb.gov.in/envtdata/envtwater.php*

Note: The data for WQMS no. 2654 & 2653 for the year 2009-10 was not available for assessment.

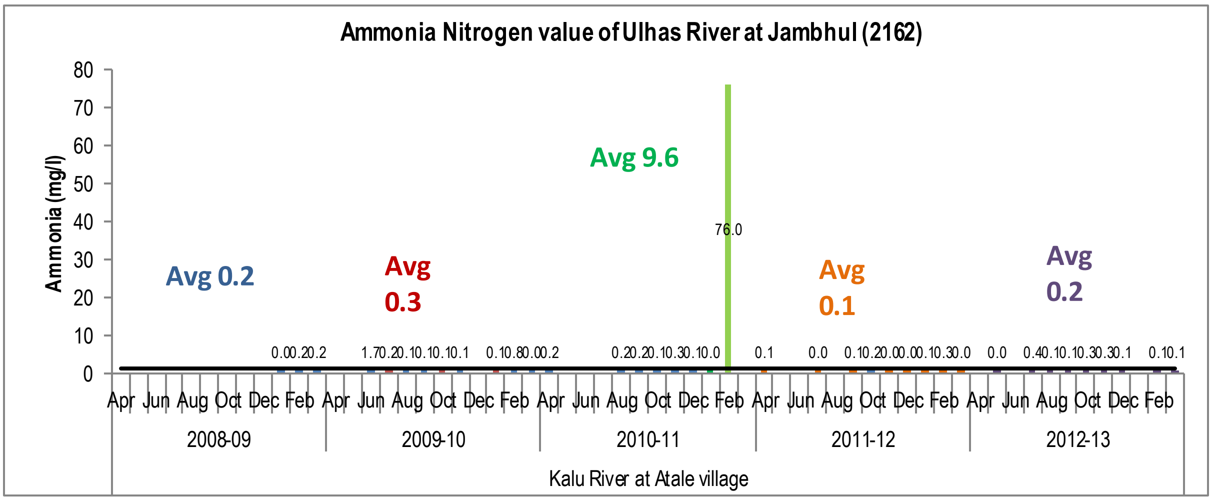


Figure No. 2-28: Ammonia value at the WQMS of Ulhas River at Jambhul (2162)

Source: *http://www.mpcb.gov.in/envtdata/envtwater.php*

The observations revealed that the ammonia reading taken in the month of February, 2011 was 76mg/l, which is an outlier as seen in Figure No. 2-28. The monthly readings were not taken consistently and were averaged out for annual ammonia reading, thus giving an incorrect inference. Hence it was not considered for any further assessment.

The higher ammonia readings at WQMS no. 1092 may be due to the agricultural runoff from the surrounding fields and untreated sewage discharge from Titwala area of Kalyan Dombivali Municipal Corporation area.

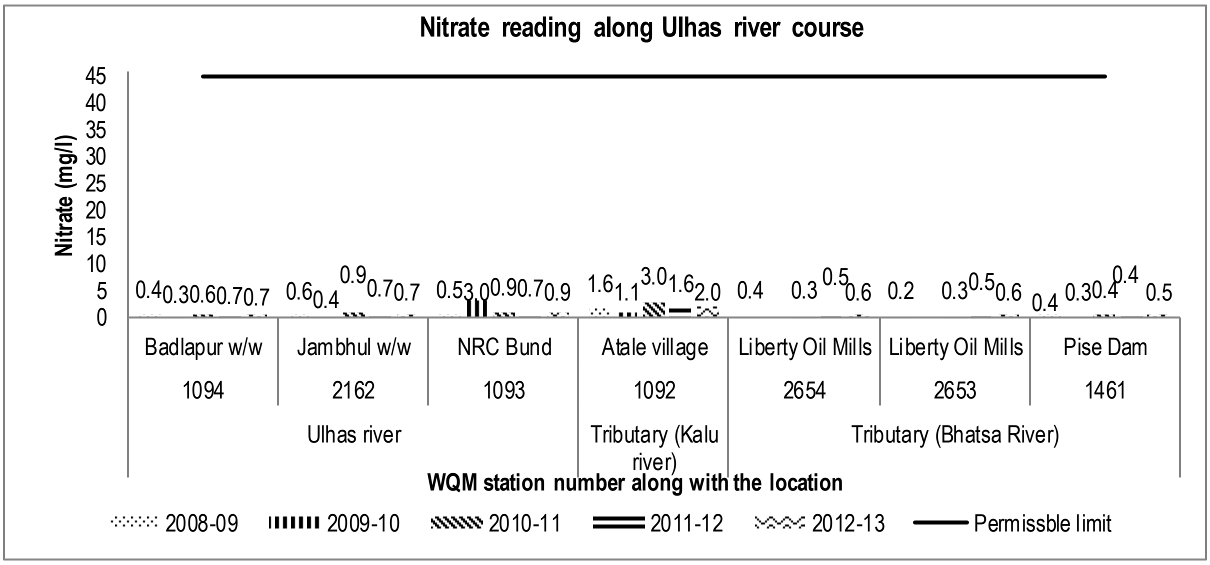
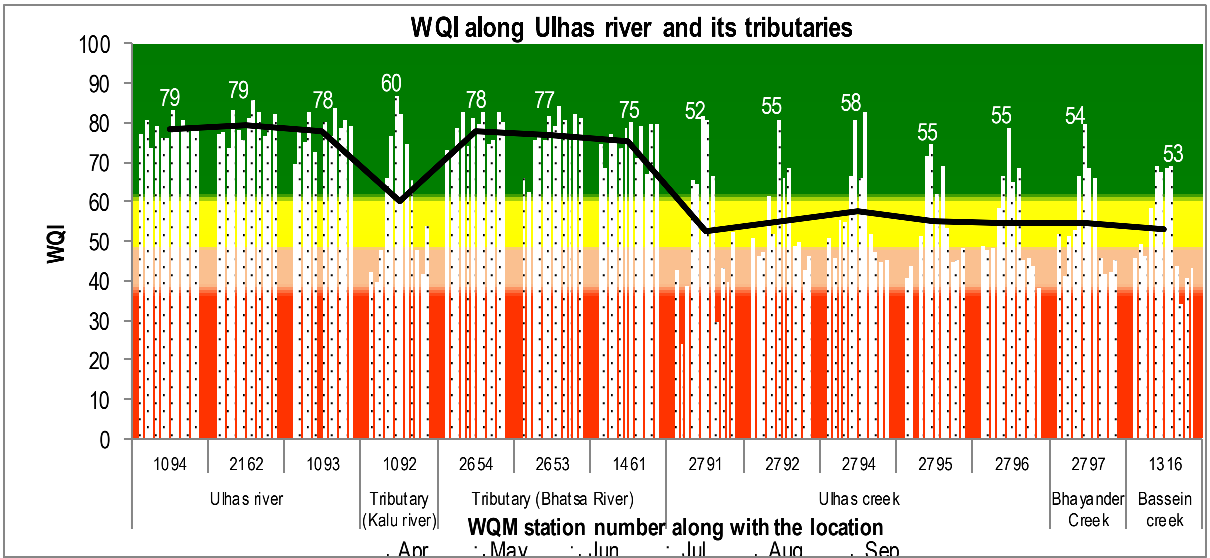


Figure No. 2-29: Nitrate value at the water quality monitoring stations

Source: *http://www.mpcb.gov.in/envtdata/envtwater.php*

Note: The data for WQMS no. 2654 & 2653 for the year 2009-10 was not available for assessment.

For SW-II category, ammonia and nitrate are not monitored by MPCB for creek water quality analysis. Hence the assessment is not presented in the report.



	Surface Water Quality		
	63 - 100	Good to Excellent	Non Polluted
	50 - 63	Medium to Good	Non Polluted
	38 - 50	Bad	Polluted
	38 and less	Bad to Very Bad	Heavily Polluted

Figure No. 2-30: WQI of Ulhas river and creek

Source: *http://www.mpcb.gov.in/envtdata/envtwater.php*

Water Quality Index

As clearly seen in Figure No. 2-30, the WQI of Ulhas River along with its tributaries, ranged from 60 to 79, indicating 'Good to Excellent' water quality. Except at Kalu tributary where it was in 'Medium to good' water quality category. Whereas, the creek WQI ranged from 52 to 58, indicating 'Medium to Good' water quality.

Overall water quality of Ulhas River

The water quality of Ulhas River meets the MPCB water quality standards of A-II for best designated usage, except the following parameter at WQMS no. 1092 on Kalu tributary.

- DO value (3.2 mg/l) for the year 2010-11
- BOD value (9.2 mg/l) for the year 2012-13
- Ammonia (3.5 and 3.3 mg/l) for the year 2009-11.

The possible reason for the exceedance may be due to run-off from surrounding agricultural fields containing phosphates and nitrates and discharge of organic matter from nearby villages of Titwala area within Kalyan Dombivali Municipal Corporation limit.

For creek water quality, BOD and FC value exceed the permissible limits of MPCB water quality standards of SW-II category for best designated usage at all the 7 WQM stations. The BOD values ranged from 6.8 to 18.3 mg/l, whereas the FC values were in the range of 112 to 1800/100 ml (MPN). The possible reason for the exceedance for both the parameters may be due to untreated sewage discharge from Thane district and the inefficiency of the STPs present near the Ulhas creek.

Further, at WQMS no. 2791 in the year 2008-09, the pH was 6.3 due to sewage & effluent discharge from Ulhasnagar area. Similarly, DO readings at WQMS no. 2791 was 2.5 and 3.6 mg/l in the year 2010-11 and 2012-13 respectively and at WQMS no. 2796 (Versova Bridge) the DO value was 3.9 mg/l in the year 2009-10. The exceedance of the permissible limits may be due to run-off from surrounding agricultural fields containing phosphates and nitrates and higher BOD values at the WQM stations.

Ulhas River meets the MPCB water quality standards of A-II for best designated usage, except the BOD, DO & ammonia at WQMS no. 1092 for the year2010-11, 2012-13 & 2009-11 respectively. The possible reason for the exceedance may be due to agricultural runoff & organic discharge from Titwala area. Whereas, for the creek water, BOD & FC exceeds the permissible standards of SW-II category at all the 7 WQMS due to untreated sewage discharge from Thane district & inefficiency of the STPs present near the WQM stations. Overall, the river water quality indicated 'Good to Excellent' quality, whereas, the creek water indicated 'Moderately good to good' quality.

Furthermore, for the year 2012-13 the WQI was calculated which indicated that the water quality of the river and its tributaries was within the range of 63-100. Therefore, as per CPCB's description it falls in the 'Good to Excellent' water quality category. Except at Kalu tributary where it was in 'Medium to good' water quality category. Also, the WQI of the creek water was within the range of 50-63 indicating a 'Moderately good to good' water quality as per CPCB as shown in Figure No. 2-31.

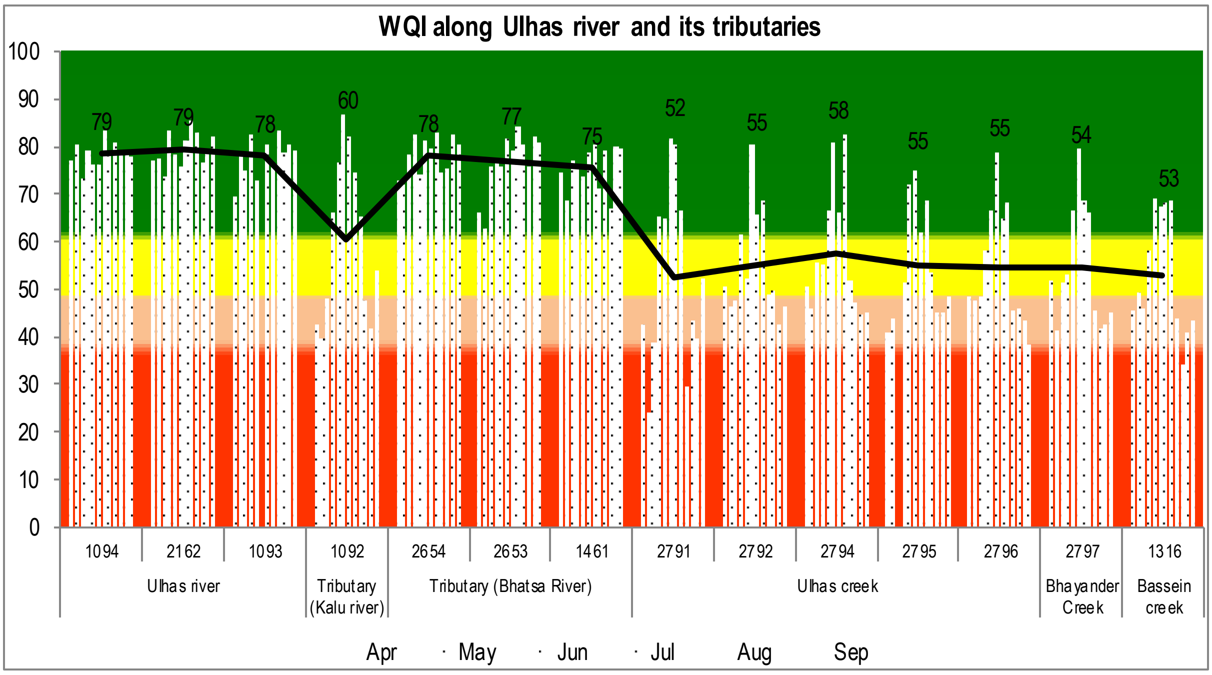


Figure No. 2-31 Overall WQI of Ulhas river

Conclusion and recommendations

Ulhas River, supplies 1850 MLD from Bhatsa, 600 MLD from Barvi and 800 MLD of water from Ulhas River to Greater Mumbai and rest of MMR. Whereas the Kalu tributary (1140 MLD) and Poshir tributary (720 MLD) are considered for augmentation of water resources for MMR[33].

Given the significance of the river, it is critical to examine the quality of the river on regular basis. Also it was observed that the Ulhas River is monitored only towards the downstream region and there are no monitoring stations at the extreme upstream region of the river. Further, out of 10 tributaries, only two tributaries are monitored, which clearly highlights the infrastructural gap. Therefore the following recommendations are given to ` overcome the issue.

[33] MMRDA

Critical observations	Specific recommendations
1. On Ulhas river, there are only 3 WQMS and out of 10 tributaries only 2 are monintored. Further, in the vicinity of the river there are 4 CETPs.	1. Need to introduce more WQMS along the stretch of the river espically at critical locations.
2.Badlapur CETP is close to the WQMS no. 1094 and for the year 2011-12 it was observed that the CETP exceeded the permissible standards for COD and BOD parameters (838 and 349 mg/l respectively).	2. The Badlapur CETP should treat the industrial effluent to tertiary level before releasing it into the river or its tributary.
3. At the upstream of the creek WQMS no. 2791, there is Aadharwadi STP, 2 solid waste dumping grounds of KDMC and UMC each and 3 CETPs in the vicinity of the station. The BOD and SS values (26 & 38 mg/l respectively) exceeded the permissible limits, whereas the CETPs also exceeded the CPCB standards for COD and BOD.	3. The creek water quality is deteriorated due to the presence of STP, Solid waste dumping grounds and CETPs in the close vicinity of the river course. Hence it is recommended to allocate these plants at a desirable distance and to ensure that from these plants at least tertiary treated water is released into the river/creek.
4. The two creek WQMS (2794 and 2795) located in Thane Municipal area revealed bad water quality due to discharge of untreated sewage from the thane area. *(In Thane, about 17% of the TMC notified area is covered by underground sewage network).*	4. Industries/CETPs violating the CPCB standards should be heavily penalized under the Water (Prevention and Control of Pollution) Act, 1974.
5. Further, the two creek WQMS located in Mira Bhayander Municipal area revealed bad water quality due to discharge of primary treated waste water. *(In MBMC only 16% waste water generated is treated whereas the remaining sewage is treated to primary level with the help of septic tanks.)*	

2.4.1.3 Dahisar River

General information[34]

Dahisar River is a westbound river flowing through Mumbai Suburban district of Maharashtra.

It originates at the spillway of the Tulsi Lake in the Sanjay Gandhi National Park located in the northern region of the city, flows roughly to North-West for a total of 12 km through the localities of the National Park

Picture No. 2-3: Dahisar River

Source: http://www.mumbai77.com/scripts/common/pictures/pictures_read_rss.php?album=13

[34] http://www.mmreis.org.in/uploadeddocuments/1203141429_Stage%203%20Report.pdf
http://en.wikipedia.org/wiki/Dahisar_River

and Dahisar Gaothan before meeting the Arabian Sea via the Manori Creek.

About 60% of the land along the river is under forest, as major part of the river passes through SGNP, followed by residential use which is about 13%. About 7.42% of land is under roads as the river has roads running parallel to it. Towards the mouth of the river there is luxuriant growth of mangroves (6.22%). As the intensity of development slowly decreases towards the end of the river the occurrences of open areas are more (6%). Various patches of slums along the river cover about 4.34% of the land. There are many outfalls which bring in sewage into the river. The number of outlets and solid waste dumping is high in the stretch where ever there are slums along the river.[35]

Table No. 2-18: General information of Dahisar River

Dahisar River	
Origin	Spillway of the Tulsi Lake in the Sanjay Gandhi National Park
Length of the river from origin	12 km
Catchment area (sq.km)	34.88
Water application	None, Highly polluted. Serves as a drain.
Dam/reservoir on the river	-

Source: http://en.wikipedia.org/wiki/Dahisar_River and Inventory of environmental features, Greater Mumbai, Prepared by HCP Design and Project Management Pvt. Ltd.

Map No. 2-12: Spatial representation of Dahisar river

Source: MRSAC, Google Earth

Water quality information and assessment

On Dahisar River there are no water quality monitoring stations.

[35] Inventory of environmental features, Greater Mumbai, Prepared by HCP Design and Project Management Pvt. Ltd.

2.4.1.4 Poisar River

General information[36]

Picture No. 2-4: Poisar River

Source: http://indian-eagle.blogspot.in/2010/10/our-rivers-contempt-and-compassion.htm

Poisar River is a river in Mumbai, India. It begins in the Sanjay Gandhi National Park and empties into the Marve Creek and finally into the Arabian Sea. The river is nothing more than a mere stream when it begins and is contaminated with industrial effluents and sewage.

About 22% of the land along the river is under slums. Large patches of slums can be observed in the beginning and the middle stretches of river course. This is followed by open areas (14.58%). About 10.23% of land on the right bank near the mouth of the river is under mangroves. About 10 % of the land is under residential use followed by commercial (7%), public/semi public (5.41%) and industrial (3.67) use. The river appears extremely polluted, as large amount of solid waste is seen in the river. There are numerous out falls which bring sewage into the river.[37]

Originating in the Sanjay Gandhi National Park, the 11.5 km long river is highly polluted and presently serves as a drain for the region. Further, there are no WQMS on the river.

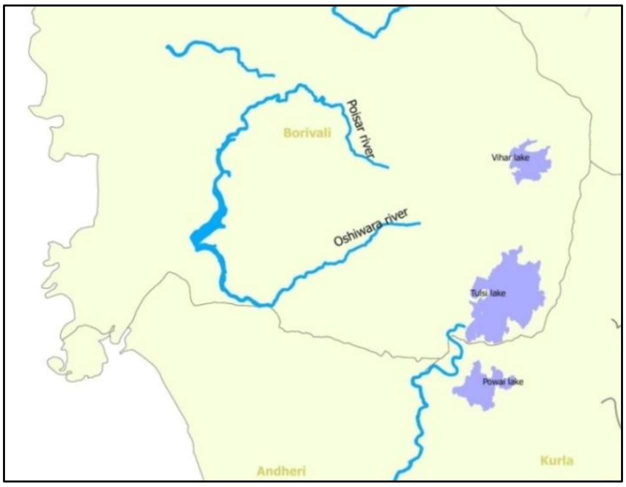
Table No. 2-19: General information of Poisar River

Poisar River	
Origin	Sanjay Gandhi National Park
Length of the river from origin	11.5 km
Water application	None, Highly polluted. Serves as a drain.
Dam/reservoir on the river	-

Source: Inventory of environmental features, Greater Mumbai, Prepared by HCP Design and Project Management Pvt. Ltd.

[36] http://www.mmreis.org.in/uploadeddocuments/1203141429_Stage%203%20Report.pdf
http://en.wikipedia.org/wiki/Poisar_River

[37] Inventory of environmental features, Greater Mumbai, Prepared by HCP Design and Project Management Pvt. Ltd.



Map No. 2-13: Spatial representation of Poisar river

Source: MRSAC, Google Earth

Water quality information and assessment

On Poisar River there are no water quality monitoring stations.

2.4.1.5 Malad River

General information

Malad River is a westbound river flowing through Mumbai Suburban district of Maharashtra. Located west of Malad, the Oshiwara River drains into it.

The 11 km long river is highly polluted and presently serves as a drain for the region. Further, there are no WQMS on the river.

Table No. 2-20: General information of Malad River

Malad River	
Length of the river from origin	11 km
Water application	None, Highly polluted. Serves as a drain.
Dam/reservoir on the river	-

Source: *http://en.wikipedia.org/wiki/Malad_Creek*

Water quality information and assessment

On Malad River there are no water quality monitoring stations.

2.4.1.6 Oshiwara River

General information[38]

Oshiwara River is a westbound river flowing through Mumbai Suburban district of Maharashtra. The river flows through the Goregaon hills and Andheri, before emptying into the Malad Creek.

The 9.63 km long river is highly polluted and presently serves as a drain for the region, There are no WQMS on the river.

About 23% of the land along the river is under wild vegetation. A part of the main river and one of its subsidiary streams flows through the Aarey Milk colony. This stretch of the main river and the subsidiary stream has its riparian zone with wild vegetation on both edges. The central part of the river and the subsidiary streams has about 18% of the land under commercial and industrial uses. About 9% land is under roads, another 9% under residential use. Slums cover about 6% of the land along the river.[39]

Picture No. 2-5: Oshiwara river

Source: http://en.wikipedia.org/wiki/Oshiwara_River

Table No. 2-21: General information of Oshiwara River

Oshiwara River	
Length of the river from origin	9.63 km
Catchment area (sq.km)	29.38
Water application	None, Highly polluted.
Dam/reservoir on the river	-

Source: Inventory of environmental features, Greater Mumbai, Prepared by HCP Design and Project Management Pvt. Ltd.

Water quality information and assessment

On Oshiwara River there are no water quality monitoring stations.

Conclusion and recommendations for Dahisar, Poisar, Malad and Oshiwara River

The rivers presently serve as a drain and are highly polluted. Further, there is no water quality monitoring stations on the entire river course. Hence, it is recommended to clean the river and monitor it regularly.

[38] http://www.mmreis.org.in/uploadeddocuments/1203141429_Stage%203%20Report.pdf
http://en.wikipedia.org/wiki/Oshiwara_River

[39] Inventory of environmental features, Greater Mumbai, Prepared by HCP Design and Project Management Pvt. Ltd

Sr. No.	Rivers	Water application/significance	Critical observations	Specific recommendations
1	Dahisar	Highly polluted and presently serves as a drain for the region	The banks of the river are encroached by slums and the untreated sewage is directly discharged in these rivers. Also, there are no WQMS on the river to comment on the water quality. However, visually the water looks eutrophicated.	1. The banks of the rivers should be protected and there should be no development zone for at least 30 meters. 2. De-siltation and debris/solid waste removal should be done on a regular basis. 3. Few WQMS should also be introduced to keep a quality check.
2	Poisar			
3	Malad			
4	Oshiwara			

2.4.1.7 Mithi River

General information[40]

Mithi River is a westbound river flowing through Mumbai Suburban district of Maharashtra.

It originates at the confluence of tail water discharges of Powai and Vihar Lake. Flows towards south from SGNP for about 15 km, changes the course and flows towards west from the point where Vakola Nala meets the river, and finally empties into Mahim Bay.

Map No. 2-14: Spatial representation of Mithi River

Picture No. 2-6: Mithi River

Source: http://en.wikipedia.org/wiki/Mithi_River

About 18.34% of the land along /in the river near its mouth is under mangroves followed by 15.37% of the area as open which is largely due to the buffer left along the river in Bandra Kurla Complex and certain other patches along the river. Transportation/roads take up about 14.52% of the land, which is due to the large area under CSI airport abutting the river. Almost 9.52% of land is under forest followed by slums which covers about 8.96% of land. About 12.42 % of land is under commercial and industrial use which is due to the industrial estates and the scrap market between Jogeshwari Vikhroli Link Road to Air India Road. Land under residential use only constitutes about 5.28% of the land along the river.[41]

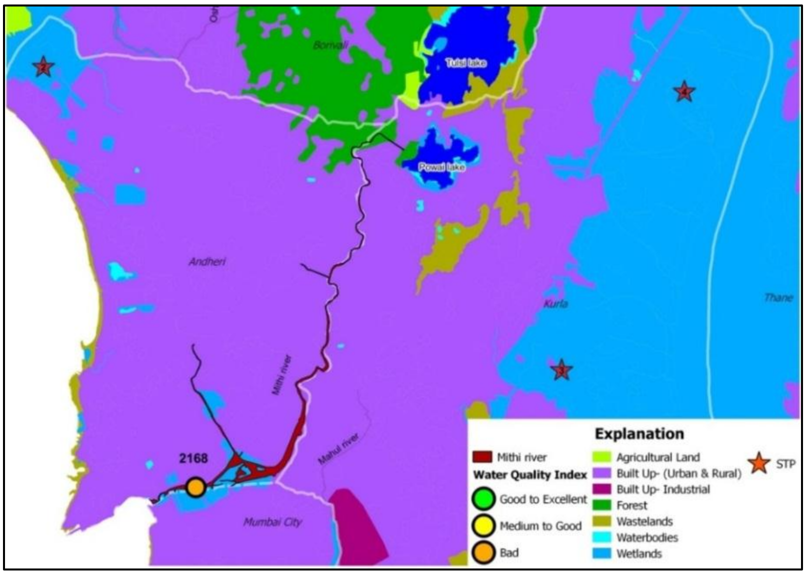
Table No. 2-22: General information of Mithi River

Mithi River	
Origin	At confluence of tail water discharges of Powai and Vihar lake
Length of the river from origin	17.8 km
Water application	Washing of vessels, animals & oily drums.
Dam/reservoir on the river	-

Source: Inventory of environmental features, Greater Mumbai, Prepared by HCP Design and Project Management Pvt. Ltd.

Water quality information and assessment

On Mithi River there is 1 WQMS towards the downstream part of the river which was installed under the SWMP programme. The major land use pattern around the WQMS is built up area (urban & rural) as seen in Map No. 2-15.



Map No. 2-15: Spatial representation of WQMS on Mithi River

Source: MPCB, MRSAC

[41] Inventory of environmental features, Greater Mumbai, Prepared by HCP Design and Project Management Pvt. Ltd.

Parameter 1: pH

Permissible MPCB standard: Between 6 and 8.5.

Observation: As seen in Figure No. 2-32, it was observed that the pH value was within the permissible limit of MPCB. Thus, indicating a good water quality for aquatic life.

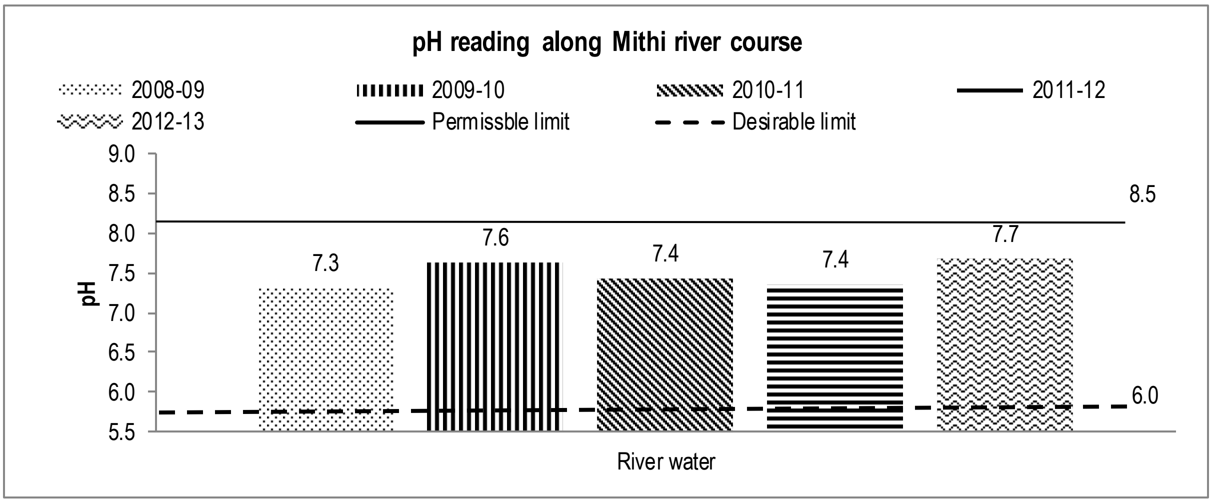


Figure No. 2-32: pH value at the WQMS of Mithi River

Source: *http://www.mpcb.gov.in/envtdata/envtwater.php*

Parameter 2: Dissolved Oxygen (DO)

Desirable MPCB standard: 4 mg/l (minimum desirable standard)

Observation: As seen in Figure No. 2-33, the DO values were observed in the range of 1.5 to 3.4 mg/l, which is below the desirable MPCB standard. The possible reason for showing a trend of low DO value could be due to excessive algae growth caused by phosphorus and nitrogen which is sourced through discharge of untreated municipal waste water in the river and also due to higher organic content in the river, which is evident from the higher BOD values observed during these 5 years.

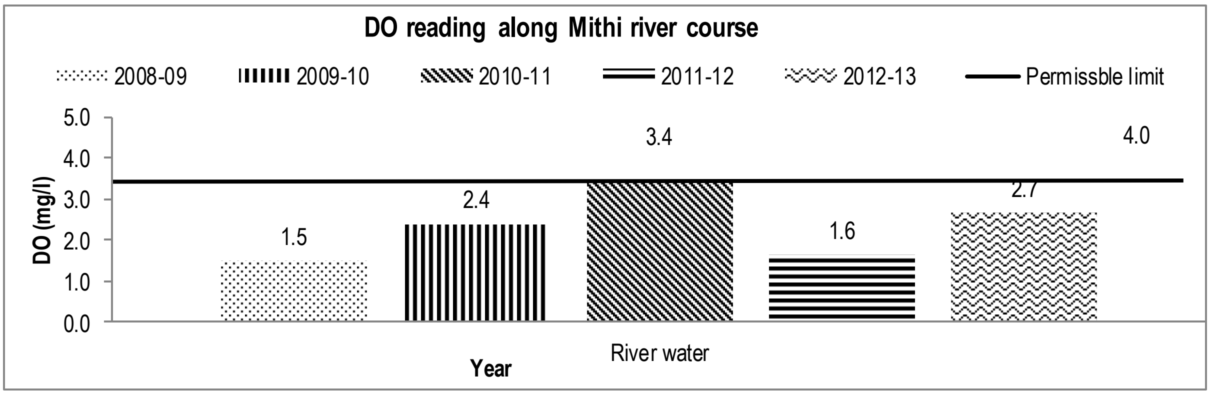


Figure No. 2-33: DO values at the WQMS of Mithi River

Source: *http://www.mpcb.gov.in/envtdata/envtwater.php*

Parameter 3: Biochemical Oxygen Demand (BOD)

Permissible MPCB standard: 5 mg/l

Observation: As seen in Figure No. 2-34, it was observed that BOD exceeded the permissible limit of MPCB and was in the range of 28.5 to 100.3 mg/l. The possible reason for the exceedance of BOD may be due to discharge of untreated waste from industries. And since the river passes through slum areas, human activities also may account for higher BOD value.

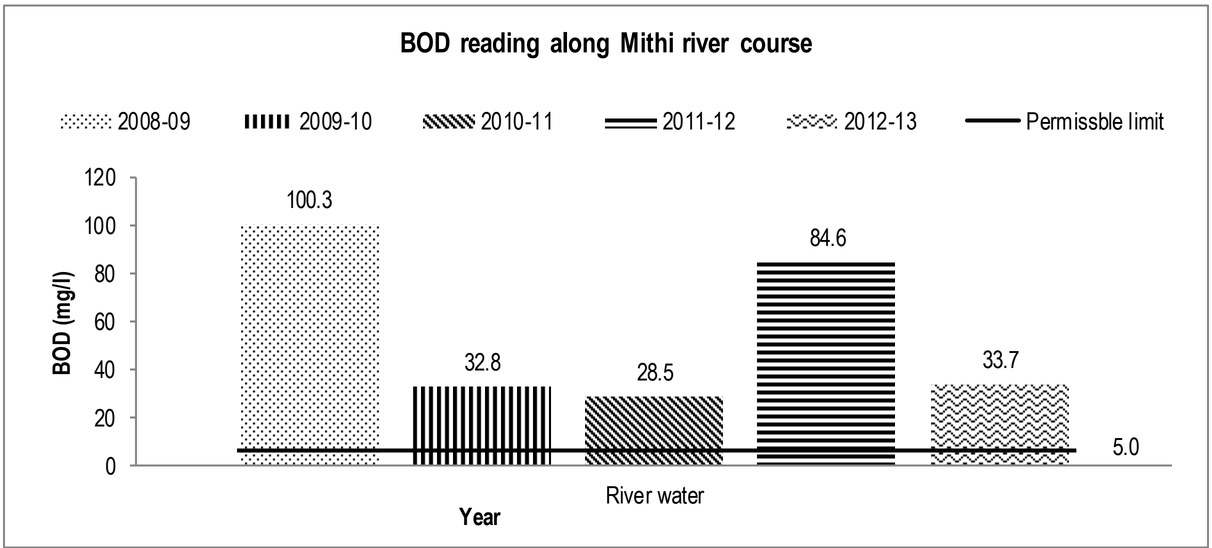


Figure No. 2-34: BOD value at the WQMS of Mithi River

Source: http://www.mpcb.gov.in/envtdata/envtwater.php

Parameter 4 & 5: Fecal Coliform (FC) and Total Coliform (TC)

Permissible MPCB standard: 5000/100 ml (MPN)

Observation: It was observed that fecal coliform and total coliform were within the permissible limit of MPCB, hence indicating acceptable presence of human or animal waste in the river water.

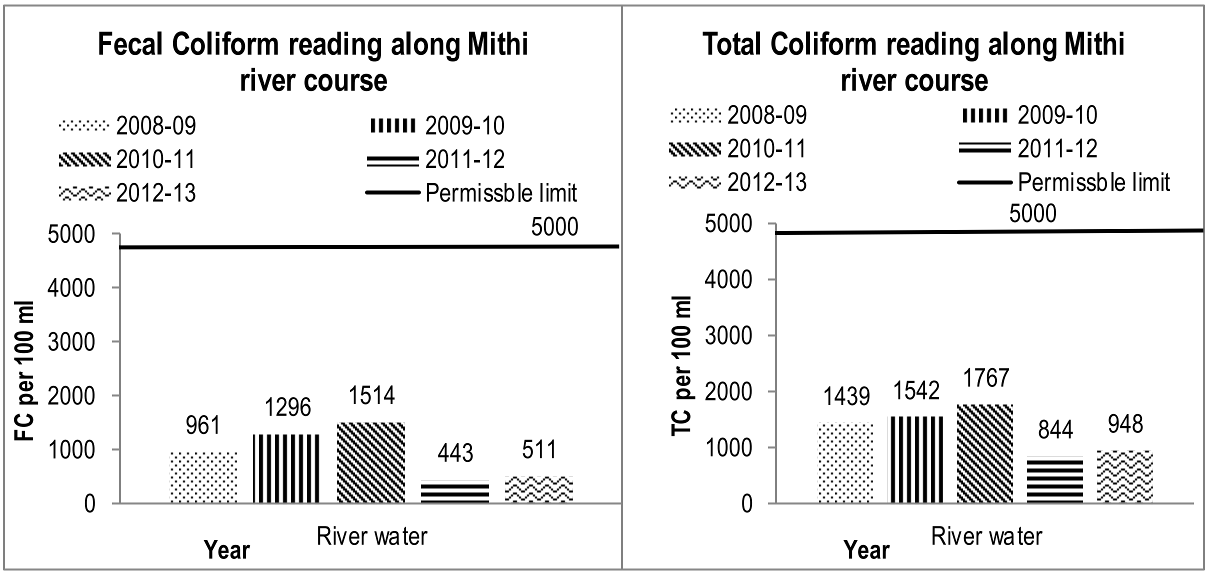


Figure No. 2-35: FC & TC value at the WQMS of Mithi River

Source: *http://www.mpcb.gov.in/envtdata/envtwater.php*

Parameter 6 & 7: Ammonia and Nitrate

Permissible MPCB standard: Ammonia: - 1.5 mg/l Nitrate: - 45 mg/l

Observation: It was observed that ammonia value ranged between 1.62 to 8.91 mg/l, thus exceeding the permissible limits of MPCB. Possible reason for high ammonia may be due to discharge of untreated waste from industrial area and the domestic & organic disposal from the slum areas. Whereas, nitrate values were within the permissible MPCB standard at the WQMS.

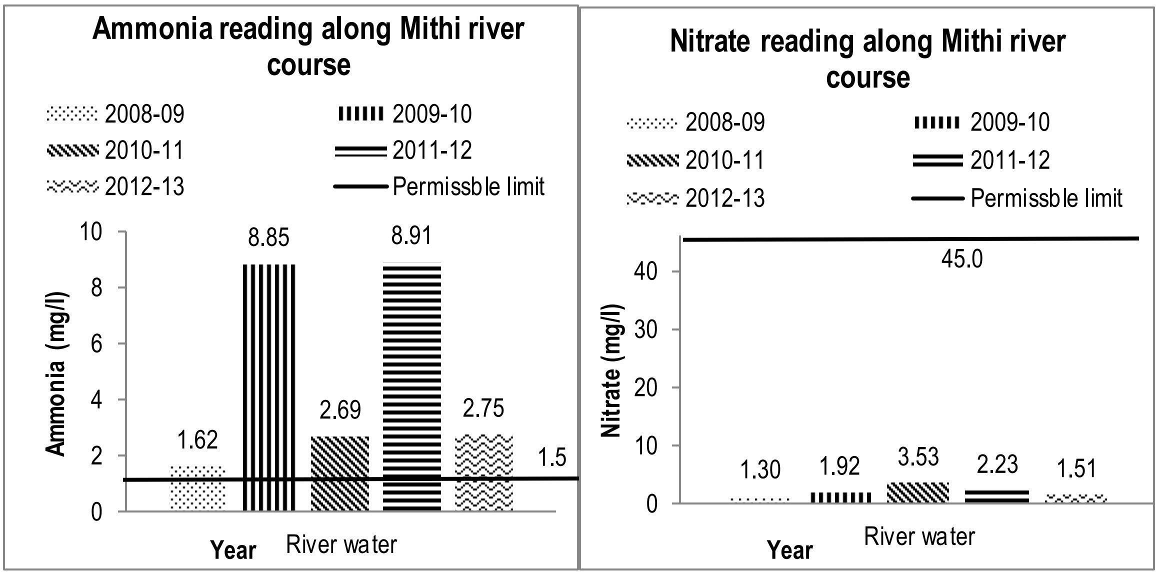
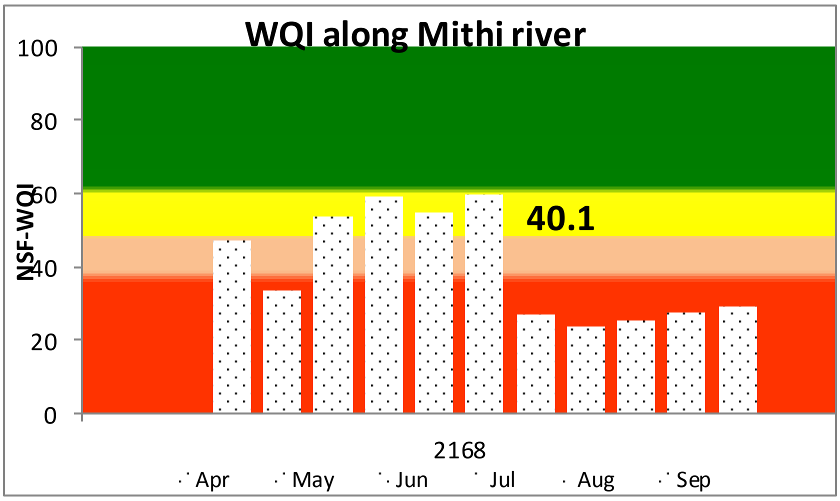


Figure No. 2-36: Ammonia & nitrate value at the WQMS of Mithi River

Source: *http://www.mpcb.gov.in/envtdata/envtwater.php*

Water quality index

As clearly seen in **Figure No. 2-37** the WQI of Mithi River, ranged between 38 to 50, indicating 'Bad' water quality.



Color code	Category of National Sanitation Foundation Water Quality Index	Range
	Good to Excellent	63-100
	Moderately good to good	50-63
	Bad to Moderately good	38-50
	Very bad to Bad	38 & less

Figure No. 2-37: WQI of Mithi River

Source: MPCB

Overall water quality of Mithi River

The water quality of Mithi River meets the MPCB water quality standards of A-II for best designated usage, except the DO, BOD and ammonia for past 5 years. The possible reason for the exceedance may be due to discharge of untreated waste from industries and since the river passes through the slum areas, domestic discharge could also account for such water quality. Further, for the year 2012-13 the WQI was calculated which indicated that the water quality of the river was within the range of 38-50. Therefore, as per CPCB's description it falls in the 'Bad to moderately good' water quality category.

Mithi River meets the MPCB water quality standards of A-II for best designated usage, except the BOD, DO & ammonia for the past 5 years. The possible reason for the exceedance may be due to untreated waste discharge from industrial area and domestic discharge from the nearby slum area.

Conclusion and recommendations

WQMS at Mithi River showed a very low WQI i.e. 40.1. Further, there is only 1 WQMS on the entire stretch of the river (17.78 km). Drawing inferences from a single sampling point is not justifiable. Hence it is recommended to have more WQM stations on the entire course of the river so as to precisely assess the water quality of the river. The river being a natural drainage channel which carry excess water during monsoon, it becomes utmost important to maintain and monitor it. Thus the following recommendations are given.

Sr. No	River	Water application/significance	Critical observations	Specific recommendations
1	Mithi	Washing of vessels, animals & oily drums.	There is illegal reclamation along the bank of the river. Thus making the water quality of the river very bad due to discharge of untreated sewage; solid waste and debris dumping. Also there is only 1 WQMS on the river.	1. The repair, rehabilitation and renovation of the river should be done immediately. 2. Periodical cleaning of the river to ensure its carrying capacity is maintained. 3. Given the significance of the river as buffer zone, it is recommended to introduce more WQMS to cover the entire stretch of the river. 4. Monthly monitoring of the entire course of the river (both upstream & downstream region) and recording data for all the parameters as per the standards.

2.4.1.8 Mahul River

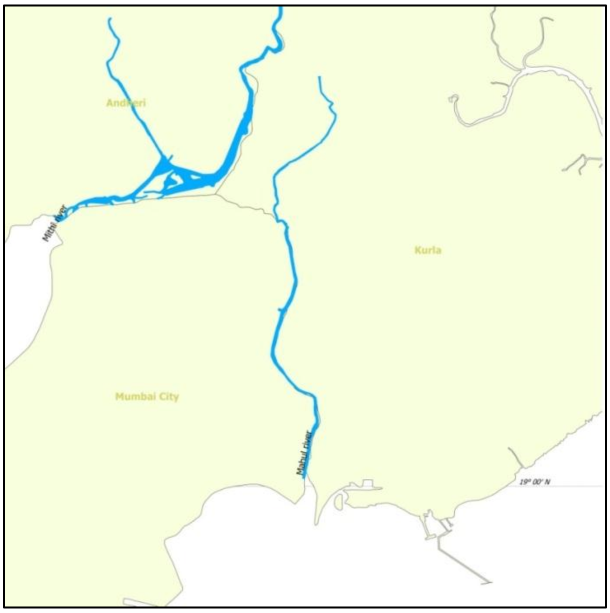
General information[42]

Picture No. 2-7: Mahul River

Source: http://mumbai-eyed.blogspot.in/2007_06_01_archive.html

Mahul River originates at confluence of Nehru Nagar Nala and Pratiksha Nagar Nala. Flows in southern direction amidst mangroves and meets Thane Creek.

About 36.35% of the land is under the mangroves. This attracts large number of migratory birds and is also roosting site for various water birds. About 22% of the land is laying vacant and 12% land is under industrial sector. This is followed by transportation /roads which are about 9.37% and about 5% is used for salt production. The river/creek edge is accessible in most part except wherever industrial estates abut the river.[43]



Map No. 2-16: Spatial representation of Mahul River

Source: MRSAC

Originating at the confluence of Nehru Nagar nala and Pratiksha Nagar nala, the 5.74 km river is highly polluted and serves as a drain. Further, there are no WQMS on the river.

[42] http://www.mmreis.org.in/uploadeddocuments/1203141429_Stage%203%20Report.pdf

[43] Inventory of environmental features, Greater Mumbai, Prepared by HCP Design and Project Management Pvt. Ltd.

Table No. 2-23: General information of Mahul River

Mahul River	
Origin	Confluence of Nehru Nagar Nala and Pratiksha Nagar Nala
Length of the river from origin	5.74 km
Water application	Water appears very polluted and black throughout the stretch. Hence not used.
Dam/reservoir on the river	-

Source: Inventory of environmental features, Greater Mumbai, Prepared by HCP Design and Project Management Pvt. Ltd.

Water quality information and assessment

There is no water quality monitoring station on Mahul River.

Conclusion and recommendations

Sr. No	River	Water application/ significance	Critical observations	Specific recommendations
1	**Mahul**	Water appears very polluted and black in color throughout the stretch. Hence not used.	The river serves as a drain. Also there is no WQMS on the river.	1. The river should be cleaned regularly. 2. The LULC along the river should be studied and relocated if required. 3. Based on the resource potential, the river should be monitored as per the applicable standards by installing WQMS.

2.4.1.9 Panvel / Kalundre River

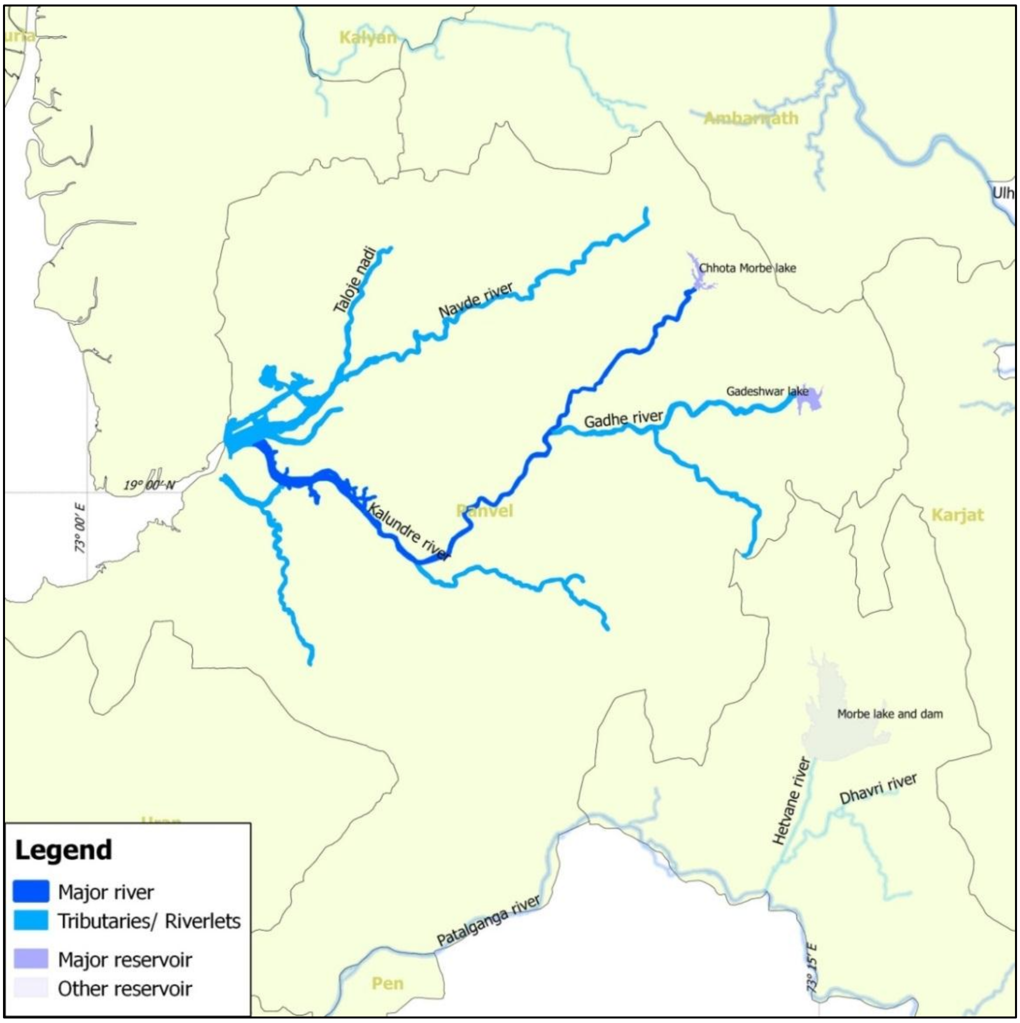
General information

Kalundre River is a westbound river flowing through Panvel taluka in Raigad district of Maharashtra.

Originates from Chotta Morbe Dam in North of Panvel. Flows in south-west direction amidst mangroves and meets Thane Creek[44].

Picture No. 2-8: Kalundre River

Source*: http://mw2.google.com/mw-panoramio/photos/medium/43720250.jpg*



Map No. 2-17: Spatial representation of Kalundre river

Source: MRSAC

[44] Google Earth

Table No. 2-24: General information of Kalundre River

Kalundre River	
Origin	Chotta Morbe Dam in North of Panvel
Length of the river from origin	30 km
Tributaries	Taloje, Navde, Lendi and Gadhe
Water application	None.
Dam/reservoir on the river	Chotta Morbe Dam

Source: MRSAC and google earth

Water quality information and assessment

There is no water quality monitoring station on Kalundre River.

Conclusion and recommendations

On Kalundre River, no monitoring of water quality parameters is done. Hence, regular cleaning and monitoring is recommended.

Sr. No.	Rivers	Tributary	Water application/ significance	Critical observations	Specific Recommendations
1	**Panvel**		360 MLD of water is supplied to NMMC from Morbe dam	1. There was very little information available about the river. 2. There were no MPCB WQMS on the river. However, the municipal corporation monitors the major water bodies in their area.	1. A comprehensive study should be carried out. 2. Given the significance of the river, it is recommended to introduce WQMS to cover the entire stretch of the river (both upstream and down stream).
2		Taloje	No data		
3		Navde			
4		Lendi			
5		Gadhe			

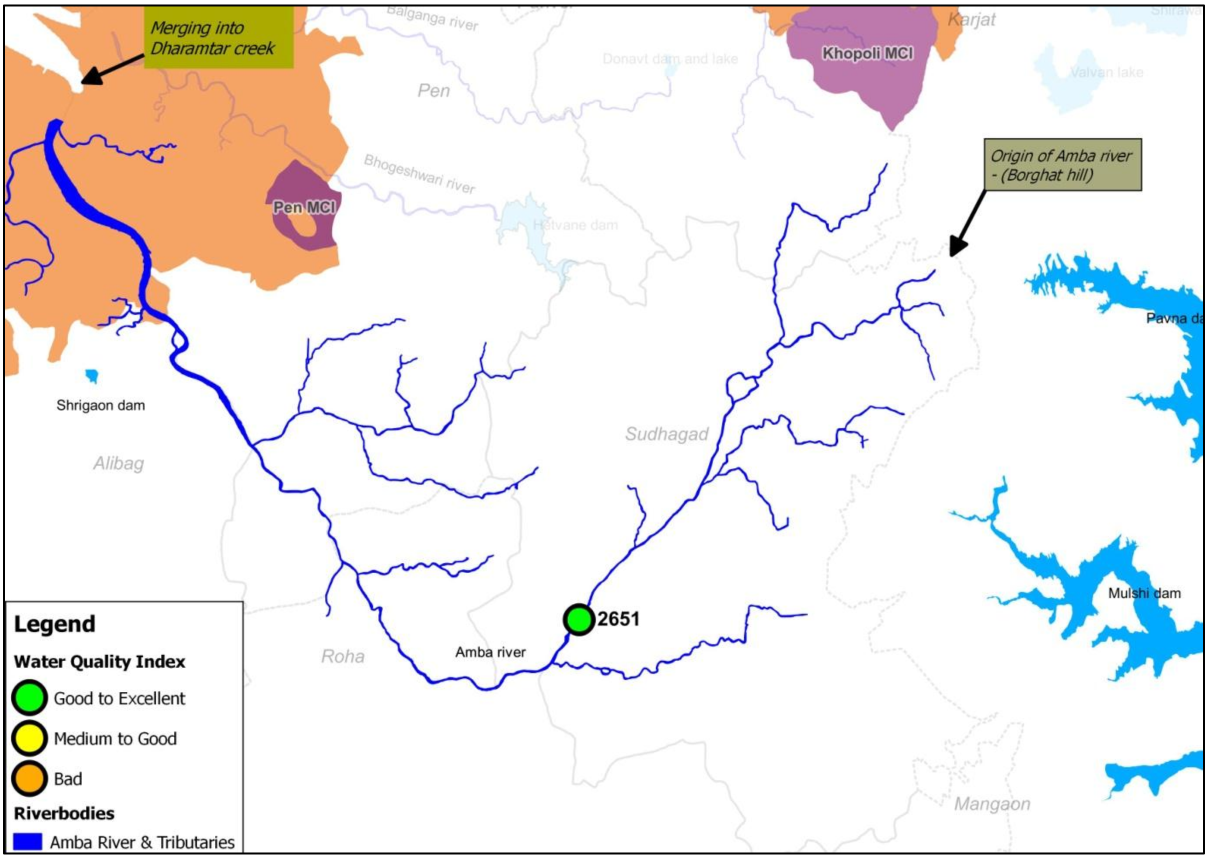
2.4.1.10 Amba River

General information

Amba River originates in the Borghat hill of the Sahyadri ranges near Khopoli-khandala road (554 mts above sea level) and flows in the South direction and then turns further into the North west direction till it joins the Arabian Sea in Dharmatar creek near village Revas[45].

Picture No. 2-9: Amba River

Source: http://wikimapia.org/1032311/Old-Bridge-On-Amba-River



Map No. 2-18: Spatial representation of Amba River

Source: MPCB, MRSAC

45 http://india-wris.nrsc.gov.in/wrpinfo/index.php?title=Amba

Table No. 2-25: General information of Amba River

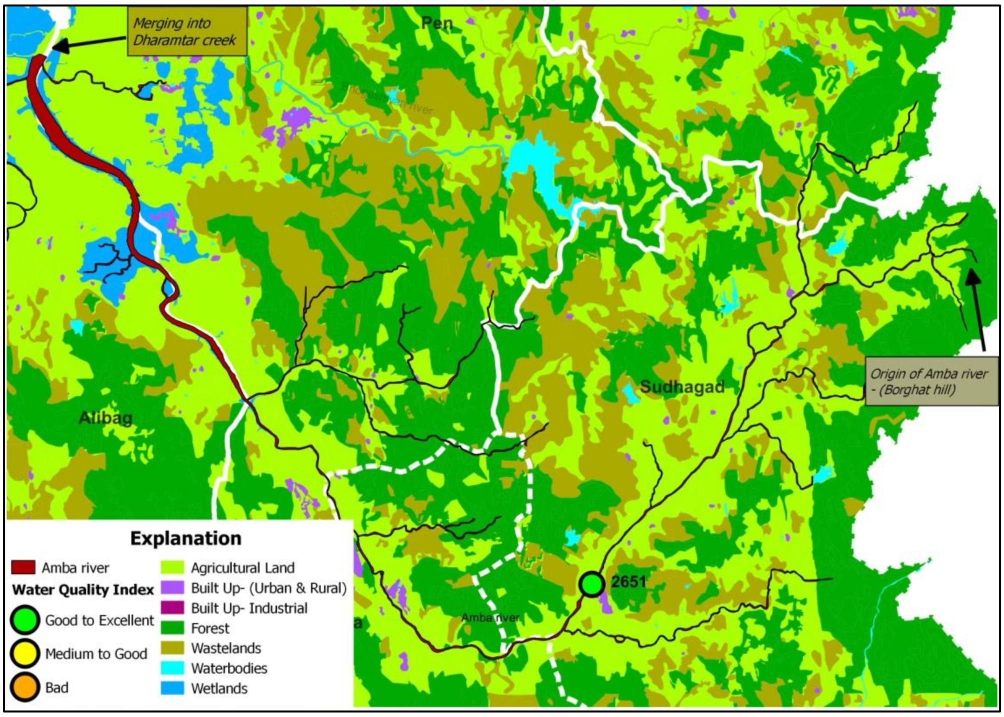
Amba River	
Origin	Borghat hill of the Sahyadri ranges near Khopoli-khandala road
Length of the river from origin	76 km
Catchment area (sq.km)	420
Gross storage capacity of the reservoir	403 MCM
Water application	Drinking & swimming by tourists
Dam/reservoir on the river	-

The third longest river (76 km) of the region, originates in the Borghat hill of the Sahyadri ranges. 168 MLD of water is supplied to rest of the MMR region. Even though, there is only one WQMS on the entire river course.

Source: http://www.kgbo-cwc.ap.nic.in/About%20Basins/West%20Flowing%20Rivers%20Basin%20Write%20-2008-09.pdf

Water quality information and assessment

On Amba river there is only one WQMS at the upstream region of the river which was initiated under the SWMP progrmme. The major land use pattern around the WQMS is agricultural land and a small patch of built up area.



Map No. 2-19: Spatial representation of WQMS on Amba River

Source: MPCB, MRSAC

Parameter 1: pH

Permissible MPCB standard:
Between 6 and 8.5

Observation: It was observed that the pH was within the permissible limit of MPCB as seen in **Figure No. 2-38**. Thus, indicating a good water quality for aquatic life.

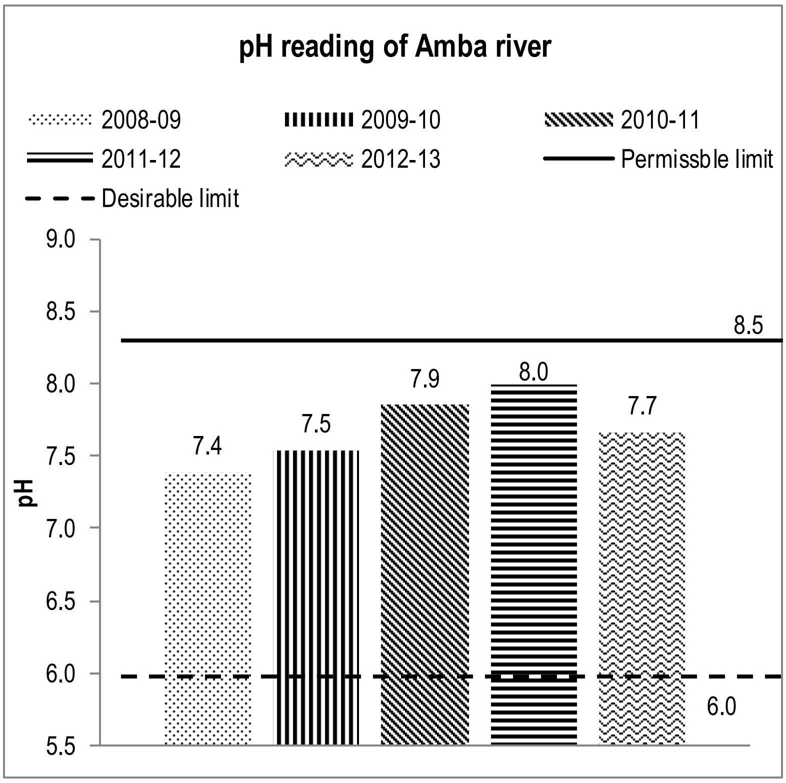


Figure No. 2-38: pH value at the WQMS of Amba River

Source: *http://www.mpcb.gov.in/envtdata/envtwater.php*

Parameter 2: Dissolved Oxygen (DO)

Desirable MPCB standard:
4 mg/l (minimum desirable standard)

Observation: It was observed that the
DO was above the minimum desirable
MPCB standards as seen in Figure No. 2-39.
Thus, indicating good water quality for
aquatic life.

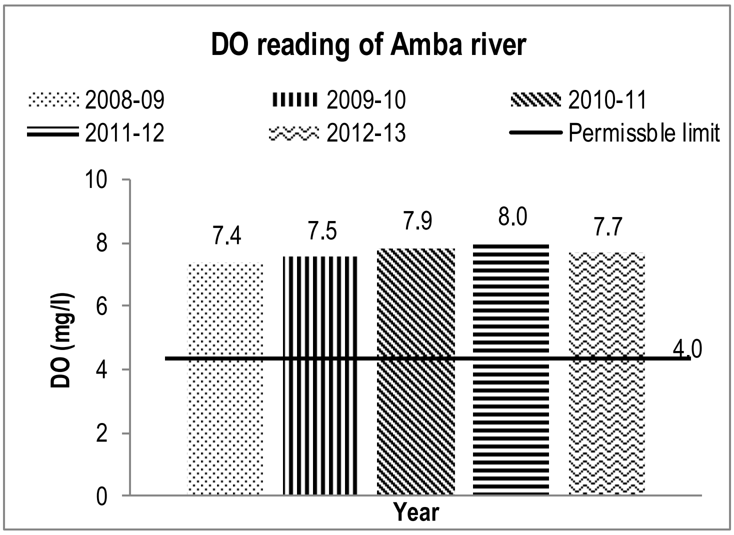
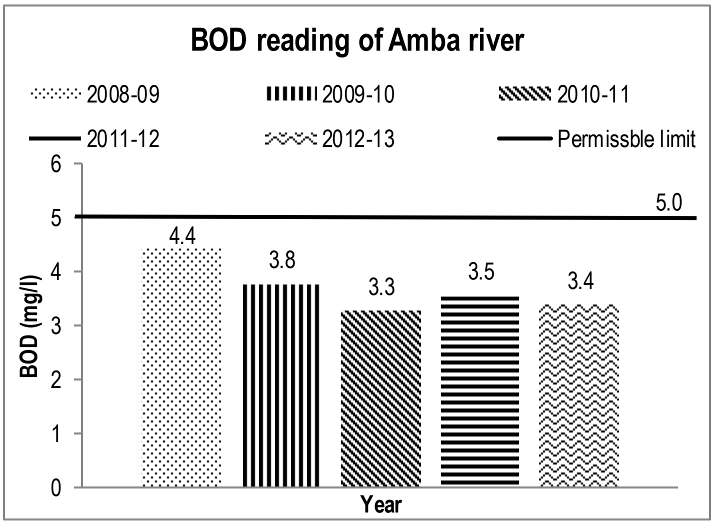


Figure No. 2-39: DO value at the WQMS of Amba River

Source: http://www.mpcb.gov.in/envtdata/envtwater.php

Parameter 3: Biochemical Oxygen Demand (BOD)



Permissible MPCB standard: 5 mg/l

Observation: It was observed that the BOD at the WQMS met the MPCB standards as seen in Figure No. 2-40. Thus, indicating acceptable content of organic matter in the river.

Figure No. 2-40: BOD value at the WQMS of Amba River

Parameter 4 & 5: Fecal Coliform (FC) and Total Coliform (TC)

Permissible MPCB standard: 5000/100 ml (MPN)

Observation: It was observed that fecal coliform and total coliform values were within the permissible MPCB standards as seen in Figure No. 2-41. Thus, indicating allowable content of human or animal waste.

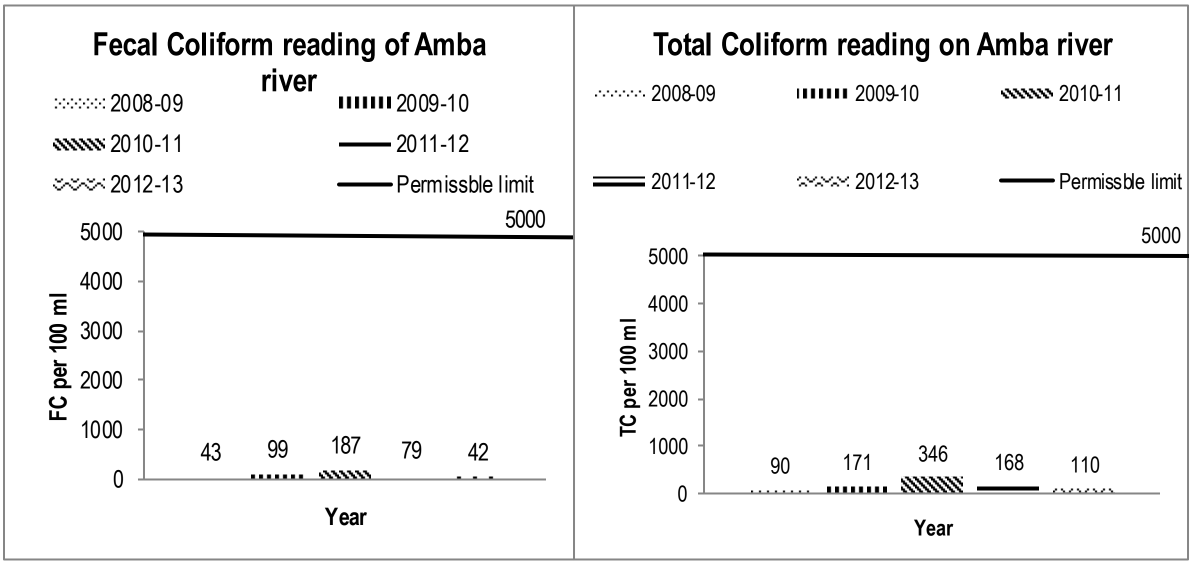


Figure No. 2-41: FC & TC value at the WQMS of Amba River

Source: *http://www.mpcb.gov.in/envtdata/envtwater.php*

Parameter 6 & 7: Ammonia and Nitrate

Permissible MPCB standard: Ammonia: - 1.5 mg/l Nitrate: - 45 mg/l

Observation: It was observed that ammonia and nitrate values at the water quality monitoring station was within the permissible MPCB standards as seen in Figure No. 2-42. Thus, indicating good water quality for aquatic life.

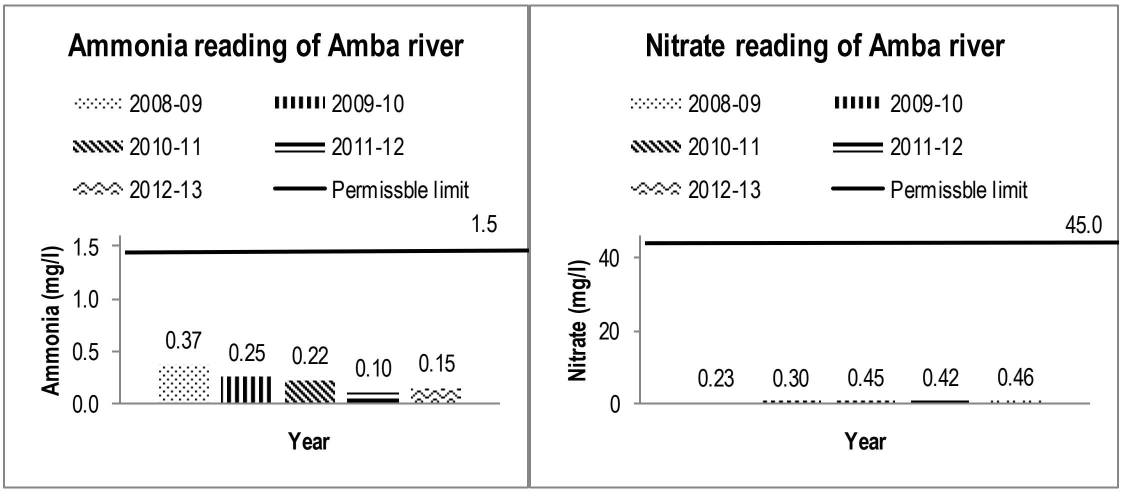
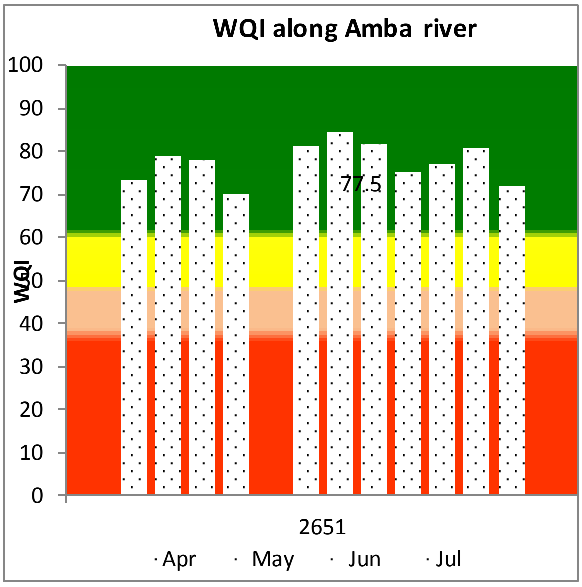


Figure No. 2-42: Ammonia & nitrate value at the WQMS of Amba River

Source: *http://www.mpcb.gov.in/envtdata/envtwater.php*

Water quality index

As seen in **Figure No. 2-43**, the WQI of Amba River, ranged from 63 to 100, indicating 'Good to Excellent' water quality.



Color code	Category of National Sanitation Foundation Water Quality Index	Range
	Good to Excellent	63-100
	Moderately good to good	50-63
	Bad to Moderately good	38-50
	Very bad to Bad	38 & less

Figure No. 2-43: WQI of Amba River.

Source: MPCB

Amba River meets the MPCB water quality standards of A-II for best designated usage. However, there is only single point sampling done on the entire river stretch of 76km. Hence the interpretations drawn may not be appropriate.

Overall water quality of Amba River

The water quality of Amba River meets the MPCB water quality standards of A-II for best designated usage and the WQI indicates 'Good to Excellent' water quality.

Conclusion and recommendations

WQMS at Amba River showed 77.5 WQI indicating its quality 'Good to Excellent' as per CPCB. However, only one station monitors the quality for a 76km long river. Hence it is recommended having more water quality monitoring stations on the entire course of the river so as to precisely assess the water quality of the river. A single sampling point gives an incorrect conclusion. The river also supplies 168 MLD of water to MMR, hence it becomes utmost important to maintain and monitor the water quality regularly at various critical locations.

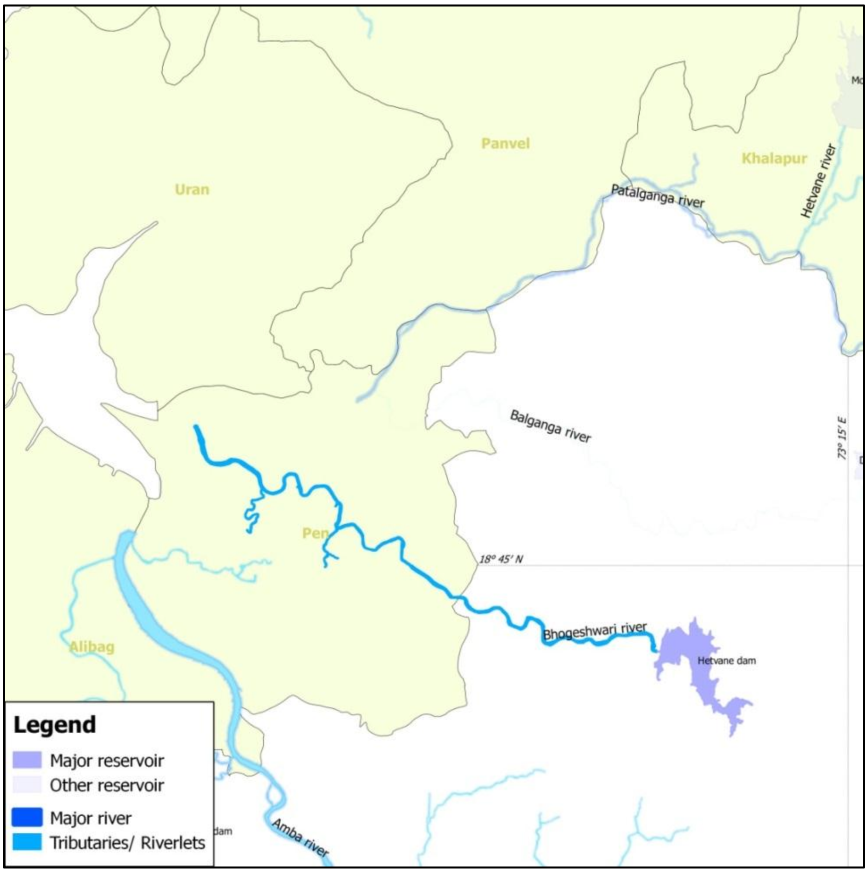
2.4.1.11 Bhogeshwari River

General information[46]

Bhogeshwari River rises in the Western Ghats near village Bhogeshwari, District- Raighad at an altitude of about 228.6 m above the sea level.

Flows in the west direction through the Taluka- Pen and merges in the Dharmtar creek near village Antora.

Picture No. 2-10: Bhogeshwari River



Map No. 2-20: Spatial representation of Bhogeshwari River

Source: MPCB, MRSAC

Bhogeshwari River flowing in the west direction through the Taluka- Pen, merges in the Dharmtar creek. The river is 40 km long; however there are no WQMS on the river.

46 http://india-wris.nrsc.gov.in/wrpinfo/index.php?title=Bhogeshwari

Table No. 2-26: General information of Bhogeshwari River

Bhogeshwari River	
Origin	Western ghats near village Bhogeshwari
Length of the river from origin	40 km
Catchment area (sq.km)	125
Water application	None.
Dam/reservoir on the river	Hetvane Dam

Source:[*http://www.kgbocwc.ap.nic.in/About%20Basins/West%20Flowing%20Rivers%20Basin%20Write%20-2008-09.pdf*](http://www.kgbocwc.ap.nic.in/About%20Basins/West%20Flowing%20Rivers%20Basin%20Write%20-2008-09.pdf)

Water quality information and assessment

There is no water quality monitoring station on Bhogeshwari River.

Conclusion and recommendations

The quantitative and qualitative information about Bhogeshwari River is not available. Hence it is recommended to carry out a comprehensive study addressing these aspects.

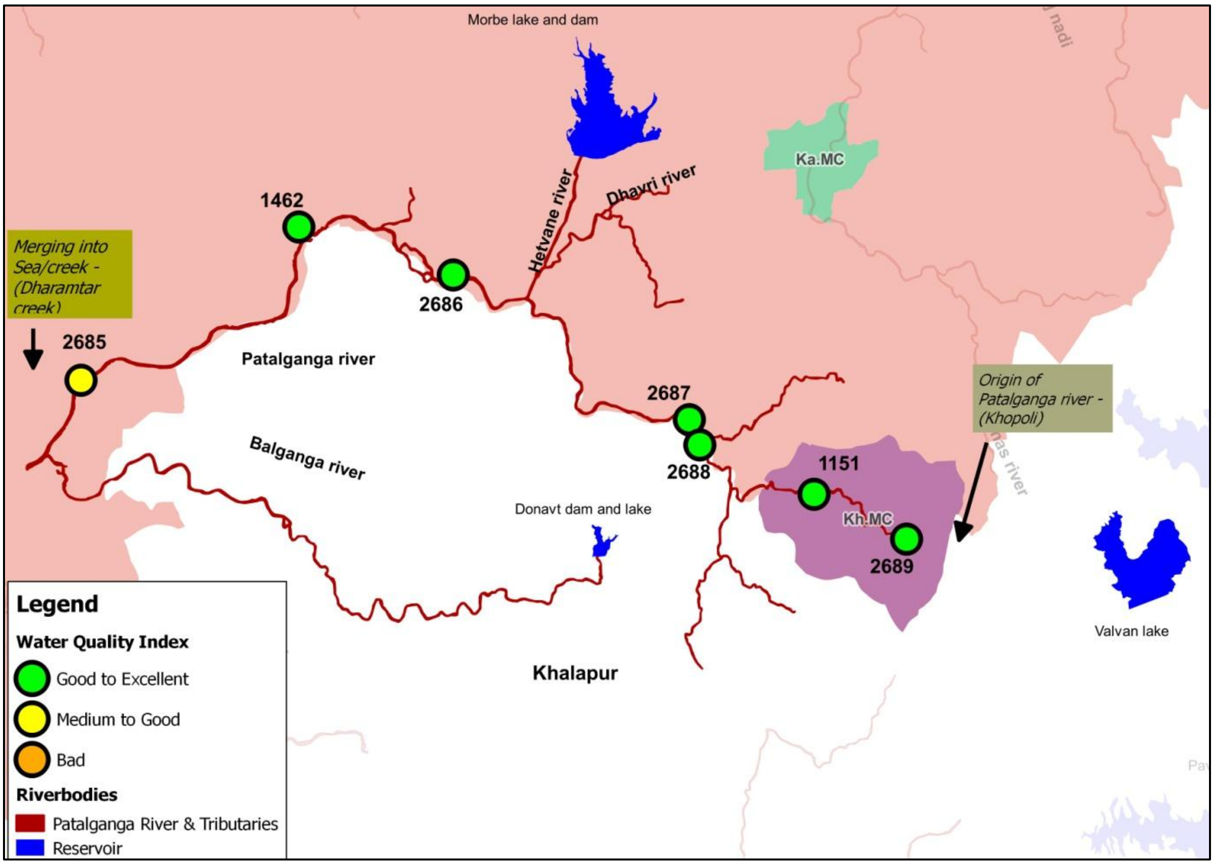
2.4.1.12 Patalganga River

General information

Patalganga River rises in the steep western scarps of the Matheran uplands, where it branches off from the main ridge near Khopoli and maintains a general westward flow till it joins the Dharamtar Creek with a wide estuary.

Picture No. 2-11: Patalganga River

Source*:* [*http://blessingsonthenet.com/travel-india/destination/id/264/patalganga*](http://blessingsonthenet.com/travel-india/destination/id/264/patalganga)



Map No. 2-21: Spatial representation of Patalganga River

Source: MPCB, MRSAC

Table No. 2-27: General information of Patalganga River

Patalganga river	
Origin	Western scarps of the Matheran uplands
Length of the river from origin	41 km
Catchment area (sq.km)	328
Gross storage capacity of the reservoir	712 MCM
Water application	Drinking
Dam/reservoir on the river	Morbe dam is being built over the Dhawri tributary of Patalganga river.

Source: http://en.wikipedia.org/wiki/Patalganga_River

The 41 km long Patalganga River rises in the steep western scarps of the Matheran uplands and maintains a westward flow until it joins Dharamtar creek. The river water (510 MLD) is supplied to the region and there are 7 WQMS on the river.

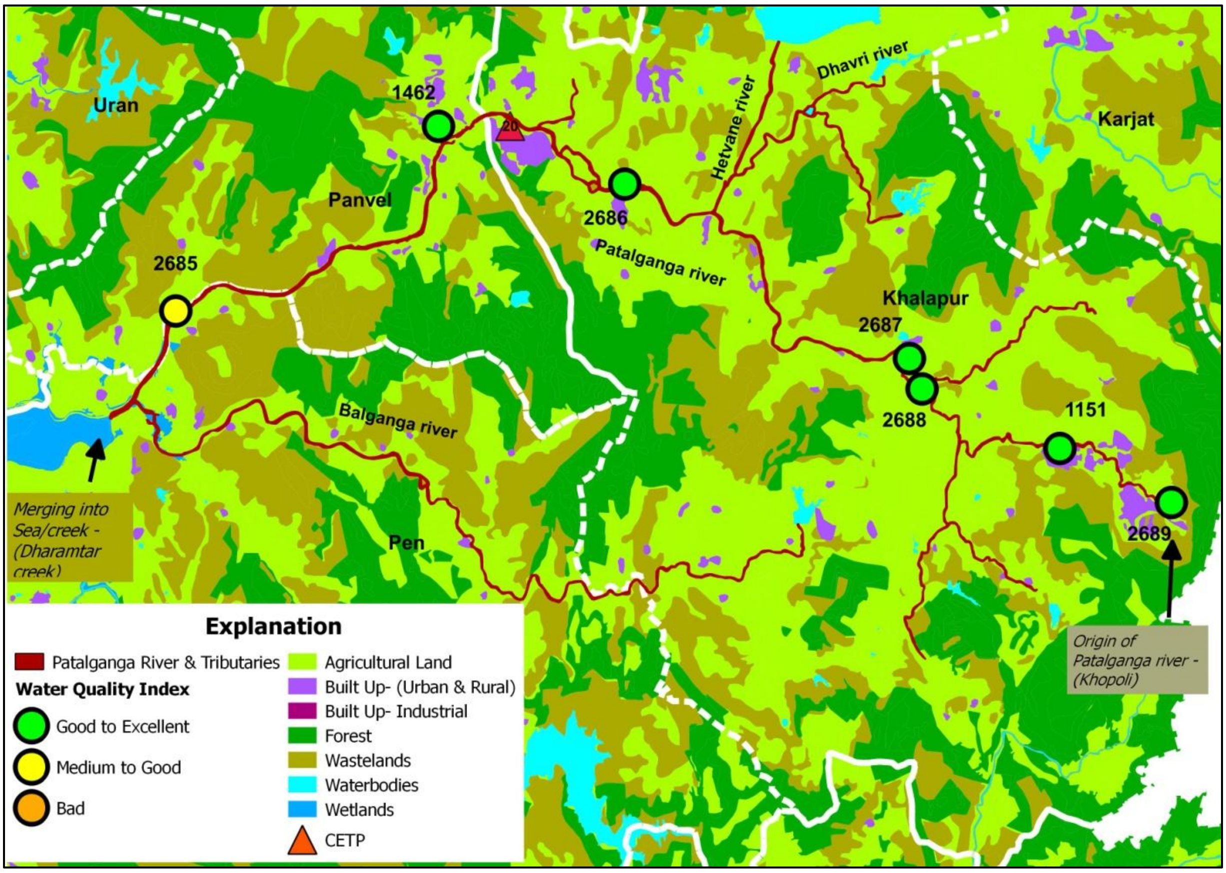
Water quality information and assessment

On Patalganga River, there are 7 WQMS as tabulated in Table No. 2-28. The WQM stations are well distributed along the course of the river as seen in Map No. 2-22.

Table No. 2-28: WQMS details on Patalganga River

Station code/program	Location	River/Tributary
1151/NWMP	Patalganga River at Shilphata Bridge	Patalganga river
2685/SWMP	Patalganga River at D/s. of Kharpada Bridge	Patalganga river
2686/SWMP	Patalganga River at Vyal pump house	Patalganga river
2687/SWMP	Patalganga River at Khalapur pumping house	Patalganga river
2688/SWMP	Patalganga River at Savroli Bridge	Patalganga river
2689/SWMP	Patalganga River at Gagangiri Maharaj Temple	Patalganga river
1462/NWMP	Patalganga near intake of MIDC water works (Turade w/w)	Patalganga river

Source: *http://mpcb.gov.in/envtdata/envtwater.php*



Map No. 2-22: Land use pattern around WQMS on Patalganaga River

Source: MPCB, MRSAC

The WQMS nos. 2689 and 1151 are located in the Khopoli Municipal Council area, whereas WQMS nos. 2688, 2687 and 2686 are located in the Khalapur area. A mixed land use pattern of built up area, agriculture and wasteland is observed around these WQM stations. At the upstream region of the WQMS no. 1462, PRIA CETP is located. The effluent treated water quality reports for the year 2011-12, revealed that the BOD and COD (149 and 354 mg/l respectively) exceeded the permissible CPCB standards. The WQMS no. 2685 is located in Panvel area and the immediate land use pattern around the WQMS is agricultural land.

Parameter 1: pH

Permissible MPCB standard: Between 6 and 8.5.

Observation: pH at all the WQMS was between the prescribed standard of MPCB. Thus, indicating good water quality for aquatic life.

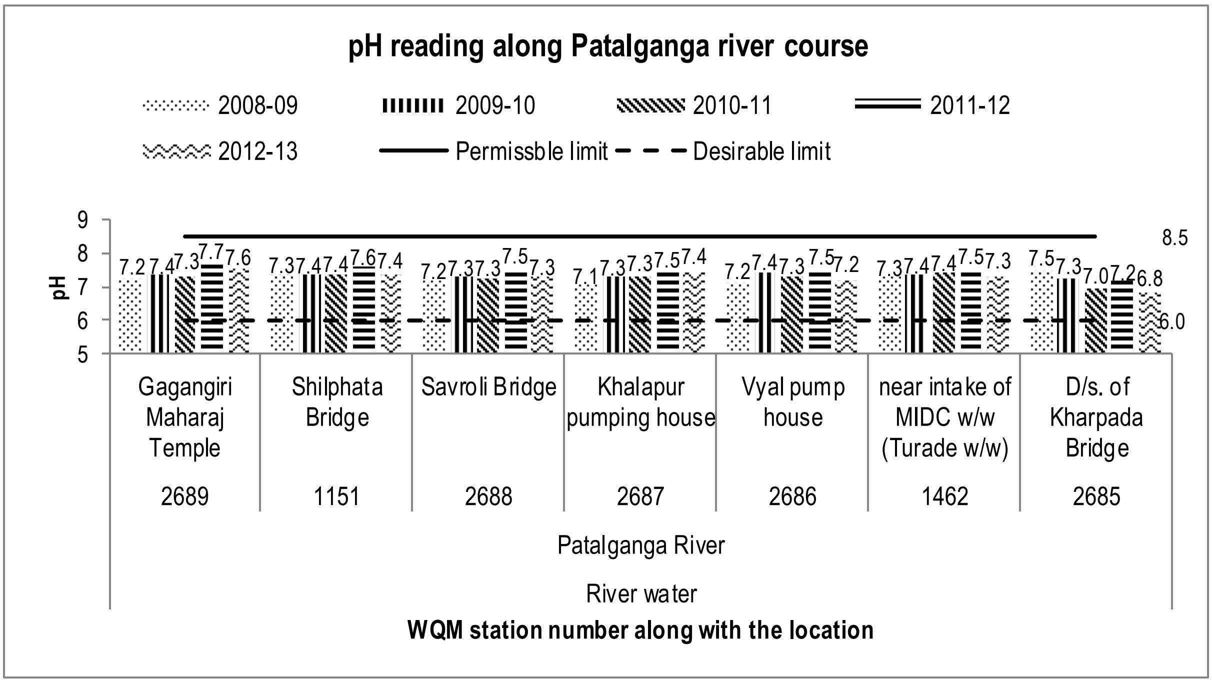


Figure No. 2-44: pH value at the WQMS of Patalganga River

Source: *http://www.mpcb.gov.in/envtdata/envtwater.php*

Parameter 2: Dissolved Oxygen (DO)

Desirable MPCB standard: 4 mg/l (minimum desirable standard)

Observation: - DO at all the WQM stations were above desirable standard of MPCB. Thus, indicating good water quality for aquatic life.

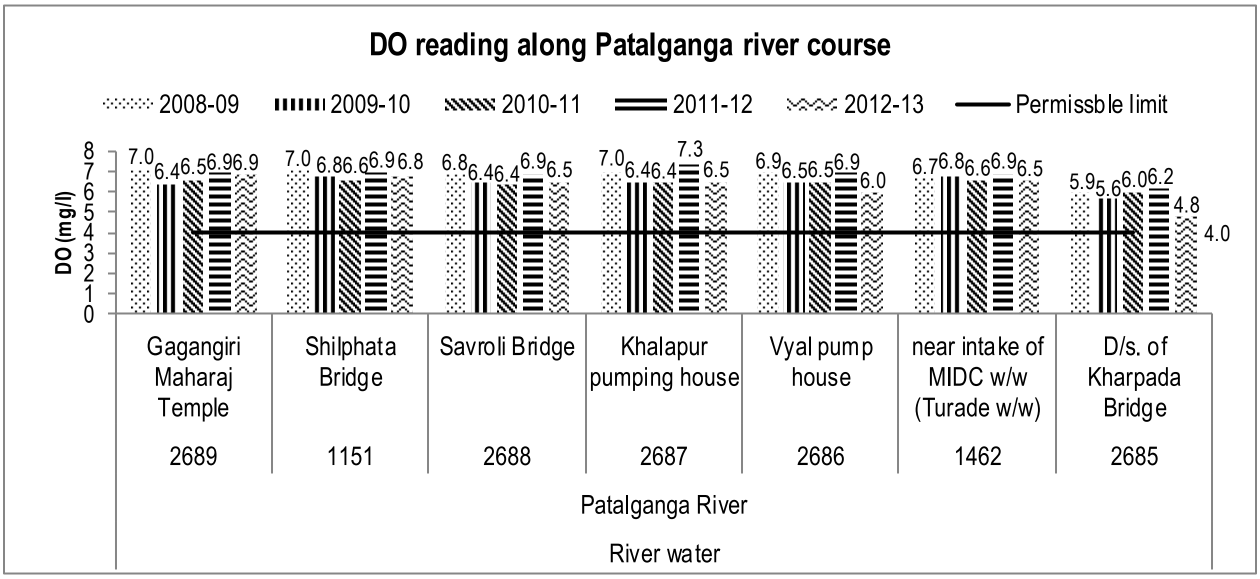


Figure No. 2-45: DO value at the WQMS of Patalganga River

Source: *http://www.mpcb.gov.in/envtdata/envtwater.php*

Parameter 3: Biochemical Oxygen Demand (BOD)

Permissible MPCB standard: 5 mg/l

Observation: BOD values at all the monitoring stations were within the permissible standard of MPCB, except at WQMS nos. 2686 and 2685 for the 2012-13 as seen in Figure No. 2-46.

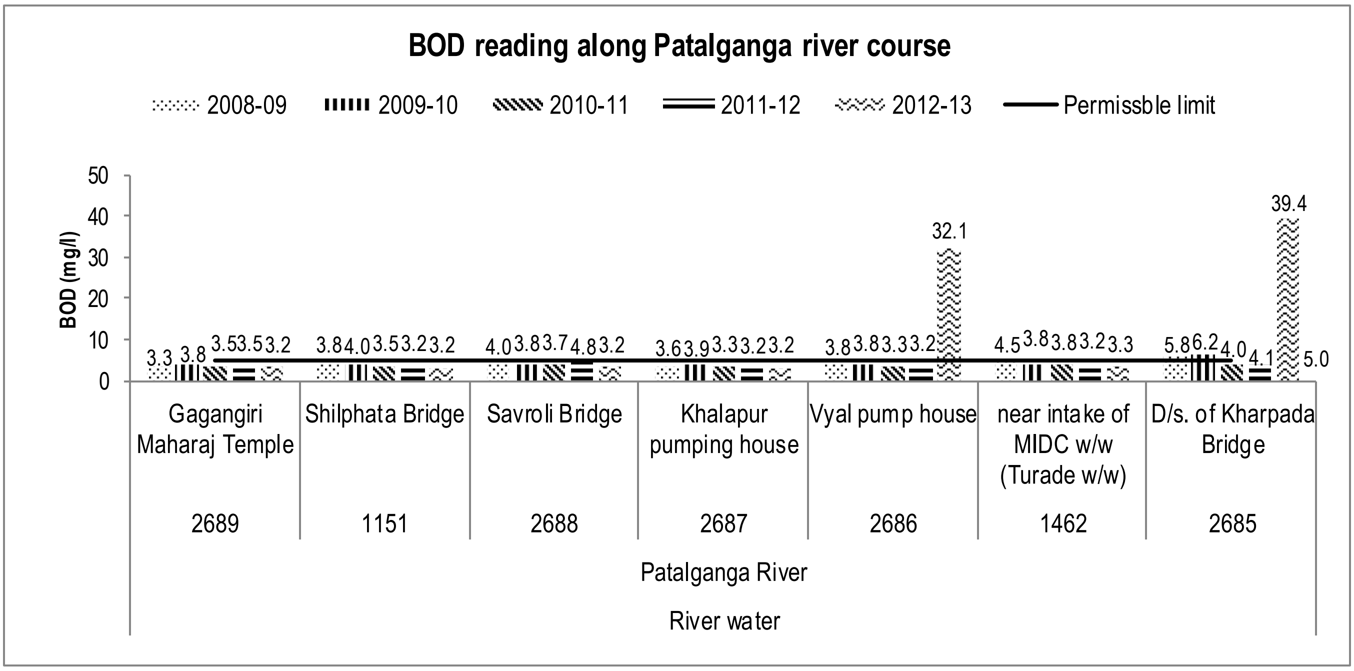


Figure No. 2-46: BOD value at the WQMS of Patalganga river

Source: *http://www.mpcb.gov.in/envtdata/envtwater.php*

At WQMS no. 2686 at Vyal pump house, the BOD values for the year 2008-13 were always below 5 mg/l (in the range of 3.2 to 3.8 mg/l), except in the month of August 2012 were it was 350 mg/l, which is an outlier value as seen in Figure No. 2-47. Hence no further investigation was done.

Further, at WQMS no. 2685 the BOD values observed were 5.8, 6.2 and 39.4 mg/l for the year 2008-09, 2009-10 and 2012-13 respectively, indicating violation of the permissible limits as seen in Figure No. 2-48. The possible reason for the exceedance may be due to higher organic content and effluent discharge from HOC limited, HIL, MIDC patalganga area.

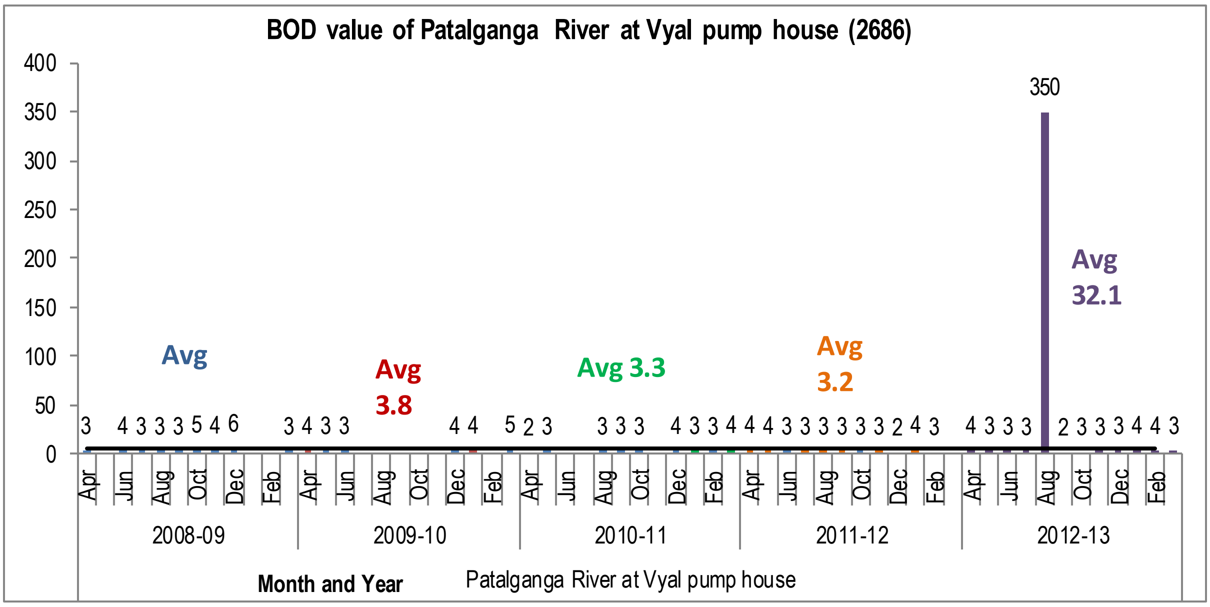


Figure No. 2-47: BOD value of Patalganga river at Vyal pump house (2686)

Source: *http://www.mpcb.gov.in/envtdata/envtwater.php*

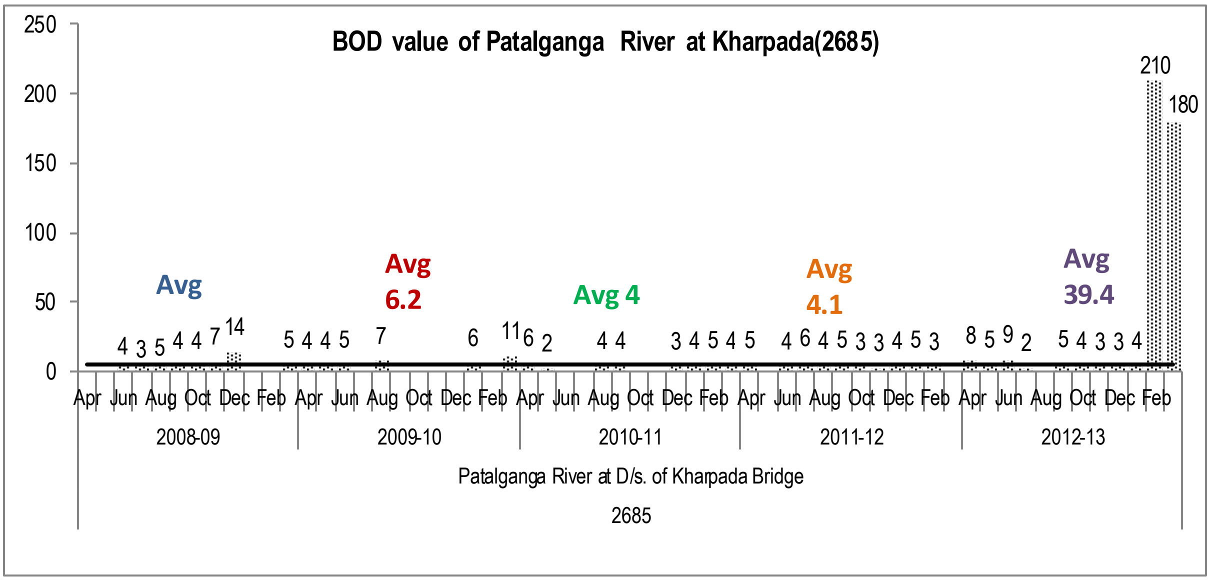


Figure No. 2-48: BOD value of Patalganga river at Kharpada (2685)

Source: *http://www.mpcb.gov.in/envtdata/envtwater.php*

Parameter 4 & 5: Fecal Coliform (FC)

Permissible MPCB standard: 5000/100 ml (MPN)

Observation: FC & TC value at all the WQMS meet the permissible standard of MPCB. Thus, indicating acceptable content of human or animal waste in the water.

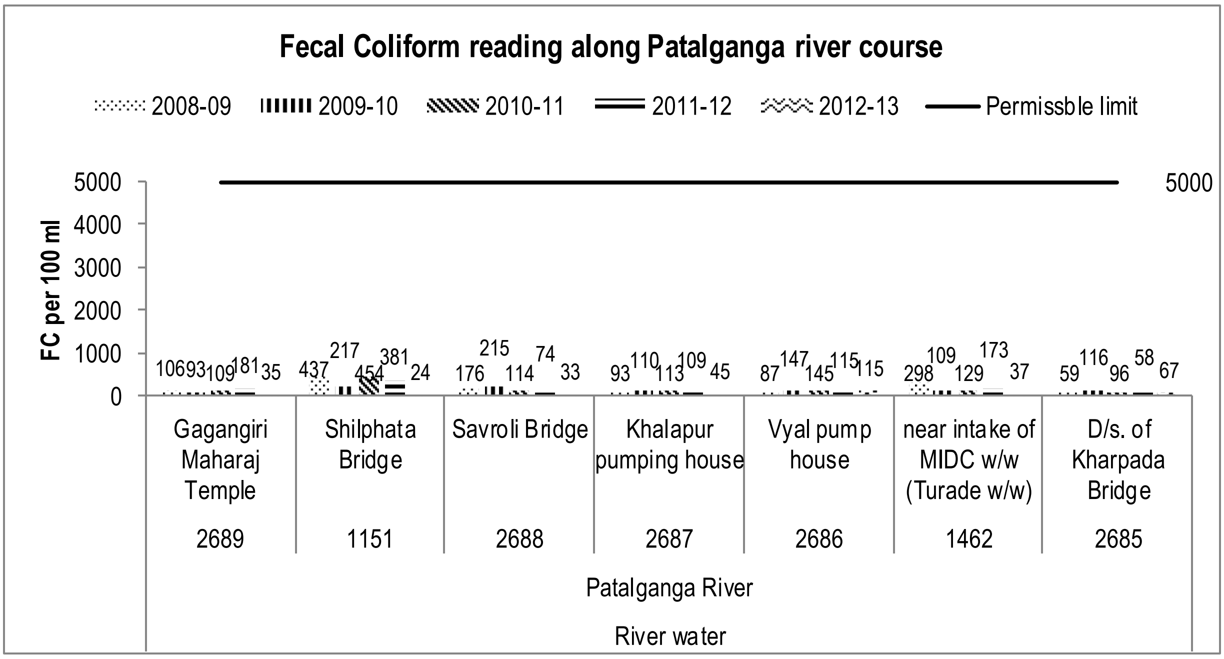


Figure No. 2-49: FC value at the WQMS of Patalganga river

Source: *http://www.mpcb.gov.in/envtdata/envtwater.php*

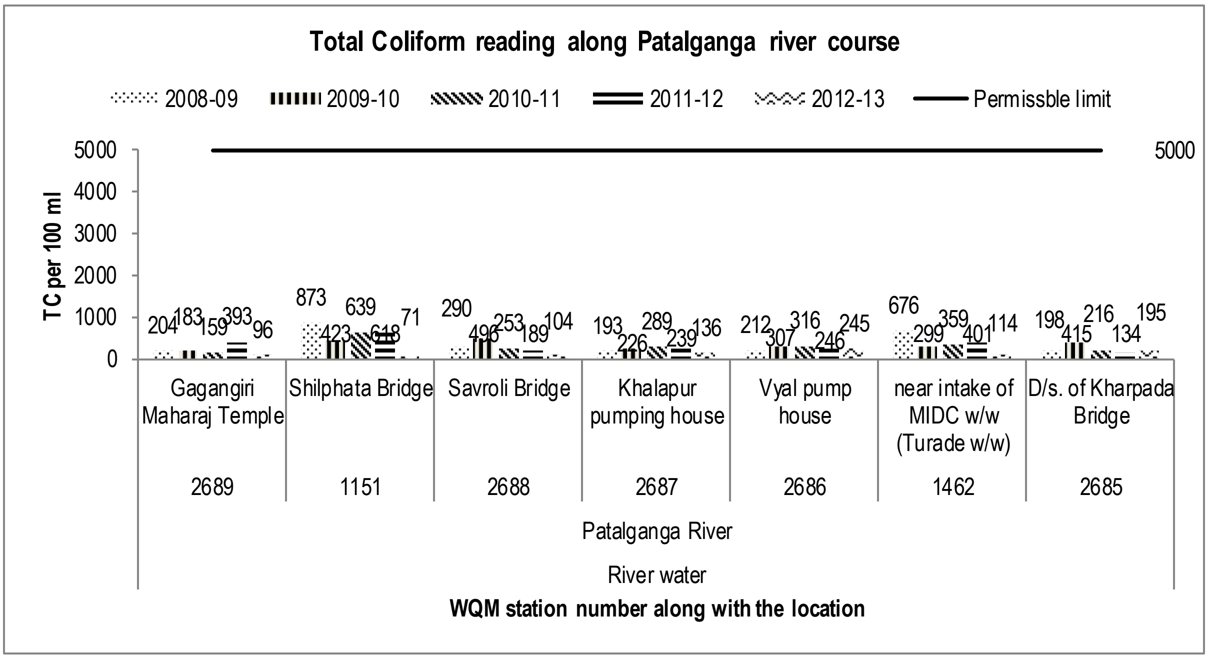


Figure No. 2-50: TC value at the WQMS of Patalganga river

Source: *http://www.mpcb.gov.in/envtdata/envtwater.php*

Parameter 6 & 7: Ammonia and Nitrate

Permissible MPCB standard: Ammonia: - 1.5 mg/l Nitrate: - 45 mg/l

Observation: It was observed that ammonia exceeded the permissible standard at 2685 station for the year 2009-12. The values recorded were 3.53, 3.36 and 4.74 mg/l respectively. The possible reason for the exceedance may be due to agricultural runoff, organic and sewage discharge from the surrounding areas.

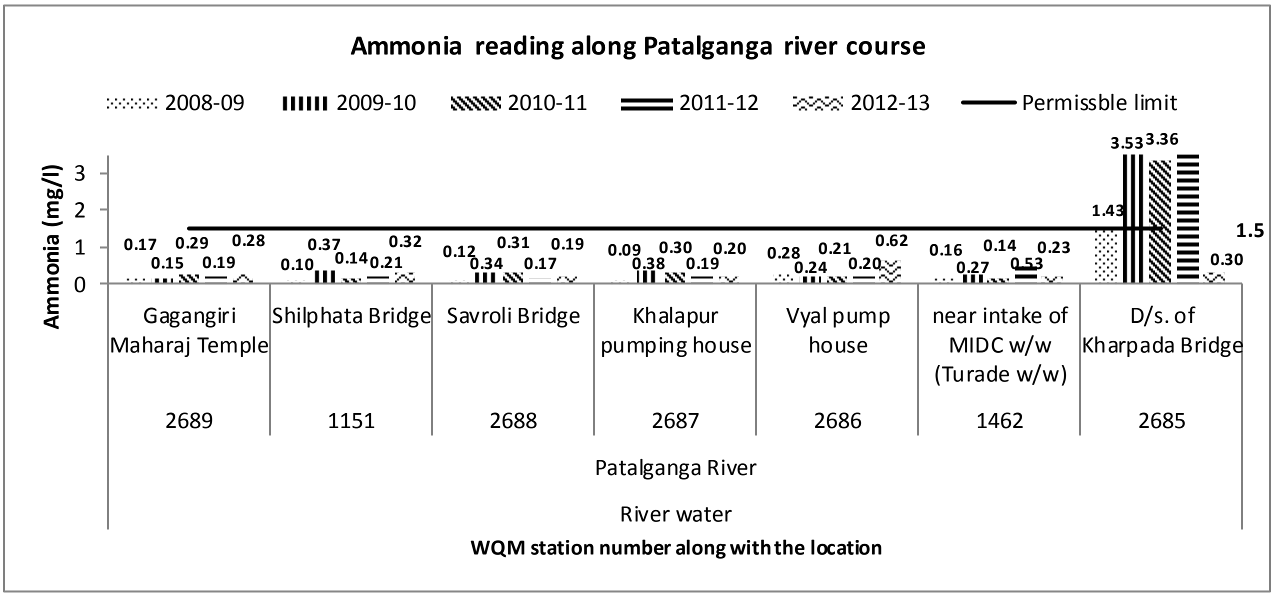


Figure No. 2-51: Ammonia value at the WQMS of Patalganga river

Source: *http://www.mpcb.gov.in/envtdata/envtwater.php*

Further, the nitrate value at all the WQMS were observed to be within the permissible limit of MPCB as seen in Figure No. 2-52.

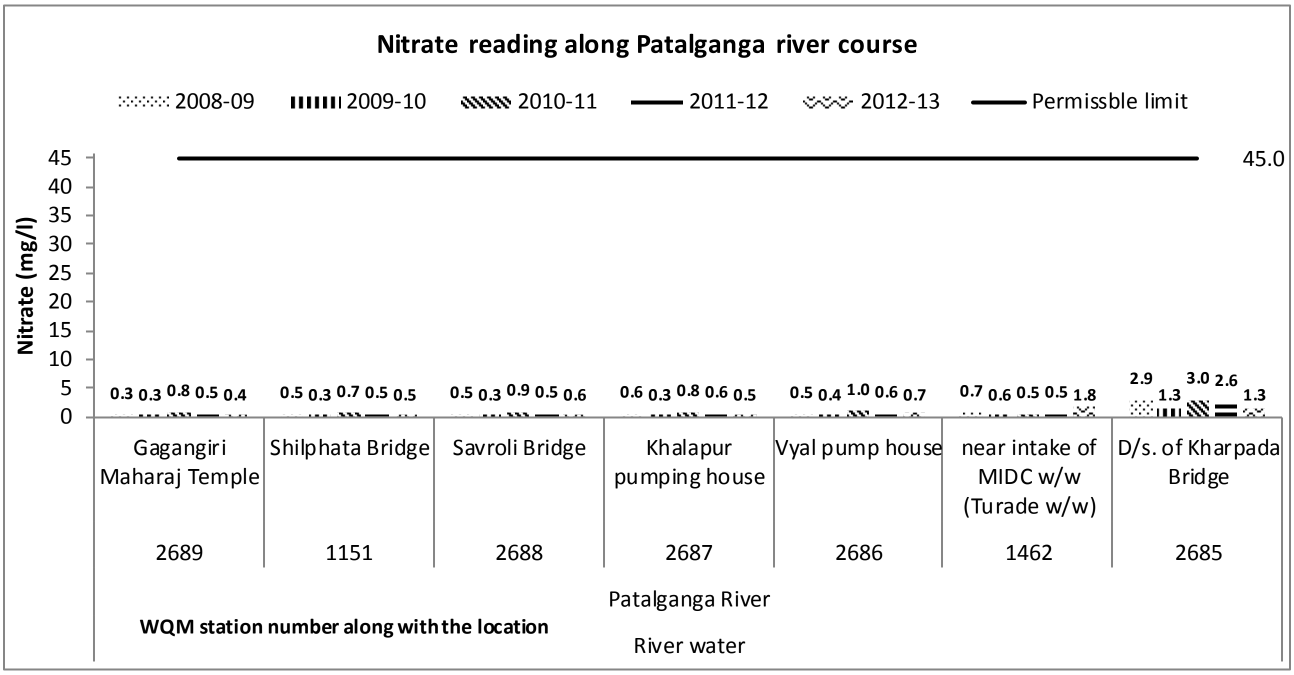


Figure No. 2-52: Nitrate reading at the WQMS of Patalganga river

Source: *http://www.mpcb.gov.in/envtdata/envtwater.php*

Water quality index

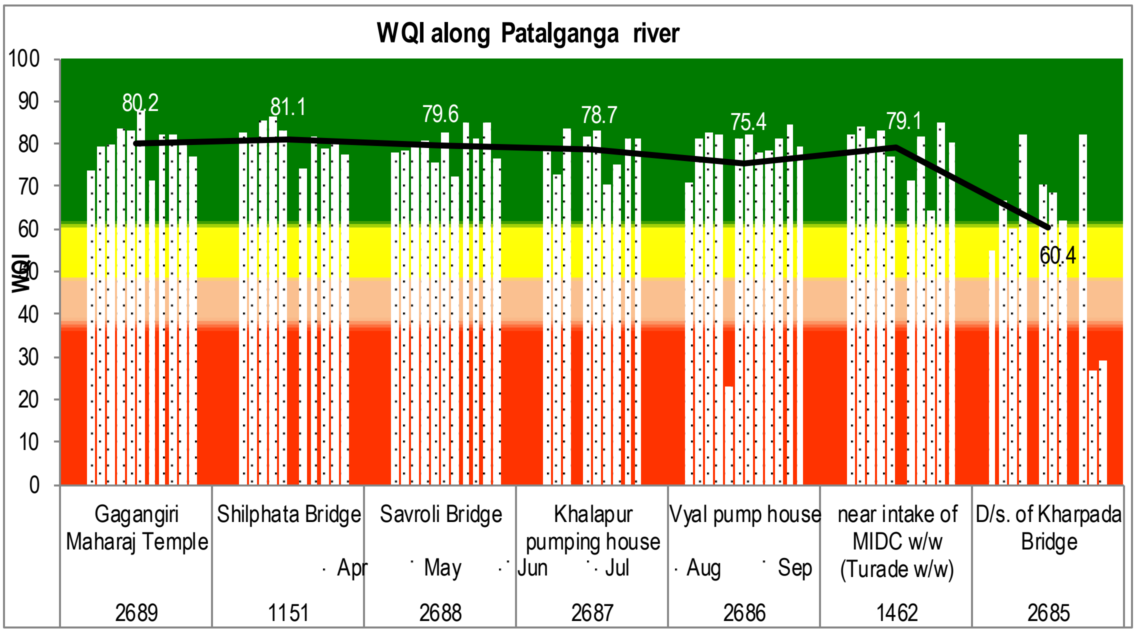


Figure No. 2-53: WQI along Patalganga river

Source: MPCB

Color code	Category of National Sanitation Foundation Water Quality Index	Range
	Good to Excellent	63-100
	Moderately good to good	50-63
	Bad to Moderately good	38-50
	Very bad to Bad	38 & less

As seen in **Figure No. 2-53**, the WQI of Patalganga River, ranged between 63 to 100, indicating 'Good to Excellent' water quality. However at WQMS no. 2685, the water quality was 'Moderately good to good'.

Overall water quality of Patalganga River

The water quality of Patalganga River meets the MPCB water quality standards of A-II for best designated usage, except the BOD value at WQMS no. 2685. The BOD values recorded were 5.8, 6.2 and 39.4 mg/l for the year 2008-09, 2009-10 and 2012-13 respectively. Further, the ammonia value (3.53, 3.36 and 4.74 mg/l for the year 2009-10, 2010-11 and 2011-12 respectively), exceeded the permissible limit of MPCB. The possible reason for the exceedance may be due to domestic discharge from nearby villages & effluent discharge from HOC Ltd, HIL, MIDC patalganga area and so on.

The WQI for the year 2012-13 indicated that the water quality of the river was within the range of 63-100. Therefore, as per CPCB's description it falls in the 'Good to Excellent' water quality category except at station 2685 (downstream of Kharpada bridge) where it was 'Moderately good to good' as seen in Figure No. 2-53.

Patalganga River meets the MPCB water quality standards of A-II for best designated usage, except the BOD value at station 2685 for the year 2012-13 and ammonia for the year 2008-12. The possible reason for the exceedance may be due to domestic discharge from nearby villages & effluent discharge from HOC Ltd, HIL and MIDC patalganga area.

Conclusion and recommendations

WQMS at Patalganga River showed good water quality as per CPCB. The tributaries of the river namely Dhavari and Hetwane are not at all monitored for its quality parameter. Hence it is recommended to have more water quality monitoring stations on the entire course of the river including its tributaries so as to assess the overall water quality of the river. The river supplies 510 MLD of water to MMR, hence it becomes utmost important to maintain and monitor the water quality regularly.

2.4.1.13 Balganga River

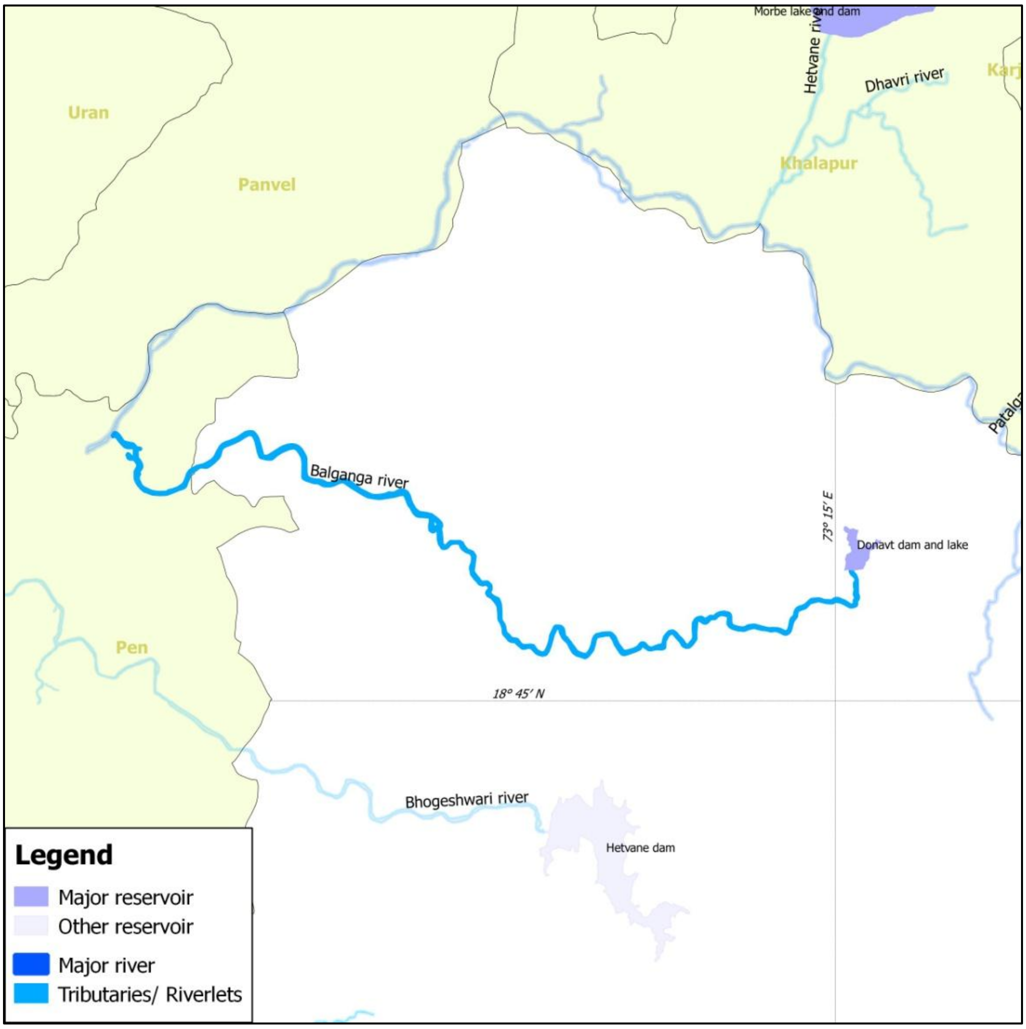
General information

Balganga River is a tributary stream of the Patalganga.

Flows almost parallel to Patalganga, though in a hillier region, and joins the Patalganga only in the Dharamtar creek.

Picture No. 2-12: Balganga river

Source: http://endowedwithmetis.wordpress.com/2010/10/25/mumbai-mondays-1-bal-ganga-river/



Map No. 2-23: Spatial representation of Balganga river

Source: MRSAC

Table No. 2-29: General information of Balganga River

Balganga River	
Length of the river from origin	27 km
Water application	Drinking
Dam/reservoir on the river	Balganga dam under construction & is expected to be complete by 2014. Once completed shall supply 350 MLD to Navi Mumbai.

Source: MRSAC and Google earth

The 27 km long river is a tributary stream of Patalganga. Balganga dam is proposed to be completed by 2014; on completion it shall supply 350 MLD to Navi Mumbai. At present there are no WQMS on the river.

Water quality information and assessment

There is no water quality monitoring station on Balganga River.

Conclusion and recommendations

Balganga River is identified as a prospective water resource for Navi Mumbai. Approximately 350 MLD is the potential yield. Given that there are no water quality monitoring stations on the river, it is strongly recommended to install WQM stations and monitor the water quality regularly.

2.4.1.14 Summary of recommendations for rivers in MMR

General recommendations applicable to all the rivers in MMR are enlisted and elaborated below.

Recommendation 1: Detailed assessment of following parameters for all the rivers in MMR should be carried out on urgent basis.

1. **Stakeholder mapping:** The local communities like fishing & agrarian, industries and urban areas demand water for their various needs. To strike a balance between demand and supply and also equitable distribution, a detailed stakeholder mapping should be carried out.

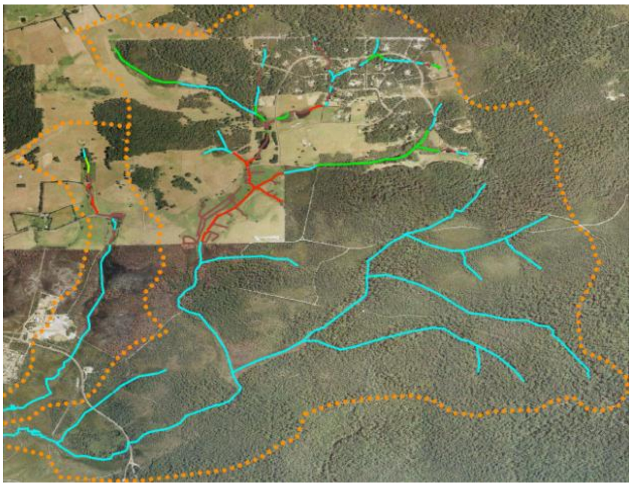
2. **Resource potential:** Assessing the resource potential in terms of environmental significance, economic benefit, centralized or decentralized water supply potential and so on should be critically assessed.

3. **Land use land cover:** A critical assessment of the major land use pattern along the river course should be done using GIS. It is also important to document and record the status of the riparian zone along the river. The riparian zone assessment may be

done using the Pen and Scott foreshore assessment technique[47] and spatial maps (Picture No. 2-13) can be prepared for further analysis.

Background: The Pen and Scott foreshore assessment technique classifies the foreshore condition of streams and rivers into A, B, C or D grade, each of which is outlined below:

i. ***A-*** *pristine – healthy riparian vegetation with no weeds or evidence of impacts caused by human activities*
ii. ***B-*** *slightly disturbed – where the riparian vegetation has been invaded by weed species*
iii. ***C-*** *disturbed – riparian zone supports only over storey and pasture or only pasture*
iv. ***D-*** *drain – where the stream is little more than an eroding drain*



Picture No. 2-13: The foreshore condition of the Collier River and Butler's creek in Australia (Blue- A, Green-B, Red- C and Brown- D)

Recommendation 2: Water quality assessment depending on the resource potential.

As per CPCB recommendation, every river should be monitored upstream and downstream for any potential source of pollution. However, the current sampling locations on the river are located either upstream or downstream, thus not providing comprehensive information which may lead to an inappropriate trend analysis. Without this analysis, the dilution capacity or the carrying capacity of the surface water body cannot be assessed. Hence,

1. Monthly monitoring of the entire course of the river and specifically at critical locations is recommended.
2. It should be an ongoing study for the entire region.
3. It would be ideal to set up real time monitoring stations along significant locations of the river with immediate effect.

[47] http://www.water.wa.gov.au/PublicationStore/first/84334.pdf

4. Documenting and recording of the data should be as per nationally accepted format for all the recommended parameters as specified in the Annex:-2: Water quality standards for best designated usages

Recommendation 3: Components which pose a serious threat to the river ecosystem should be closely monitored and mapped on the river management/development plan with the help of GIS application.

Sand mining/dredging: When sand, the medium in which coastal fauna and flora thrive, is removed, the entire ecosystem is inevitably and irreversibly destroyed. This would have an effect on every type of flora and fauna, the coastal & terrestrial life including migratory birds, turtles and almost every species which make up coastal biodiversity.[48] Sand mining, apart from impacting biodiversity, also impacts traditional livelihoods, especially of fishing and agrarian communities dependent on the habitats and life forms which thrive in sand. Hence it is strongly recommended to conduct ground truthing and map all the sand mining points on the development plan with the help of GPS (Global Positioning System) to assign geo coordinates and accordingly erect boundary pillars so as to avoid illegal unscientific mining.

Further, in spite of International trade of sand between countries, no International protocol governs the extraction of sand or any other aspect of sand mining including biodiversity, water security, land security etc. The scenario is no different in MMR region, hence there is an urgent need to address this issue of sand mining and carry out scientific studies through participatory planning for better policy making.

Background: Government should allow construction industry to use Manufactured sand (M-Sand) which is mass-produced from rocks and is considered a good alternative to river/sea sand. Extracting sand from the sea could also lead to future erosion and hence it should be completely avoided but the use of aggregate rock to make M-Sand may be a viable option. This material is extensively used in Kerala, Tamil Nadu and Andhra Pradesh.[49]

Land use pattern along the river course: In MMR at many instances it was observed that major land use pattern is right adjoining the river course, leading to misuse and degradation of the resource. Given below are few examples to highlight the fact that at least 15-30 meters in width along the river course should be dedicated as no development zone. These LULC should be differently marked on the development plan so as to take the necessary action at policy and implementation level.

[48] https://www.cbd.int/doc/emerging-issues/emergingissue-2013-10-Awaaz-Foundation-Bombay-NHS-en.docx.

[49] http://www.business-standard.com/article/economy-policy/moef-to-lift-ban-on-sand-mining-in-non-coastal-zones-111041600016_1.html

i. Cow shed along the Ulhas river- *The waste water from the cow shed is directly released in the river. (Picture A)*

ii. Slums along Dahisar and Mithi river- *Sewage and solid waste are dumped in these rivers. (Picture B)*

iii. Kalyan Dombivali Municipal Corporations' solid waste dumping ground along the Ulhas river- *The leachate from the solid waste dumping ground may pollute the river as well as the ground table. (Picture C)* However there is no buffere zone and no monitoring station to assess the impact of pollution.

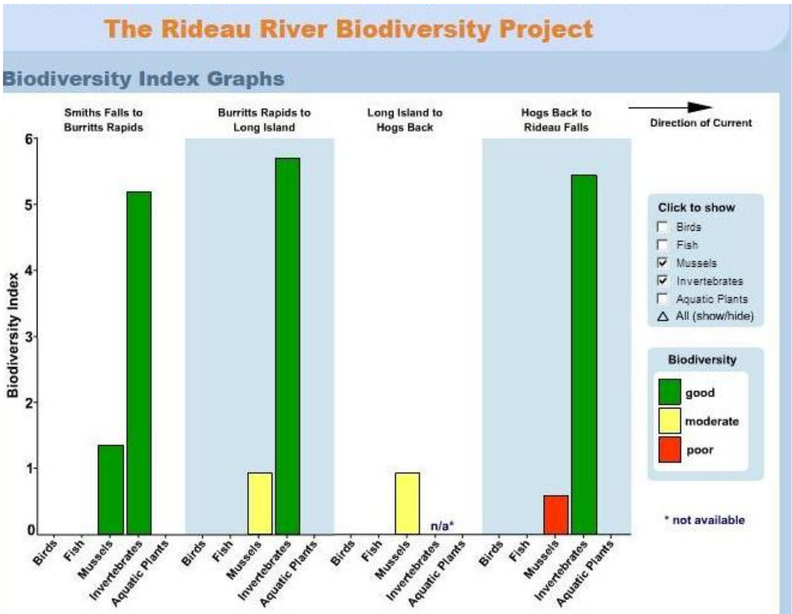
Picture No. 2-14 Major LULC along the river course

Background: As per USDA Forest Service there should be 3 zones. Zone one of the model begins at the normal water level or at the edge of the active channel and extends a minimum of 15 feet along a line perpendicular to the watercourse. Dominant vegetation consists of existing or planted woody vegetation suitable for the site and intended purpose. This zone should remain undisturbed; therefore, tree removal is generally not permitted. Zone two begins at the edge of zone one and extends a minimum of 60 feet perpendicular to the watercourse. While vegetation in zone two should be similar to zone one, removal of tree and shrub products is permitted on a regular basis provided the tree and shrubs are replaced. The third zone begins at the outer edge of zone two and has a minimum width of 20 feet. Vegetation in this zone can be grazed or un-grazed grass or other plant communities as long as it facilitates sediment filtering, nutrient uptake, and the conversion of concentrated flow to uniform, shallow, sheet flow through the use of structural practices such as level spreaders (Lowrance et al., 1995).[50]

[50] http://ec.europa.eu/environment/water/pdf/WFD_brochure_en.pdf

Recommendation 4: River Biodiversity Index should be calculated for all the major rivers in MMR

River Biodiversity Index describes the species diversity (number of species) and abundance (number of specimens of each species) in a given area. The index should be calculated for major sections of river. Indices of different species cannot be compared. Rather, it is possible to compare the status of a single species in different environments, or in one environment at different times, but it could give a fair idea of the diversity in the ecosystem. Hence it is strongly recommended to calculate the River Biodiversity Index for all the major rivers in MMR and revalidate the index at an interval of 3 to 5 years to compare the status of the biodiversity of the river. A sample outcome of the biodiversity index calculated for Rideau River located in Canada is shown in Picture No. 2-15.



Picture No. 2-15: Biodiversity index of Rideau River, Canada

Source: http://nature.ca/rideau/e/e1ef-e.html

Recommendation 5: Riparian zone restoration managemet:[51]

Riparian buffers are vegetated areas next to water resources that protect water resources from nonpoint source pollution and provide bank stabilization and aquatic & wildlife habitat. Given the significance of the buffer zone it is recommended that the government/planning authority should integrate buffer restoration into state basin plans and watershed plans. Also intergovernmental funding mechanism that link buffer acquisition to water quality benefits, coordinates land acquisition efforts with private and non-profit organizations should be established. Further, plantation in the barren and eroded land should be done on large scale by government in collaboration with the local

[51] http://w.ipublishing.co.in/ijesarticles/twelve/articles/volthree/EIJES31064.pdf

communities, whereas dirty pathways along or within buffer zones should be replaced with grasses so as to revitalize the riparian zone.

Recommendation 6: Specific species to be grown in the riparian buffer[52]

Species that are particularly valued by the local community and has multiple uses and functions can be selected. There are native trees in all localities suitable for the riparian zones and capable of *yielding* useful products. Some of the multiple functions and products to look for in a tree are wind resistance, erosion control, soil fertility and improvement, nitrogen fixation, shade, wildlife habitat, mulch or green manure, pest control, animal fodder, living fences, fuel wood, food (fruit, vegetables, root, shoot, oil), medicinal uses, tannin, dyes, soaps, cosmetics, bee forage for honey, crafts, carving, and timber.

Recommendation 7: Program of measures to be included in the river basin management plans

Along with the following mentioned components, the river basin management plans must also include a programme of measures, that details which measures will be undertaken, where, and by when.

- A description of the river basin district, including maps
- A summary of the main significant pressures and environmental impacts of human activities
- A map of specially protected areas (e.g. natural habitats)
- A map of monitoring networks, and results of the monitoring
- A list of environmental objectives or targets
- A summary of the programme of measures to maintain or improve water status
- A summary of public consultations and their influence
- A list of competent authorities and contacts.

Recommendation 8: River water quality monitoring stations should be increased to cover the entire course of the river

The WQMS on the rivers should be significantly increased as per the CPCB norms. As seen in Table No. 2-30, at present 8 rivers (out of 13) and 17 tributaries (out of 21) are not at all monitored. This infrastructure gap needs to be addressed on a priority basis.

[52] http://www.agroforestry.net/the-overstory/105-overstory-167-riparian-buffer-zone-restoration-for-food-security

Table No. 2-30: Number of monitoring stations on the river

Sr. No.	Name of the river *(Length of the river from origin in Km)*	Tributaries	No. of monitoring stations
1	**Patalganga** (41)	Hetvane and Dhavri	7 *(on the river)*
2	**Ulhas** (122)	Varna, Kamvadi, Kumbhari, **Bhatsa**, Shai, **Kalu**, Murbadi, Barvi, Poshir, Shillar and Pej	7 *(3 on river & 4 on tributary)*
3	**Vaitarana** (154)	**Susari,** Pinjal, Gargai and **Tansa**	5 *(1 on the river and 4 on tributary)*
4	**Amba** (76)		1 *(on the river)*
5	**Mithi** (17.8)		1 *(on the river)*
6	Dahisar (14.5)		**0**
7	Poisar (11.5)		**0**
8	Malad (11)		**0**
9	Oshiwara (9.63)		**0**
10	Mahul (5.74)		**0**
11	Panvel (30)	Taloje, Navde, Lendi and Gadhe	**0**
12	Bhogeshwari (40)		**0**
13	Balganga (27)		**0**
	Total		**21**

1 WQMS per 43.03 km of river length

Bold and highlighted rivers & tributaries are monitored by MPCB.

2.4.2 Lakes/Ponds/Wetlands/Water Bodies

There is no specific definition for Lakes in India. The word "Lake" is used loosely to describe many types of water bodies viz natural, manmade and ephemeral including wetlands[53]. Lakes are important part of urban ecosystem. Though it's relatively small in size, they perform significant environmental, social and economic functions like recharging groundwater, being a source of drinking water, acting as sponges to control flooding, supporting biodiversity and providing livelihoods.

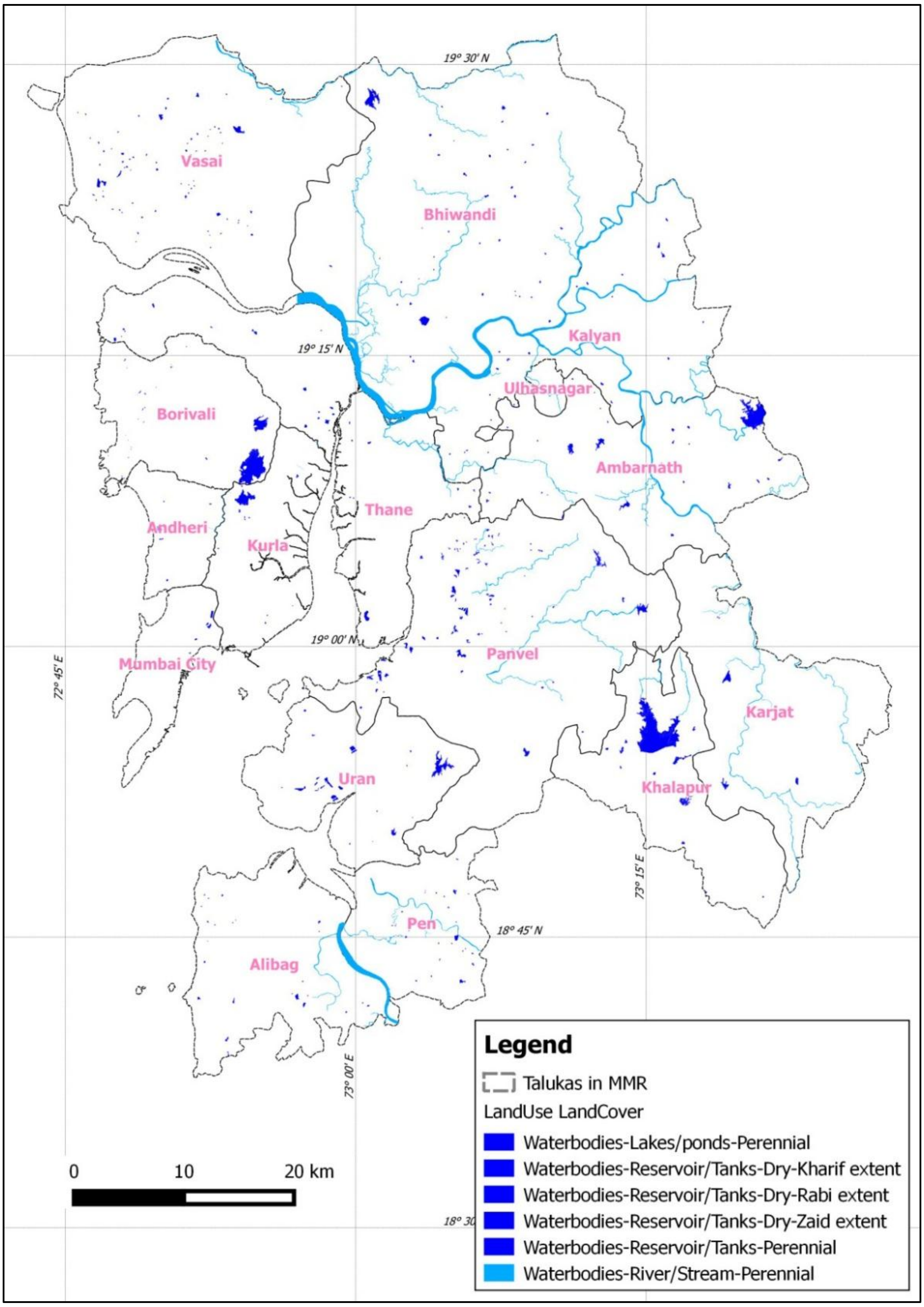
In MMR, there are 107 water bodies in Greater Mumbai and around 324 in rest of MMR. In all there are approximately 431 waterbodies in the region.

At present in MMR, lakes and wetlands are in extremely bad shape and in varying degrees of environmental degradation. The water bodies are illegally encroached, full of sewage and garbage, in spite of their significance. The disappearance or the bad condition of these sponges of the city may result in floods, as experienced by Mumbai city in the year 2005. Although there is a plethora of policies and acts for the protection and restoration of urban lakes and wetlands, still the water bodies are in extremely poor condition.

In the Development Plan (DP) of 1991, out of 107 water bodies present in Greater Mumbai, only 10 water bodies are marked as either 'tank' or 'lake'. Rest of the water bodies do not have any specific DP classification.

53 http://www.worldlakes.org/uploads/Management_of_lakes_in_India_10Mar04.pdf

As per the secondary data, it was estimated that there are around 431 water bodies within the jurisdiction of various ULBs in MMR (Map No. 2-24Table No. 2-25). However this number may increase upon having a detailed inventorisation of water bodies for rural and peri urban areas of MMR.



Map No. 2-24: Waterbody map of MMR

Source: MRSAC

2.4.2.1 Greater Mumbai

In the year 2012, Mumbai Metropolitan Region-Environment Improvement Society (MMR EIS), had entrusted M/s Adarkar Associates of Mumbai with the task of inventorising and documenting all the water bodies existing in Greater Mumbai. This is the first time ever that such a comprehensive study of environmental features has been undertaken. As per the study, there are 107 water bodies in Greater Mumbai (Annex-4) and are classified in 4 categories namely small, medium, large and very large depending on their size as seen in Figure No. 2-54.

In Greater Mumbai, there are 6 very large water bodies, followed by 15 large sized water bodies, 37 medium sized water bodies and the highest count of the small water bodies i.e. 49.

Further, out of the 107 water bodies, only 10 water bodies are mentioned in the Development Plan (DP) of 1991 as either 'tank' or 'lake'. That means approximately 97 water bodies existing on ground do not have any specific DP classification to indicate their status as a water body. Some have classifications like RG (Recreational Ground), PG (Play Ground), and so on. While some of the water bodies are on other reservations. Hence it is strongly recommended to document all the existing water bodies in the entire MMR and mention it in the DP under a specific category and sub category as required.

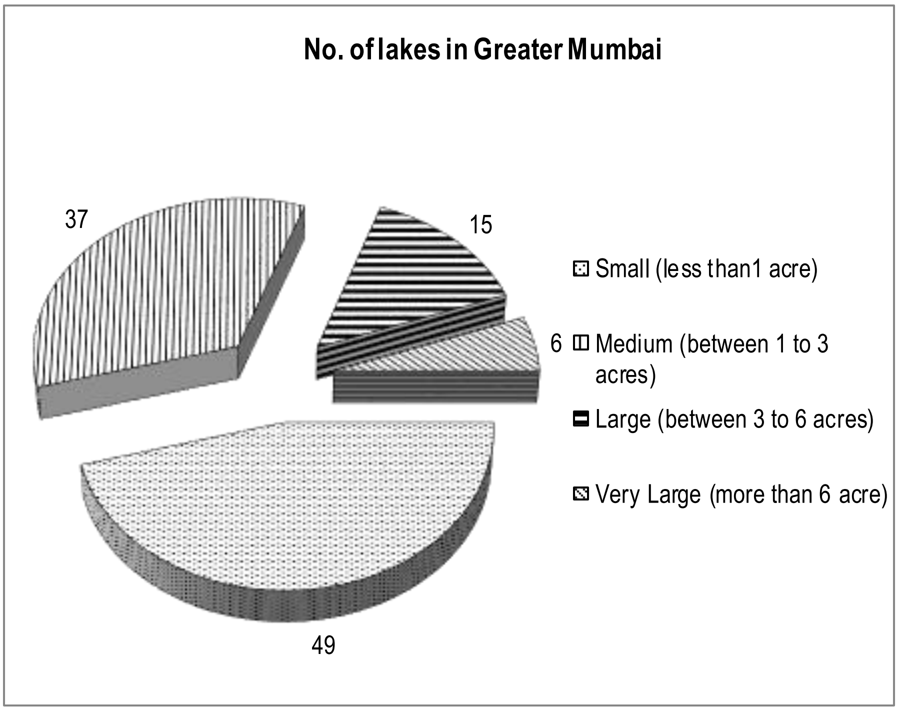


Figure No. 2-54: Classification of lakes of Greater Mumbai

Source: Inventorisation of open spaces & water bodies in Greater Mumbai for MMR-EIS, 2012

In Greater Mumbai, there are maximum small water bodies (49 nos.) followed by medium water bodies (37 nos) and then large water bodies (15 nos.). Further, there are 6 very large water bodies in the city. The detail of these water bodies is mentiond Table No. 2-31.

The observations of the comprehensive study conducted by M/s Adarkar Associates has been presented in the following section

Table No. 2-31: General information about very large water bodies of Greater Mumbai

Sr. No.	Name of the water body (area in acres)	Description	Photograph
1	Bandra Talao, Bandra- (7.43 acres)	The water body also known as the lotus tank is a major landmark of Bandra. There was no vegetation cover within the catchment area, only a few scattered trees within surrounding zones. Rain water and surrounding road water enters into the lake. Based on the visual assessment of the lake carried out by M/s Adarkar Associates, the water was found to be mesotrophic in nature. Also there existed issues such as siltation, eutrophication, solid waste dumping and evaporation losses.	
2	Lake- Pawan Hans, Juhu (52.97 acres)	The lake is located in the heart of the suburbs in Juhu. Due to the proximity to the sea, it has water throughout the year. There was overall sparse vegetation within the catchment area and has no major feeder channels. Rainwater and surrounding surface water enters the lake. Garbage dumping, defecation, eutrophication, sewage water discharge, evaporation lossess, siltation, heavy growth of aquatic weeds and concretization in the catchment were some of the issues that existed in and around the lake. Hence the lake water was not visually very clean, as per the assessment carried out by	

Sr. No.	Name of the water body (area in acres)	Description	Photograph
		M/s Adarkar Associates.	
3	Chandivali Lake, Powai- (8.67 acres)	The lake is situated very close to the Powai lake at a height of 35 m above MSL. It slopes towards the south west side into a nallah which ultimately drains into the Mithi river. Water is retained throughout the year. However, no distict feeder channels were seen during the visits conducted by M/s Adarkar Associates. Garbage dumping, encroachment, eutrophication and algal growth were few of the major issues. The water was slightly greenish brown and turbid in color.	
4	Powai Lake, Powai [54] -- (445.91 acres)	Powai Lake is an artificial lake, situated in Mumbai, in the Powai valley, where a Powai village with a cluster of huts existed. The city suburb called Powai shares its name with the lake. The estate where the lake is now located was leased to Mr. Framaji Kavasji, then the vice-president of the Agricultural and Horticultural Society of Western India after whom the lake was named when it was built in 1891[55]. Earlier, the lake used to supply drinking water to the city of Mumbai, but presently lake water has been declared unfit to drink. Growth of water hyacinth indicates eutrophication in the lake as seen in the picture.	

54 http://redgannet.blogspot.in/2012/03/mugger-at-powai-lake-mumbai-march-2012.html
55 http://en.wikipedia.org/wiki/Powai_Lake

Sr. No.	Name of the water body (area in acres)	Description	Photograph
5	Vihar Lake, Borivali- (1195.73acres)	Vihar Lake is located near Vihar village on the Mithi River within the precincts of the Borivali National Park, also called the Sanjay Gandhi National Park, in North Mumbai. It is hemmed between the Tulsi Lake and the Powai Lake. It is the largest fresh water lake in Mumbai and the Vihar reservoir was the first piped water supply scheme of Mumbai[56]. The lake was built in 1860 and the catchment area is approximately18.96 sq.km. Presently, it supplies 60 MLD of water to South Mumbai.	
6	Tulsi Lake, Borivali- (264.34 acres)	Tulsi Lake was built by damming the River Tasso, and redirecting the flow to the nearby Vihar Lake. Rain water from the catchment area of 676 hectares of Powai-Kanheri hill ranges drains into the lake. During the rainy season the flood flows out into the Powai Lake and further down into the Mithi River. Tulsi Lake is a fresh water lake in northern Mumbai and is stated to be the second largest lake in Mumbai [57]. Presently, it supplies 15 MLD of water to northern Mumbai.	

Source: Inventorization of open spaces & water bodies in greater Mumbai by M/s. Adarkar Associates

56 http://en.wikipedia.org/wiki/Vihar_Lake

57 http://en.wikipedia.org/wiki/Tulsi_Lake

Usage pattern of water bodies

It is observed that many water bodies in the city are developed as recreational sites. Hence the maximum usage of the water bodies is for recreational purpose as seen in Figure No. 2-55. Further, a majority of water bodies are in the gaothan areas like Manori, Gorai and Uttan and are not within the vicinity of residential areas. Hence the next dominating usage pattern is domestic. Out of 107 water bodies; 19 were used majorly for domestic purposes like washing clothes, utensils and also for cattle. Given that water has a central place in the practices and beliefs of many religions, in Greater Mumbai, 18 water bodies are used for religious activities.

In Greater Mumbai, the water bodies are mainly used for recreational, domestic and religious activities depending on their location. 6 water bodies are used for drinking purpose as well.

Further, there are around 16 water bodies belonging to the Textile mills, which are mainly used for fire-fighting when the mills are operational. The other important usage of water bodies is for drinking purpose which includes Tulsi and Vihar Lake and 4 reserviours of MCGM. Followed by defecation (9 water bodies), fishing (6 water bodies) and boating (5 water bodies). The detailed list is tabulated in Annex-5.

In Greater Mumbai, 50% of the water bodies are accessible to public and the remaining 50% of the water bodies have restricted entry or are accessible after buying a ticket.

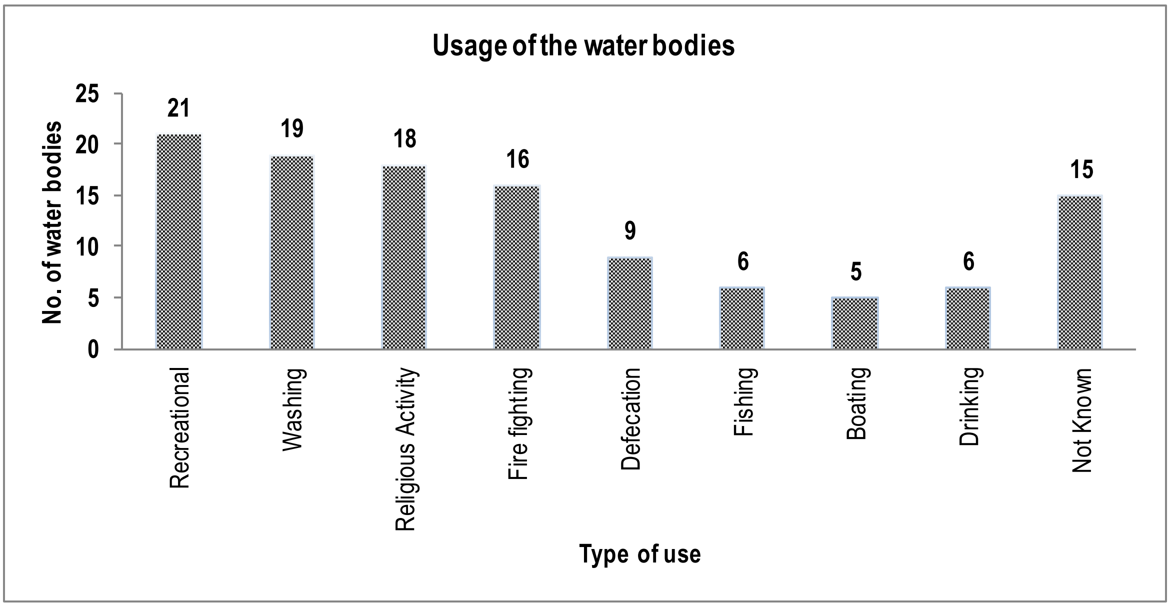


Figure No. 2-55: Usage pattern of lakes of Greater Mumbai

Source: Inventorisation of open spaces & water bodies in Greater Mumbai for MMR-EIS, 2012

Accessibility to the water bodies

As seen in Figure No. 2-56, out of the 107 water bodies, 53 water bodies (50%) are accessible to the public, 49 have restricted entry, 4 are accessible after buying a ticket, and 1 is not accessible to the public at all. On an average 200 to 500 people visit these accessible water bodies daily and at select locations the footfall was observed by M/s Adarkar associates to be in the range of 1000 to 2500 people per day.

In Greater Mumbai, 80% of the water bodies have issues of algal bloom which makes the trophic state of the water bodies as either mesotrophic or eutrophic.

Further, the Ganga Bawdi, near Madh Island is the only water body which was not accessible during the survey carried out by M/s Adarkar associates. As the name suggests it is a large reservoir and not a lake/pond which is located very close to the Harba Devi Talao, and was surrounded by slums all around. It is bounded by a compound wall on all sides and hence not easily accessible to the outside public.

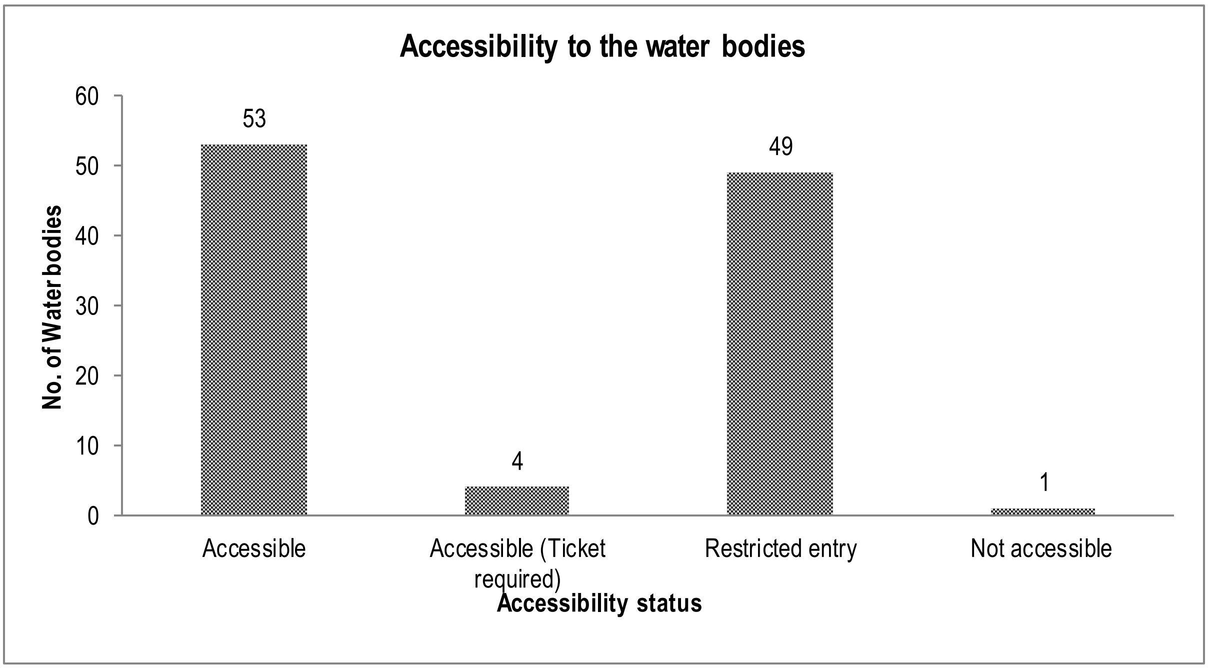


Figure No. 2-56: Accessibility to the water bodies

Source: Inventorisation of open spaces & water bodies in Greater Mumbai for MMR-EIS, 2012

Visual status of the water bodies

As seen in Figure No. 2-57, out of 107 water bodies, 58 have mesotrophic water condition, 28 have eutrophicated condition and 6 are oligotrophic in nature. The trophic state of the water body is explained in box no. 2[58] and the observations of the visual status as reported by M/s Adarkar Associates are tabulated in Annex-6. The study did not include water quality analysis of these water bodies, hence not included in this report.

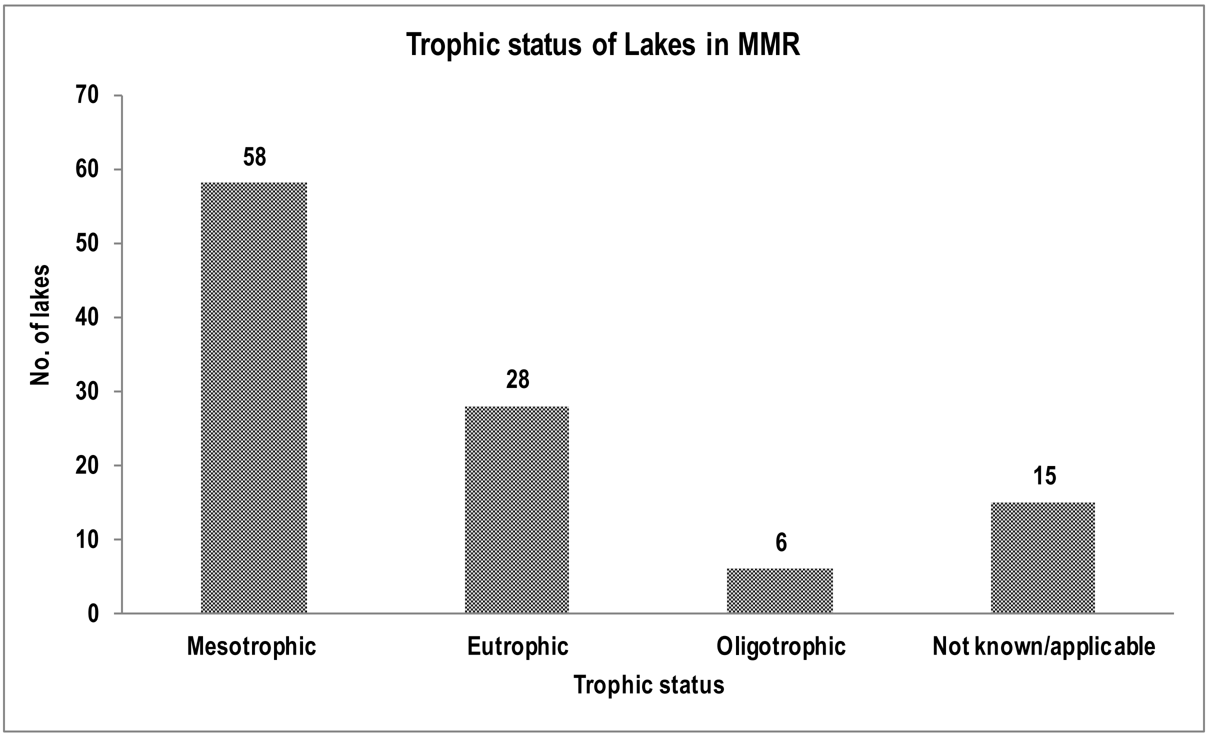


Figure No. 2-57: Trophic status of lakes in MMR

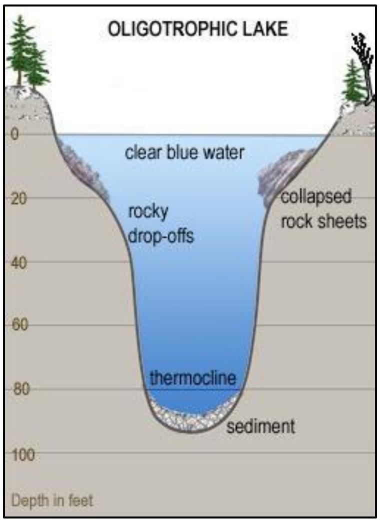
Source: Inventorisation of open spaces & water bodies in Greater Mumbai for MMR-EIS, 2012

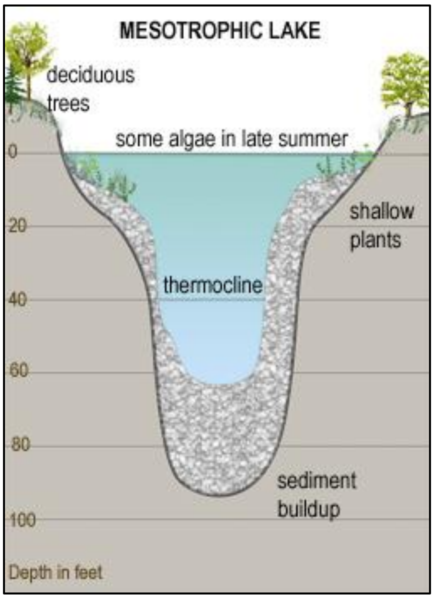
[58] http://rmbel.info/lake-trophic-states-2/

Box no: 2 Trophic state of a lake

Trophic states (mesotrophic, eutrophic and oligotrophic) are based on lake fertility. The root "trophy" means nutrients; therefore, lakes are classified based on the amount of available nutrients (Phosphorus and Nitrogen) for organisms. More fertile lakes have more nutrients and therefore more plants and algae. In the newly formed lakes, the edges and bottom are exposed rock, which doesn't erode very quickly, meaning there are not many nutrients available. As a lake ages, sediment from the watershed is washed in, filling in the bottom of the lake. This sediment is rich in nutrients, and therefore also increases the fertility of the lake.

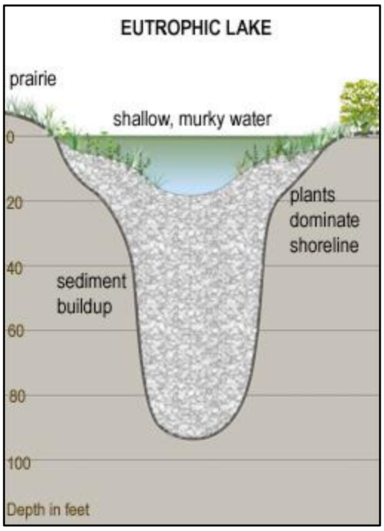
"Oligo" means very little; therefore, oligotrophic means very little nutrients (Phosphorus and Nitrogen). In oligotrophic lakes, oxygen is found at high levels throughout the water column. In addition, low algal concentration allows deeper light penetration and less decomposition. When algae, zooplankton and fish die, they sink to the bottom and are decomposed by microbes and invertebrates. This decomposition process uses up oxygen. Since oligotrophic lakes are less fertile and have less algae and other organisms, there is less decomposition and the oxygen doesn't get used up.





Meso" means middle or mid; therefore, mesotrophic means a medium amount of nutrients. Mesotrophic lakes behave differently than oligotrophic lakes in that they stratify, meaning they separate into layers in the summer[*http://rmbel.info/stratification-and-mixing/*](http://rmbel.info/stratification-and-mixing/)*. The top layer of water becomes warm from the sun and contains algae. Since the by-product of photosynthesis is oxygen, oxygen concentration remains high at the surface of the lake. The bottom layer remains cooler and can become anoxic in mid-summer. This change occurs because as all the algae and other organisms die and are decomposed at the bottom of the lake, oxygen gets used up. Since this bottom layer of water does not mix with the top layer of water in the summer, oxygen cannot be replenished. The implications of anoxia are that no fish or other organisms can live where there is no oxygen; therefore, in late summer, fish move shallower where there is still oxygen available.*

"Eu" means true; therefore, eutrophic literally means true nutrients or truly nutrient rich. Eutrophic lakes are very fertile due to the nutrients carried into the lake from the surrounding landscape. These nutrients support high densities of algae, fish and other aquatic organisms. Since eutrophic lakes have so much biomass, there is a lot of decomposition occurring at the bottom. This decomposition uses up oxygen, causing the bottom of the lake to become anoxic in the summer. In very shallow lakes, the whole lake can become anoxic, causing a fish kill.



Common issues identified and recommendations

The major issues identified in and around the water bodies are mainly encroachment, dumping of solid waste & construction debris, embankment of edges and deteriorating water quality.

Residential area

Water bodies located in the vicinity of residential areas had problems like garbage dumping, debris dumping and sewage flow. Concretization of the catchment area of the water body, minimal vegetation and lost riparian zone are few other identified issues.

Slum area

The main issues for the water bodies near the slums were of excessive garbage dumping, sewage flow and of deterioration of edges due to encroaching on the water body itself.

Gaothan area/peri urban area/outskirt of the city

Water bodies in the gaothan areas are predominantly used for domestic purposes like washing clothes, utensils and also cattle. Hence the deteriorating water quality is a major area of concern.

To summarize, the major issues are as follows:

- Debris dumping
- Deteriorating water quality
- Embankment of edges

- Encroachment
- *Solid waste dumping*
- *Evaporation losses due to loss of green cover*

In order to prioritize and categorize the lakes on the basis of the threats as stated above, each of these aspects was assigned a value based on its understanding and analysis carried out during the study by M/s Adarkar Associates. The values assigned were 1, 2, or 3 depending upon the extent of the particular threat to the water body. A score of 3 was given to a particular water body if the threat observed was "alarming" or severe. Whereas if the threat was currently of moderate intensity, but can become severe if not attended to, a value of 2 was assigned. Low intensity threat was given a value of 1. The summation of all such values evolved one score (out of 15) which decided the priority level for that lake. Higher the total, higher should be the priority given to that lake and lower the summation; the lower it is on the priority level. Out of 107, 36 water bodies need immediate attention of the respective ULBs and MMRDA for its conservation and restoration (Annex 7) as per the grading.

As per the secondary data available, there are 324 water bodies within the jurisdiction of various ULBs. This number may increase upon having a detailed inventorisation of waterbodies for rural and periurban areas of MMR.

2.4.2.2 Rest of MMR

As per the available secondary data, there are 324 water bodies in rest of MMR. 36 water bodies (24 lakes and 12 holding ponds) in Navi Mumbai, 150 water bodies in CIDCO area, 25 lakes in Thane, 9 lakes in Kalyan Dombivali, 90 lakes in Vasai Virar, 8 in Panvel and 3 lakes each in Bhiwandi Nizampur and Mira Bhayander[59].

Navi Mumbai

As per the ESR 2011-12, in Navi Mumbai Municipal Corporation (NMMC) limit, there are 24 lakes and 12 holding ponds as shown in Table No. 2-32 and Table No. 2-33. These 24 lakes cover an area of 2, 23,661 sq m, which is approximately 0.13% of the total land use pattern in NMMC limits.

In Navi Mumbai, there are 24 lakes and 12 holding ponds. These water bodies are regularly monitored by NMMC. The water quality assessment for the year 2011-12 revealed that the pH and DO were within the permissible limit. However the BOD at maximum water sampling locations was higher than the standards (in the range of 13 to 316). The possible reason for the exceedance may be organic and religious waste disposal.

[59] ESR and CSP

Table No. 2-32: Lakes in Navi Mumbai

Sr. No	Lakes	Area (Sq.mts)
1	Gothivali Khdan	32635
2	Karave	23506
3	Belapur	17905
4	KhokadDighi	17842
5	Khairane	13870
6	Shirvane	13686
7	Agroli	12693
8	Ghansoli Talvpali	11590
9	Vashigaon	10620
10	Kopari	10000
11	Nerul	9894
12	Turbhe	8482
13	Rable	7823
14	Savligaon	6060
15	Darave	5724
16	Airoli	3988
17	Gunali,Ghansolj	3596
18	Killa	2650
19	Sanpada	2500
20	Koparkhaime	2231
21	Diva	2042
22	BorolDigha	1500
23	Juhugaon	1486
24	Mahape	1338

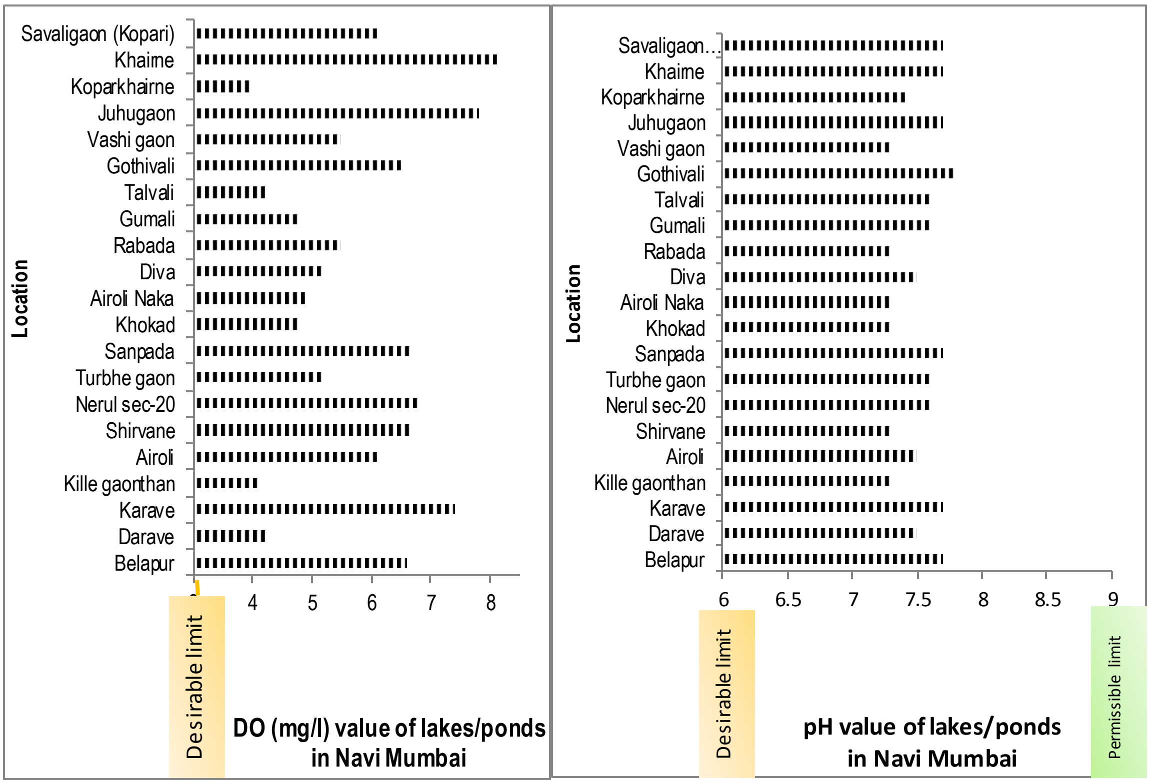
Table No. 2-33: Holding ponds in Navi Mumbai

Sr. No	Holding ponds	Location	Area (Sq.mts)
1	Vashi- Sanpada	Behind Rly. Station	77
2	Vashi	Sector-11&12	24
3	Sanpada	Sector-18, 19&20	22
4	Airoli	Sector-18	16
5	Vashi	Sector-10A	15
6	Airoli	Sector-19	14
7	Belapur	Sector-15A	13.85
8	Bonkode	Sector-14	9
9	Belapur	Sector-12	8.5
10	Koper Khairane	Sector-19	3.2
11	Vashi	Sector-8	2.3
12	Vashi	Sector-30	1.93

Source: NMMC ESR 2011-12

Lake water quality assessment

NMMC takes regular samples of lake water and compares it with the drinking water standards. In the year 2011-12, it was found that quality of water in these lakes was improved due the initiatives taken by the municipal corporation especially the Lake vision project. The results of the water quality assessment are presented below in table:



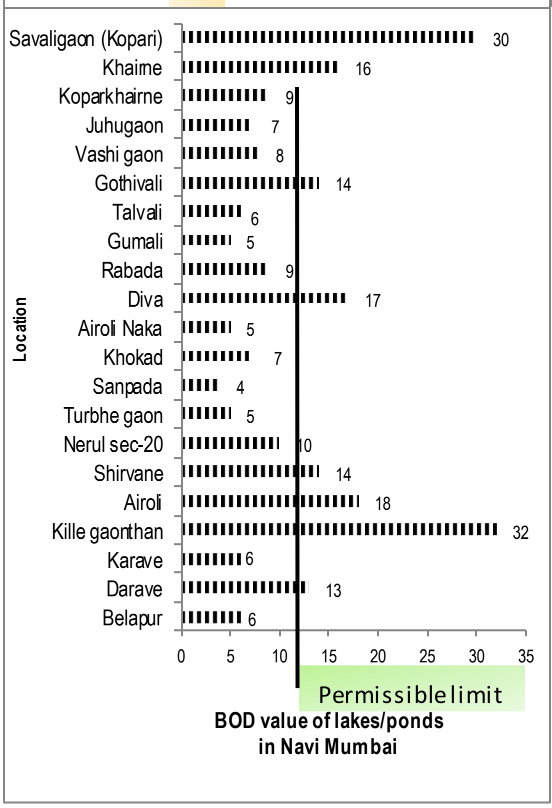


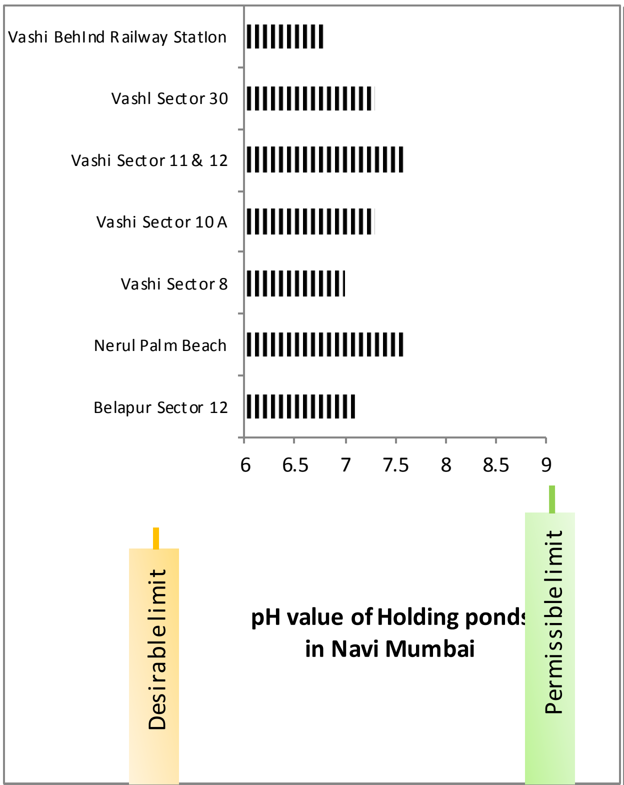
Figure No. 2-58: pH, DO and BOD value of lakes in Navi Mumbai

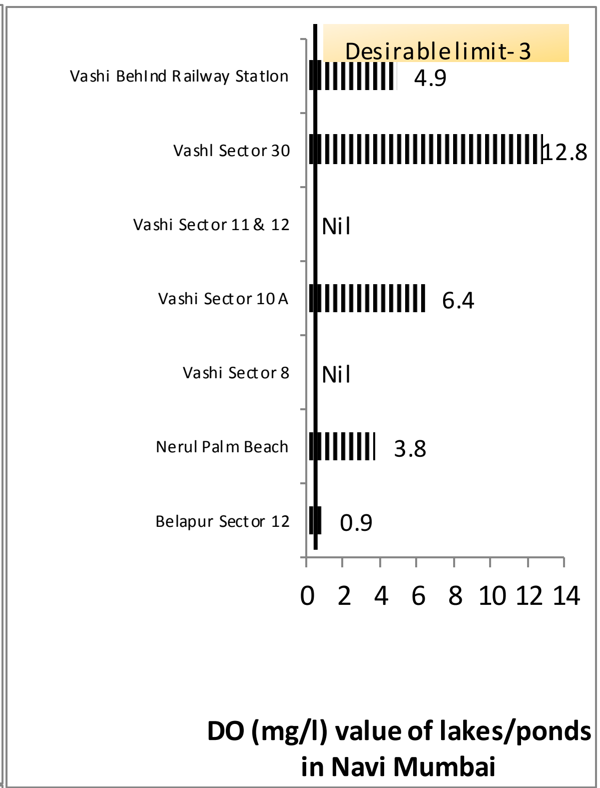
Source: NMMC ESR 2011-12

The pH and DO value was well within the desirable limits of MPCB. However the BOD at 8 locations (out of 21) exceeded the permissible li`mits. The possible reason for the exceedance may be due to disposal of organic and religious waste.

Holding pond water quality assessment

The pH readings for the holding ponds were within the permissible limit of MPCB, however DO value at Belapur and the BOD value at all the locations exceeded the permissible-limits.





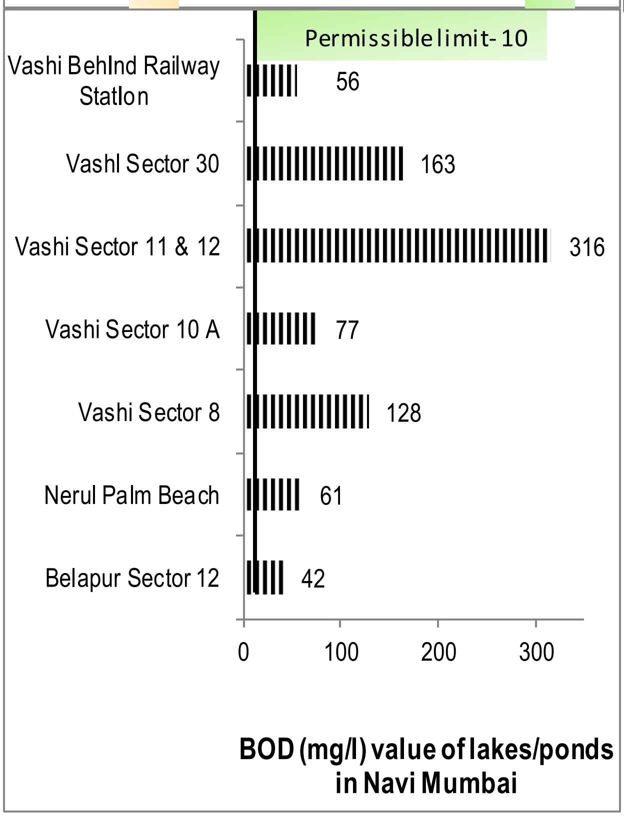


Figure No. 2-59: pH, DO and BOD value of holding ponds in Navi Mumbai

Common issues identified

- Idol immersions during festivals.
- Washing of clothes in lake water.
- Presence of invasive species of plants like Water Hyacinth and Ipomoea.
- Disposal of organic waste in the lake by local residents and visitors.
- Disposal of medicinal waste in lake water.

Picture No. 2-16: Common issues associated with lakes and ponds

Photo credit: TERI

Initiatives taken by the corporation

Out of 24, 18 water bodies were restored and renovated under the lake vision project of NMMC.

Picture No. 2-17: Impact of Lake Vision project in NMMC

Photo credit: NMMC

City and Industrial Development Corporation of Maharashtra (CIDCO) area

In City and Industrial Development Corporation of Maharashtra Ltd (CIDCO) area, there are more than 150 water bodies. However there are no research studies which prove the same. Hence it is recommended to conduct a comprehensive study about to document the existing water resources of the region.

Thane

As per the Environmental Status Report (ESR) 2010-11, in thane there are 25 lakes as tabulated in **Table No. 2-34**. Most of the lakes are rain fed & are not used for supplying drinking water to the city. However they have significant ecological & economic features. Many of the lakes are not only major revenue generators for the city fisherman but also the hub of economic activity, providing an indirect source of livelihood for many citizens.

Table No. 2-34: Lakes in Thane

Sr. No.	Name of the lake	Sr. No.	Name of the lake	Sr. No.	Name of the lake
1	Jail	10	Owla	19	Kasar wad vali
2	Rewale	11	Masunda	20	Rayaladevi
3	Makhmali	12	Brahmala	21	Kqlshet
4	Diva	13	Upvan	22	Khidakali
5	Dativali	14	Kachrali	23	Kharegaon
6	Shil	15	Kausa	24	Ambeghosale
7	Phadakepada	16	Kolbad	25	Gokulnagar
8	Desai	17	Shiddheshvar		
9	Shivajinagar	18	Hariyali		

Source: TMC ESR 2010-11

Lake water quality assessment

The pH and ammonical nitrogen values were well with the desirable limits of MPCB. But the BOD at 14 locations and DO at Diva monitoring station exceeded the permissible limits. The possible reason for the exceedance may be disposal of organic waste and release of untreated sewage. (Only 20% of sewage generated is treated & released in the creek.)

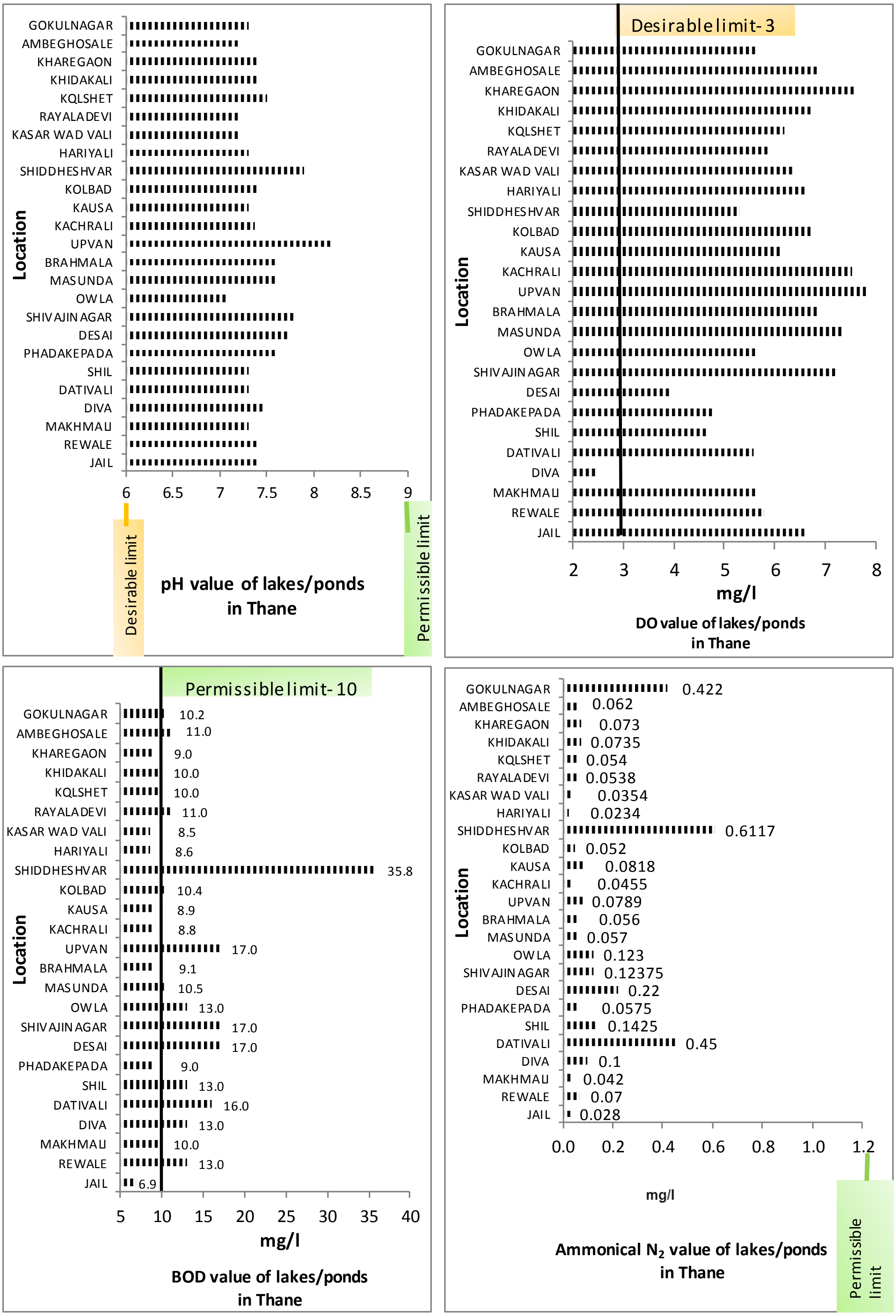


Figure No. 2-60: pH, DO, BOD, Ammonical N_2 value of lakes in Thane

Source: TMC ESR 2010-11

Common issues identified

- Eutrophication causing Foul smell/odour etc making the water quality unfit for drinking, bathing, washing or even recreational activity.
- Excessive growth of weeds & hyacinths
- Siltation & sedimentation
- Breeding of mosquitoes

The other major problem is the decline in the carrying capacity and the receding lake area due to heavy siltation & sedimentation resulting in one meter effective depth difference in some cases.

In Thane, there are 25 lakes, which are regularly monitored by TMC. Given that only 20% of the sewage generated in the city is treated and the rest is allowed to be released in the nallhas after giving a primary treatment with the help of septic tanks. This practise has affected the lake water quality, which is evident by the observed BOD values ranging between 10.2 to 35.8 mg/l.

Initiatives taken by the corporation[60]

- Revival of Kacharali Lake in the year 2000, under the lake conservation programme.
- 9 lakes sanctioned for conservation under the National Lake Conservation Plan (NLCP), IX year plan, in December, 2002.
- 10 more lakes for conservation in the year 2004 under TMC initiative.
- Bioremediation of Ambeghosale Lake with support from MMR Environment Improvement Society.

Kalyan Dombivali

As seen in Table No. 2-35, there are 9 lakes which accounts to 1.63% of the total land use pattern in Kalyan Dombivali region. KDMC monitors lake water quality; however the details are not published in their annual ESR. Therefore, TERI had conducted site visits to two of the major water bodies of the city to understand their status as of date.

Table No. 2-35: Lakes in Kalyan Dombivali

Sr. No.	Lakes	Location	Area (sq.mts)
1	Kala talav lake	Kalyan	96757
2	Umbarde lake	On Bhiwandi Murbad Kalyan Byepass road, Village Umbarde, Kalyan.	29915
3	Gauripada Lake	Behind birla college, Milin nagar road, Gauripada, Kalyan.	22915

[60] Source: http://www.pib.nic.in/newsite/erelease.aspx?relid=16404

Sengupta, M. and Dalwani, R. (2008) Proceedings of Taal2007: The 12th World Lake Conference: 1628-1634

Sr. No.	Lakes	Location	Area (sq.mts)
4	Rahatale lake	Near Bhiwandi Murbad Kalyan bypass road, Wadeghar village, Kalyan.	16683
5	Sapad lake	Near Bhiwandi Murbad Kalyan bypass road, Sapad village, Kalyan.	12415
6	Adharwadi Lake	Near Bhiwandi Murbad Kalyan bypass road, Adharwadi Jail, Kalyan.	10165
7	Bhatale lake	Near Durgadi fort, Reti Bunder Road, Kalyan.	9325
8	Chole lake	Village chole, Dombivali	3230
9	Titwala lake	Near Siddhivinayak Mandir, Titwala, Kalyan.	ND

Source: KDMC ESR 2011-12

Site visit conducted by TERI within Kalyan Dombivali Municipal Corporation

Kala talav lake, Kalyan:

Kala talav admeasures approximately 23.91 acres. It is the largest water body in the city. The periphery of the lake has been concretized. No solid waste or sewage waste was seen around the lake during the visit, hence visually it appreared clean. Further, the lake is used for recreational purposes by joggers, students and senior citizens. Lake's authority under KDMC garden department operates the paddle boating service. Hence, overall the lake was well maintained.

Picture No. 2-18 Kala talav lake

Photo credit: TERI

Gauripada Lake, Kalyan:

The lake is the third largest lake in the city measuring approximately 5.66 acres. Along the periphery of the lake was a Hindu temple. Hence it was highly polluted due to religious activities; sewage and open solid waste dumping. A lot of debris and floating material was seen in the lake during the visit.


Picture No. 2-19: Gauripada lake with a temple at its bank.

Photo credit: TERI

Common issues identified

- Unplanned development around the lakes and use of lake water for non-domestic application like washing.
- Eutrophication and rampant growth of water hyacinth.

Initiatives taken by the corporation

Lake system has been analysed and a proposal for conservation & beautification of the lakes has been prepared by the corporation.

Bhiwandi Nizampur[61]

In Bhiwandi Nizampur, there are 3 lakes namely Varhala, Bhadwad & Narpoli Lake.

Varhala Lake: It is a major water body in the city; it spans approximately 50 hectares, with an average depth of 3.25 meters. This lake fills up with rainwater and has no natural springs. Further, the lake has been put to various uses like washing, bathing, recreational facilities, idol immersion & as a supplementary source of water supply. The lake is monitored by BNMC for its water quality since 2 MLD of water is drawn from the lake for municipal supply.

In BNMC, there are 3 lakes and the common issues identified are mushrooming of slums and disturbance/concretization of the catchment area. Initiatives have been undertaken by BNMC to improve the overall lake water quality.

61 BNMC ESR 2011-12

- Issues identified: Unplanned development, mushrooming of slums, and rampant quarrying of the lake catchment.
- Initiatives taken by corporation: Comprehensive study was conducted. With the assistance from Ministry of Environment and Forest (MoEF), GoI, under NLCP, bioremediation has been taken place. Physical removal of water hyacinth & dredging for removal of silt & other sediment has also been carried out. A 1200 meters long canal has been constructed to gather and enable clean rainwater to flow into the lake.

Bhadwad & Narpoli Lake: Both these lakes are located at a strategic location, hence been converted into a recreational area.

- Issues identified: Water quality of both the lakes is quite poor.
- Initiatives taken by corporation: The locations of both these places make them attractive recreational areas. Hence remediation of both these lakes has been taken up. INR 2.5 cr has been spent on bioremediation and now there is improvement in the lake water quality.

Vasai Virar

As per the 2011-12 ESR, it was observed that there are 90 lakes in Vasai- Virar region, which was the highest among all the municipal corporations in MMR. However no further information about them was available in the ESR report. Therefore TERI decided to conduct few site visits to these locations, to understand this phenomenon. The list of lakes which were visited was as follows.

1. Netaji Lake, Juchandra, Vasai
2. Pelhar Lake and Dam, Virar
3. Shirgaon Lake, Virar
4. Nirmal Lake, Vasai
5. Chakreshwar Lake, Nalasopara
6. Wagholi Lakes (2), Nalasopara

In VVMC, there are 90 water bodies. However no further information was published in the latest ESR. Since, VVCM had the highest number of water bodies as compared to other ULBs, TERI decided to conduct ground truthing for few of these locations.

Netaji Lake is situated in Wakipada village in Juchandra. It was a very beautiful lake with no inhabitants around the water front as seen in Picture No. 2-22. Hence the lake is visibly clean. Several birds were also identified near the lake. Communities were witnessed at a distance of approximately 50 meters from the lake. The communities used the lake water for domestic as well as drinking purpose. Additionally, the lake also recharged the nearby underground aquifers. Water tankers from the village as well as nearby areas drew water from borewell (Picture No. 2-20) to supply water to construction sites. There is no regulatory mechanism to monitor the amount of water drawn from these borewell. Further, there is an overhead water tank located near the lake; however no filtration system was observed (Picture No. 2-23). The lake was administered by Minor Irrigation Department, Vasai Sub Division, Thane District.

Picture No. 2-20: Tanker refilling water from the borewell

Photo credit: TERI

Picture No. 2-21: Overhead water tank near Netaji Lake

Picture No. 2-22: Netaji Lake

Pelhar Lake is one of the major lakes in this area and a dam was constructed on it to supply water to the region as seen in Picture No. 2-24 . This was a major source of water for the region, before the formation of Vasai Virar Municipal Corporation. Recently, when the corporation was formed, Surya dam was one of the major sources of water for this region. The dam was accessible and water looked visibly clean with no pollution immediately around the lake. According to the manning officers near the dam, a flocculent was added to the water near the dam's first outlet and then filtered in a water tank near the dam using alum (Picture No. 2-24). The water in the dam was visibly clean with no pollution or waste thrown in the lake.

Picture No. 2-23: Overhead water filtration tank

Photo credit: TERI

Picture No. 2-24: Pelhar Lake and dam

Photo credit: TERI

Shirgaon Lake is located in Virar region close to the National Highway 8. It is also another beautiful lake with serene surroundings and no visible pollution observed (Picture No. 2-26). Similar to Netaji Lake, no inhabitants are observed near the waterfront. Some arrangements are made in one section of lake indicating fishing activity carried out as seen in Picture No. 2-25. The water is only used for domestic purpose by nearby villagers.

Picture No. 2-25: : Shirgaon Lake

Photo credit: TERI

Picture No. 2-26: Arrangements for fishing in Shirgaon Lake

Photo credit: TERI

Nirmal Lake was one of the biggest lakes in Vasai Nalasopara region. It is also one of the most polluted lakes in the entire region. A large part of the lake is eutrophicated and laden with water hyacinth as seen in Picture No. 2-27. A road divides the lake into two, thus indicating changes in the physiology of the lake in the past. The lake was used by the locals for washing clothes as seen in Picture No. 2-28. No filtration systems or cleaning of the lake was observed.

Picture No. 2-27 : Nirmal Lake

Photo credit: TERI

Picture No. 2-28: Lady washing clothes in the lake and the garbage strewn outside the lake

Photo credit: TERI

Other than these, Chakreshwar Lake (Picture No. 2-29) and lakes near Wagholi Naka (Picture No. 2-29) and Wagholi Zilla Parishad (ZP) School in Nalasopara were also visited. These were smaller than the above mentioned lakes. Chakreshwar Lake was located in an urbanized area surrounded by buildings and used only for recreational purposes. Along the lake, paved blocks have been placed and landscaping was done to enhance the beauty and aesthetics of the lake. Residents of this region come to the lake for morning and evening walk. The other lakes in Wagholi area were small lakes. One of it was located in the interiors of the area and was alongside a main road and hence was conserved and visibly clean. While the other one was highly polluted, with waste thrown by commuters as it was located adjacent to the main road.

Picture No. 2-29: Chakreshwar Lake

Photo credit: TERI

Picture No. 2-30: Lake near Wagholi Naka

Photo credit: TERI

Picture No. 2-31: Lake near Wagholi ZP School

Photo credit: TERI

The conclusions that can be drawn from these site visits are:

- Lakes which are notified (Pelhar Lake) and with minimal human interference (Netaji, Shirgaon and lake near Wagholi Naka) were well preserved.
- Also lakes (Chakreshwar Lake) which are developed for recreational purposes and having arrangements for disposal of waste generated by the residents visiting the lake, were well maintained and preserved.
- Lakes (Nirmal and lake near Wagholi ZP School) which were adjacent to the roads were primarily used for dumping of waste by commuters. Hence very polluted.

Hence it can be inferred that visitors/ residents should be given limited access to such water bodies. They are best preserved when they have minimum or restricted human interaction and anthropogenic impacts.

Mira Bhayander

As per the City Sanitation Plan, 2012, in MBMC there are3 major lakes namely:

- Murdha Ram Mandir Lake
- Uttan Moh Lake
- Raani Ram Mandir lake

The lakes have been put to various uses like washing, bathing, recreational facilities, idol immersion & as a supplementary source of water supply.

In MBMC, there are 3 lakes and the common issues identified are mushrooming of slums and rampant quarrying of the catchment area. Initiatives have been undertaken by MBMC to improve the overall lake water quality.

<u>Common issues identified</u>: Unplanned development, mushrooming of slums, rampant quarrying of the lake catchment. Deteriorating water quality of Murdha Ram Mandir & Uttan Moh Lake.

<u>Initiatives taken by corporation:</u> Comprehensive study was conducted to assess the current status of the lake in terms of its quality, morphometric, hydrology, biodiversity & land use pattern. Since the lakes are attractive recreational areas, bioremediation has been carried out.

An estimate of INR 5 crores was calculated for beautification and protection of the lakes. The investment plan as mentioned in the CSP, says that funds could be procured from Government of Maharashtra (0.4 cr every year) as well as Government of India (0.5 cr every year) to the tune of 4.5 crores over a period of 5 years. Similarly, MBMC shall make a provision of 0.5 crores over a period of 5 years for the cause.

Panvel

In Panvel, there are 8 lakes as shown in Table No. 2-36: . These lakes formed important public open spaces, where unregulated development made open spaces scarce. Panvel in particular may be considered a temple town, given its flourishing temples (and other religious places) and their proximity to water bodies. Wadale Talav, the largest in Panvel, is home to about 100 species of birds.

In PMC, there are 8 water bodies. However, very little information is available on the status of these lakes and their water quality. Further, CIDCO & TERI has developed the Khandeshwar Lake as a sustainable model for wetland preservation & revenue generation. This model has potential for replication at different locations across the region.

Table No. 2-36: Lakes in Panvel

Sr. No	Name of the lake
1	Wadale
2	Krishnale
3	Devale
4	Lendale
5	Israel
6	Dundale
7	Khandeshwar
8	Dhakta Khanda

The information on Wadale and Dhakta Khanda was not available. Hence it is not mentioned below.

Krishnale Lake[62] is roughly a semi-circular lake in the commercial heart of Panvel, surrounded by vehicular streets on all sides. It is seen in association with Krishneshwar Mahadev Mandir, a temple in Peshwahi style built by the influential family of the Bapats, with a huge Banyan tree just outside the temple. The poet saint Tukaram is said to have sold chillies near the tree. From its northern edge, it affords a view of the hills beyond. It is approached from the temples side with steps leading to the water. The lake is in a poor state

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of preservation. Further, the future projections in the developemental plan failed to realize the potential of the Talav as a recreational and visual focus.

Picture No. 2-32: Krushnale Lake in Panvel

Devale Lake[63] forms an impressive foreground to the Karamali Shah Dargah, one of the oldest monuments in Panvel. Together they form an important landmark in the heart of the town, facing the municipal council building. The condition of this lake is relatively much better with water fairly clean. However, activities like washing of clothes on the steps hamper the overall condition. The periphery of the lake is maintained clean. Also, the bund wall though is in good condition, but is incongruous in design.

Picture No. 2-33: Devale Lake in Panvel

Lendale Lake[64] situated in the heart of Patel Mohalla, this rectangular Talav together with the ancient Jami Mosque forms a local landmark of the Mohalla (area). It is located close to the Gadhi River. The quality of lake water was poor and was largely covered with harmful

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plants and floating garbage. Even though, it is ideally located in the area, where it can become a cultural and recreational focus, the potential remains unrealized.

Picture No. 2-34: Lendale lake in Panvel

Israel Lake[65] is a manmade lake, rectangular in shape, not having any specific bund wall. The lake when constructed was not intended to be an integral part of any religious structure. It was little later that it got symbolically linked to the Jewish community of Panvel when Sheth Karamshi Hansraj donated a piece of adjoining land to that community for their burial ground. The water quality of the lake is extremely poor and needs immediate attention of the municipality and the community.

Picture No. 2-35: Israel Lake in Panvel

Khandeshwar Lake[66] derives its name from the Khandeshwar Mahadeo Temple situated on its bank. This 125-year old temple, said to be built in 1884-85, attracts large numbers of devotees throughout the year. The site, including the lake, the nursery, the temple and the

[65] The Urban Talav - a catalyst for public participation: Strategies for conserving man-made water bodies in Navi Mumbai by Smita Dalvi and Mustansir Dalvi

66 TERI

CIDCO Guest House, covers a total area of 4.2 hectares, and is very conveniently located along the Mumbai-Pune Highway (NH 4). The major threats to the lake included:

- Idol immersions during festivals
- Washing of clothes in lake water
- Presence of invasive exotic species of plants like Water Hyacinth and Ipomoea
- Disposal of organic waste from the temple
- Indiscriminate disposal of waste by local residents and visitors

Khandeshwar Lake: TERI had conceptualized the theme of a sustainable revenue generation model for the lake preservation and executed the project in collaboration with CIDCO. The salient features of consultancy included site survey, providing conceptual and working drawings, landscape designs, layout for services, BOQ (Bill of Quantities), site supervision, coordination with contractor and implementing agency. Even after 4 years of handing over of the project site to the government, the lake and the sustainable complex are very well maintained. The renovated complex is now ranked among the top three landmarks of Navi-Mumbai[67].

Picture No. 2-36: Khandeshwar Lake in Panvel

2.4.2.3 Summary of recommendations for Lakes in Greater Mumbai

Overall it can be concluded that the lakes and water bodies are in bad state and in varying degrees of environmental degradation. The bad state of the water bodies may be because the citizens have an easy access to water as a commodity that is supplied by the Urban Local Bodies (ULBs) and also they are unaware about the significance of these lakes. Hence it is important to create awareness & encouragement among the citizens for conservation and sustainable utilization of water bodies. Further, strict implementation of prevailing

67 http://m.mumbaimirror.com/index.aspx?Page=article&sectname=CITY%20-%20Briefs&sectid=35&contentid=20111111201111111120430659853b834a

policies/laws to protect lakes and water bodies should be practiced to retain the existing land use pattern and to avoid encroachment of the water bodies. In addition, it is recommended to conduct an inventory of existing water bodies in MMR since this information is not available at the regional level.

Recommendation 1: Demarcating all the water bodies on the Development Plan (DP).

In the DP of 1991, out of 107 water bodies of Greater Mumbai, only 10 water bodies have been marked as 'Tanks' or as 'Lakes'. Therefore, it is utmost important to mark all the water bodies on the DP and reserved only as 'Water bodies'. This will ensure that they are protected and the land use pattern is not changed in the future.

Recommendation 2: Stringent regulations must be formulated to have sustainable development in the vicinity of the water body like

a. Minimum 8-10 meters around the water body should be declared as a no development zone.

b. Riparian zone along the water body should be created. In the case where it is present, measures should be taken to protect it.

c. Since the catchment area around the existing water bodies have been disturbed to a large extent, at least limitation on the impervious surface/hard surfaces should be in place.

d. Concretization of the edges of the water body should be completely avoided.

e. The feeder channels of the water body should be well maintained to ensure supply of water to the water body.

Recommendation 3: Water bodies within the mill or industrial compounds should be acquired by MCGM and handed over to the relevant department for its restoration and maintenance.

Recommendation 4: Water bodies within gaothan area should have alternate arrangements for washing of clothes and cattle as shown in Picture No. 2-37.

Picture No. 2-37: Water body having an alternate arrangement for washing of clothes. (Initiative of NMMC)

Recommendation 5: Water bodies, where idol immersion practises are followed, Municipal Corporation can build an artificial tank near the main water body or construct a baffle wall as seen in Picture No. 2-38 .

Picture No. 2-38: Idol immersion in artificial lakes (Initiative of TMC)

Recommendation 6: Regular cleaning of the water bodies should be carried out.

Recommendation 7: Root zone treatment plant should be proposed where religious activities are associated with the water bodies.

Recommendation 8: The water quality analysis should also be carried out periodically as per the standard procedure of operation and necessary remedial actions should be taken to overcome the quality issue.

Recommendation 9: Awareness programmes/campaigns should be conducted to sensitize the stakeholders.

2.4.3 Reservoirs/dammed reservoirs

2.4.3.1 General information & status

A reservoir is a natural or artificial lake, storage pond or impoundment from a dam which is used to store water. Reservoirs may be created in river valleys by the construction of a dam or may be built by excavation in the ground or by conventional construction techniques such as brickwork or cast concrete. The term reservoir may also be used to describe naturally occurring underground reservoirs such as water well.[68]

In MMR, there are 22 dammed reservoirs, out of which 6 are used for water supply and 14 for irrigation purpose.

In MMR jurisdiction, there are 22 dammed reservoirs. Konkan Irrigation Development Corporation (KIDC) is responsible for survey, planning, design, construction and management of some major, medium and minor irrigation projects in Konkan Region. The detailed listing of dams is presented inTable No. 2-37 [69].

Table No. 2-37: Details of the dams of MMR

Name of Dam	Bhatsa	Barvi	Hetwane	Kalu
Nearest city	Shahapur	Ulhasnagar	Pen	Parner
District	Thane	Thane	Raigad	Ahmadnagar
River Name	Bhatsa and choma	Barvi	Bhogeshwari	Kalu
Basin	West flowing rivers Tapi to Tadri			Godavari
Type of Dam	Earthen	Earthen	Earthen	Earthen +Masonry
Purpose of Dam	Irrigation,Hydroelectric,Drinking /Water Supply	Drinking Water Supply	Irrigation,Drinking and Hydroelectricity	Irrigation
Year of Completion	1983	1978	2000	-
Catchment Area (Th ha)	38.8	16.6	7.045	18.884
Length of Dam (m)	969	746	675	2350
Max Height above foundation (m)	88.5	48.78	52.2	40.08
Max water Level(m)	143.59	68.6	90	669
Full Reservoir Level(m)	142.07	65.9	86.1	667.4
Min Draw Down Level (MDDL)(m)	792	41.15	51.05	-
Gross storage Capacity (MCM)	976.1	178.58	147.49	14.858
Live storage Capacity (MCM)	942.1	176.94	144.98	11.75

Source: ***http://india-wris.nrsc.gov.in***

68 http://en.wikipedia.org/wiki/Reservoir

69 http://india-wris.nrsc.gov.in

Name of Dam	Dolkhamb	Chotta Morbe	Velholi	Jamdhurde	Bhoj	Ransai	Usgaon	Jambhe
Nearest city	Shahapur	Panvel	Shahapur	Murbad	Ulasnagar	Uran	Bhiband	Shahapur
District	Thane	Raygad	Thane	Thane	Thane	Raygad	Thane	Thane
River Name	Local Nallah				Ulhas	Vidhane Nalla	Local Nallah	
Basin	West flowing rivers Tapi to Tadri							
Type of Dam	Earthen	Masonry	Earthen	Earthen	Earthen	Earthen	Earthen	Masonry
Purpose of Dam	Irrigation	irrigation	Irrigation	Irrigation	Irrigation	Drinking /water Supply	Irrigation	Irrigation
Year of Completion	1972	1975	1978	1984	1932	1970	1977	1972
Catchment Area (Th ha)	-	-	-	-	-	1.502	-	-
Length of Dam (m)	270	276	319	400	419	292	634	306
Maximum Height above foundation (m)	20.3	22.4	24.53	25	22.25	25.91	19.57	17.07
Max water Level(m)	-	-	-	-	-	37.2	-	-
Full Reservoir Level(m)	-	-	-	-	-	34	-	-
Minimum Draw Down Level (MDDL)(m)	-	-	-	-	-	-	-	-
Gross storage Capacity (MCM)	4.09	3.6	3.25	3.06	2.52	10	5.16	5.18
Live storage Capacity (MCM)	3.8	3.12	3	3	2.3	8.55		

Name of Dam	Kharade	Adivali	Murbadi	Morbe	Pelhar	Manivali
Nearest city	Shahapur	Shahapur	Murbadi	Khalapur	Vasai	Murbad
District	Thane			Raigad	Thane	
River Name	Local Nallah		Murbadi	Dhavari	Tr. Of Amba	Local Nallah
Basin	West flowing rivers Tapi to Tadri					
Type of Dam	Earthen	Earthen	Earthen + Masonry	Masonry	Earthen	Earthen
Purpose of Dam	Irrigation	Irrigation	Drinking /water Supply	Drinking/water Supply	Irrigation	Irrigation
Year of Completion	1985	1980	1982	2006	1975	1980
Catchment Area (Th ha)	-	-	1.592	-	-	-
Length of Dam (m)	303	386	650	3420	7.1	643
Maximum Height above foundation (m)	23.77	25.52	17.5	59.1	26	18.4
Maximum water Level(m)	-	-	-	-	-	-
Full Reservoir Level (m)	-	-	-	-	-	-
Minimum Draw Down Level (MDDL)(m)	-	-	-	-	-	-
Gross storage Capacity (MCM)	2.32	2.22	1.6	19.089	-	4.81
Live storage Capacity (MCM)	2.3	2	1.1	0.16001	-	4.7

Data for Wanjale, Thakurwadi, Jambhivali and Owe dam was not available. Hence it is not presented in the report.

Source: *http://india-wris.nrsc.gov.in*

2.4.3.2 Current issue & recommendations

Dams under construction and proposed for Mumbai Metropolitan Region are set to displace more than 30000 tribals and submerge more than 14000 hectares of primarily tribal land, including 6062 hectares forest land in global biodiversity hotspot of Western Ghats[70].

The under construction or proposed dams would displace more than 30000 tribals and submerge more than 14000 hectares of land, including 6062 hectares of forest land.

- Around 3,800 acres covering 11 villages and 4,000 families will be affected because of the Balganga dam in Pen. Land acquisition is going on, but so far there is no rehabilitation package," said Surekha Dalvi of the Shramik Kranti Sanghtana, a local NGO fighting on behalf of the affected villages.

Projects planned and Under construction: Dams around Mumbai

Name of the Dam	District	Live Storage Capacity (MCM)	Total Submergence Area (ha)	Forest Area (ha)	Population Affected
Kalu	Thane	407.99	2100	999	3169
Shai	Thane	348	3040	494 (43000 trees to be cut)	5124
Middle Vaitarna	Thane	172	3473	760 (Over one lakh trees cut)	Eight villages (minimum 1600 people)
Balganga	Raigad	127.76	1240	265	8000
Gargai	Thane	180	900	765	
Pinjal	Thane	425	1900	1188	
Barvi	Thane	338.84	4442.03	513.66 (only for the current stage)	5825
Susari	Thane, Dahanu	67.7	971	144	13 Adivasi Padas of 3 villages (minimum affected population: 5000
Lendi/Khargihill	Thane	420	1558	734	10 Villages 1484 people
Kondhane	Raigad		400	200	2000
Poshir		191			
Shilar					
Gadgadi					
Total		**2678.29**	**14929.03**	**6062.66**	**32202**

Source: ***Praineeta Dandekar, South Asia Network on Dams, Rivers and People***

- In case of dams like Kalu, Balganga and Kondhane, work on the dams already started even before a formal Forest Clearance (FC) is in place.
- Balganga Dam (Forest submergence 360 hectares) is 90% complete without host of permissions in place, including FC. (Apart from several other illegalities)
- Gargai Dam will submerge 765 hectares of forest land inside Tansa wildlife sanctuary.
- Middle Vaitarna has already submerged parts of the sanctuary.

[70] Praineeta Dandekar, South Asia Network on Dams, Rivers and People

Hence, there is an urgent need for a detailed study on the subject, to conserve the remaining forests and tribal communities in Western Ghats of Maharashtra.

2.4.4 Coastal and marine ecosystem in MMR

MMR has a coastline of 256km, on which 160 thousand people *(fishing community)* are completely depended for their livelihood. MMR has a large number of coastal and marine ecosystems representing different habitats such as estuaries, salt marshes, bays, creeks, sandy beaches, mud flats, marshes and mangrove forests that support a rich biodiversity. The shoreline is thus dominated by rocky coastal habitats between the high and low tide limits and estuarine habitats along the estuaries. Coral reefs and sea grasses are completely absent. Mangroves have been an integral part of the landscape of Mumbai since its inception. The halophytic trees and shrubs are mainly confined to areas around Thane Creek.[71] The salt pans which derive water from the coastline, **contributes to more than 98% of the salt production of the state of Maharashtra**.

Parts of the coastal zone of MMR have also become increasingly susceptible to human induced environmental stresses and economic damage by natural geophysical factors such as erosion, siltation and coastal flooding. The waste generation and disposal pressures due to domestic and industrial activities have further contributed to the deterioration of coastal marine water quality and coastal fisheries. Although several attempts have been made by local government to improve the coastal environment, this is hampered by uncontrolled growth of population and economic activity of the region.

The main problems in MMR coastal region are land use pattern, residential and industrial water supply and waste disposal, transportation-related air, soil and noise pollution, coastal marine pollution, depletion of important coastal habitats like wetlands and mangroves. It is necessary to assess the status of various sectors that are associated with these problems before deciding appropriate strategies to address them through integrated coastal management (IACM) measures.[72]

Despite the benefits offered by these ecosystems, they are highly vulnerable to reclamation, urbanization, illegal dumping of waste and debris. Dumping sites at Mulund and Kanjurmarg are located right in the mangrove belts and the aerated lagoons treating the sewage at Ghatkopar and Bhandup are too located right in the mangrove areas. Approximately, 40% of the region's untreated sewage is discharged into the creeks, thus deteriorating the creek water quality which is very much evident from the assessment of the secondary creek water quality data (elaborated in the section below). Further, oil spillage from freight movement and oil refineries is another major threat to these ecosystems. Recently (November, 2013), it was reported that the oil spill off Mahul coast, destroyed 30 acres of mangroves. Thus, it becomes essential to conserve and protect these ecosystems for the benefits they offer to nature as well as mankind.

2.4.4.1 Greater Mumbai

In Greater Mumbai, there are 46 coastal features like rocky outcrops, beaches, mangrove stretch and developed coastal edges, as per an inventory prepared by HCP Design and

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[71] http://digilab2.let.uniroma1.it/ojs/index.php/SECOA/article/download/140/129.

[72] http://www.academia.edu/6025934/Integrated_coastal_management_of_Mumbai_metropolitan_region.

Project Management Pvt. Ltd, Ahmedabad in February, 2012 for Mumbai Metropolitan Region – Environment Improvement Society (MMR-EIS)[73]. These above mentioned coastal features have been created due to the action of sea waves over a period of time.

Greater Mumbai has about 128 Km of coastline which is indented with large and small creeks. The long coastline is intersected at two points by creeks viz Manori, Malad and has two bays viz Mahim and Back Bay. So to identify the various coastline features, the entire coastal stretch from Gorai (MCGM boundary to west) to MCGM Boundary (above Airoli Bridge) was divided into 7 stretches, based on land form characteristics for ease of the study conducted by HCP Design and Project Management Pvt. Ltd.

- Stretch 1: Gorai Rocky Outcrop to Gorai Village Boundary
- Stretch 2: Dahisar to Malavani
- Stretch 3: Mindspace to Bandra
- Stretch 4: Mahim to Girgaon Chowpatty
- Stretch 5: Girgaon Chowpatty to Gateway of India
- Stretch 6: Gateway of India to Sewri Fort
- Stretch 7: Sewri Fort to MCGM Boundary (above Airoli Bridge)

The observations and findings of the study have been elaborated in the following section.

In Greater Mumbai, there are 17 rocky outcrops, 15 beaches, 7 mangrove stretches and 7 developed coastal edges. The stretch wise details are mentioned below.

Stretch 1: Gorai Rocky Outcrop to Gorai Village Boundary

The stretch 1 is located in Manori and Gorai area which is relatively at a distance from the main city, and hence it is predominantly used as a tourist spot during weekends. The different coastal features in this stretch are tabulated below in Table No. 2-38. Given that it has limited access and has been designated as a no development zone, most of the stretch has remained untouched by development. Therefore the major land use along these features are wild vegetation (20%), water bodies (17%) and scrub lands (14%) and the built land uses include various bungalows and other dwelling units outside the gaothans (10%), recreational activities (6%) and commercial setups like resorts and restaurants (3%).

During the study, it was observed by HCP Design and Project Management Pvt. Ltd that in this stretch, activities like sand and stone quarrying are quite common. Further, due to inadequate numbers of dustbins in the stretch, locals and tourists throw their wastes on the beaches and rocky outcrops. Also, lack of public toilets forces locals and tourists to use the rocky outcrops for defecation. Thus, hampering the ecological balance as well as the scenic beauty.

73 http://www.mmreis.org.in/uploadeddocuments/1203141429_Stage%203%20Report.pdf

Table No. 2-38: Coastal features in stretch 1 (Gorai Rocky Outcrop to Gorai Village Boundary)

Coastal features	No. of features	Name of the feature	Picture
Rocky outcrops	5	Gorai Culvem Sumlai Hillocks Manori Gagangiri	 Gorai rocky outcrop
Beaches	4	Gorai Beach Culvem Beach Manori Beach Manori Fishing Beach	 Gorai beach
Mangroves	1	Manor-Gorai Mangroves	 Manor-Gorai Mangroves
Coastal edges with development	0		
Total	**10**		

Source: Inventory of environmental features, Greater Mumbai, Prepared by HCP Design and Project Management Pvt. Ltd.

Stretch 2: Dahisar to Malavani

The stretch begins at Dahisar near the MCGM boundary, moves southwest up to Air Force Station Rocky Outcrops and takes a turn to the northeast abutting Madh Mangroves up to the Malavani. It is about 35 Km long stretch and the coastal features in this stretch are tabulated below in Table No. 2-39. It is also an important and popular recreational and tourist area, which is easily accessible by road from the main city. Some properties on this stretch belong to the defense, and hence are heavily guarded and inaccessible. Therefore, the major land use along the features in this stretch is water bodies (25%), open areas (15%) mudflats and scrub lands (11%). The built land uses include residences (13%), transportation and slums (4% each). As observed by HCP Design and Project Management Pvt. Ltd, the stretch was vulnerable to dumping of solid waste and open defecation on the rocky outcrops by the visitors. Some portions of Akse, Bhati and Madh beaches were inhabited and used by local fishermen and their daily activities caused the beach to remain dirty and filled with solid waste. At some places along the stretch, construction debris was also dumped, damaging the coastline and the existing ecosystems.

Table No. 2-39: Coastal features in stretch 2 (Dahisar to Malavani)

Coastal features	No. of features	Name of the feature	Picture
Rocky outcrops	6	Dana Pani Erangal Bhati Lighthouse Madh Air force Station	 Dana Pani rocky outcrop
Beaches	6	Marve Akse Dana Pani Erangal Bhati Madh	 Marve beach
Mangroves	2	Borivali Mangroves Madh Mangroves	 Borivali Mangroves
Coastal edges with development	0		
Total	**14**		

Source: Inventory of environmental features, Greater Mumbai, Prepared by HCP Design and Project Management Pvt. Ltd.

Stretch 3: Mindspace to Bandra

The stretch begins at Mindspace, moves southwest towards Versova Beach and turns southward to end at Bandra Reclamation. It is about 20 Km long stretch and the coastal features on this stretch are tabulated below in Table No. 2-40. Juhu Beach, which is a part of this stretch, is an extremely important and popular recreational and tourist area of the city. It is completely open to public and accessible by road. This whole part of the suburbs was once marshy area which over decades have been reclaimed and developed upon, the latest being the Bandra reclamation area. The mouth of Poisar, Oshiwara & Mithi Rivers and Piramal Nagar, Mogra, Irla & SNDT Nalas open out into the sea along this stretch. The predominant natural land use along the features in this stretch are open areas (34%) and water bodies (26%) and the built land uses include residences of Juhu, Khar and Bandra (16%), transportation (8%) and gaothans (4%). The northern portion of Versova Beach is inhabited and used by local fishermen. Their daily activities cause the beach to remain dirty and filled with solid waste. Due to lack of public services like, these features are prone to solid waste dumping as reported by HCP Design and Project Management Pvt. Ltd.

Table No. 2-40: Coastal features in stretch 3 (Mindspace to Bandra)

Coastal features	No. of features	Name of the feature	Picture
Rocky outcrops	2	Khar Bandra	 Khar rocky outcrop
Beaches	2	VersovaJuhu	 Versova beach
Mangroves	1	Malad Mangroves	 Malad Mangroves
Coastal edges with development	1	Bandra reclamation	 Bandra reclamation

Coastal features	No. of features	Name of the feature	Picture
Total	**6**		

Source: Inventory of environmental features, Greater Mumbai, Prepared by HCP Design and Project Management Pvt. Ltd.

Stretch 4: Mahim to Girgaon Chowpatty

The stretch begins near Bandra Reclamation, moves along Mahim Bay, turns to the south up to Girgaon Chowpatty. It is about 20 Km long stretch and the coastal features on this stretch are tabulated below in Table No. 2-41. The stretch predominantly has residential areas of Prabhadevi, Dadar, Cumballa hill and Malabar hill. The beach along the Mahim Bay as well the Girgaon Chowpatty is an extremely important and popular recreational and tourist spot. Some portion of stretch in Cumballa-Malabar Hill is heavily guarded and restricted as it is occupied by the Governor's residence and various other embassies. The mouth of Mithi River, Love Grove and Cleveland Bunder open out into the sea along this stretch.

Table No. 2-41: Coastal features in stretch 4 (Mahim to Girgaon Chowpatty)

Coastal features	No. of features	Name of the feature	Picture
Rocky outcrops	3	Worli Sea Face, Haji Ali Curve and Cumballa-Malabar Hill	 Worli sea face rocky outcrop
Beaches	3	Mahim, Dadar-Prabhadevi and Girgaon	 Mahim beach
Mangroves	0	-	-
Coastal edges with development	0	-	-
Total	**6**	-	-

Source: Inventory of environmental features, Greater Mumbai, Prepared by HCP Design and Project Management Pvt. Ltd.

Stretch 5: Girgaon Chowpatty to Gateway of India

The stretch begins at Marine Drive, moves south to Navy Nagar, turns to the northeast and ends at the Gateway of India. It is about 18 Km long stretch and the coastal features on this stretch are tabulated below in Table No. 2-42. Most of the stretch is completely developed up to the edge and the sea is also not accessible. The stretch is considered to be the commercial center of Mumbai, and houses the offices of the state government. Hence the land use along the stretch included residential (20%), transportation (15%), recreational institutions (11%), slums (10%), commercial buildings (approx 10%) and public/semi public institutions (8%). The natural land use was quite minimal, and predominantly included parks and gardens (6%) and open areas (5%). Many outfalls open out on to this edge and let out foul smell. Also various slums have flourished along the edge and regularly dump solid wastes and untreated sewage into the sea, as per the report prepared by HCP Design and Project Management Pvt. Ltd.

Table No. 2-42: Coastal features in stretch 5 (Girgaon Chowpatty to Gateway of India)

Coastal features	**No. of features**	**Name of the feature**	**Picture**
Rocky outcrops	1	Colaba Lighthouse	 Colaba light house rocky outcrops
Beaches	0		
Mangroves	0	-	-
Coastal edges with development	5	Marine Drive Back Bay Navy Nagar Sassoon Docks Colaba	 Marine drive
Total	**6**	-	-

Source: Inventory of environmental features, Greater Mumbai, Prepared by HCP Design and Project Management Pvt. Ltd.

Stretch 6: Gateway of India to Sewri fort

The stretch begins at Gateway of India and moves northwards up to Sewri Fort. It is about 15 Km long stretch and the coastal features on this stretch are tabulated below in Table No.

2-43. It has a natural deep water harbour of 400 Sq Km, and hence has been reclaimed and developed as dockyards and ports since 1750. Since it is occupied by the naval and port authorities, the entire stretch is highly guarded and restricted. The major land use is industrial (70%), as it consists of docks and allied usage. The other land uses include public/semi public institutions (15%), transportation (10%) and slums (3%). Oil spills were seen in these parts of the waters which come during boat repairs etc near the docks and the ferry wharf. Similarly sewage and waste waters from the docks were also let out into the sea, as reported by HCP Design and Project Management Pvt. Ltd.

Table No. 2-43: Coastal features in stretch 6 (Gateway of India to Sewri fort)

Coastal features	No. of features	Name of the feature	Picture
Rocky outcrops	0	-	-
Beaches	0	-	-
Mangroves	0	-	-
Coastal edges with development	1	Docks and Ports	 Docks and Ports
Total	**1**		

Source: Inventory of environmental features, Greater Mumbai, Prepared by HCP Design and Project Management Pvt. Ltd.

Stretch 7: Sewri fort to Airoli Bridge

The stretch begins from Sewri Fort, moves towards the north abutting the Mahul Creek, BARC and Bhandup/Mulund Mangroves and ends at MCGM boundary above Airoli Road. It is about 20 Km long stretch and the coastal features are tabulated below in Table No. 2-44. The stretch is popular area for bird watchers. Some portion of the stretch in Trombay is heavily guarded and restricted as it is occupied by Bhabha Atomic Research Center (BARC). The entire stretch is not very accessible due to the presence of vast stretches of mangroves. The natural land use included water bodies (34%) and scrub land (7%). Further, large tracts of salt pans (26% of total land use) were observed in and around the mangroves by HCP Design and Project Management Pvt. Ltd. The other built land use along the features is quite minimal and include industries and transportation (5% each), public/semi public institutions (3%) and slums (2%). Further, it was observed by HCP Design and Project Management Pvt. Ltd that Mahul Creek receives a lot of organic sewage and effluents from oil refineries and waste water from the Thermal Power Station. The debris from construction activities carried to restore the Sewri Fort was also dumped in the nearby mangroves. Also various settlements and slums have sprawled all along the coast, dumping untreated sewage and wastes directly into the mangroves and the sea.

Table No. 2-44: Coastal features in stretch 7 (Sewri fort to Airoli Bridge)

Coastal features	No. of features	Name of the feature	Picture
Rocky outcrops	0	-	-
Beaches	0	-	-
Mangroves	3	Mahul Creek Mangroves BARC Mangroves Bhandup / Mulund Mangroves	 Mahul creek mangroves
Coastal edges with development	0	-	-
Total	**3**		

Source: Inventory of environmental features, Greater Mumbai, Prepared by HCP Design and Project Management Pvt. Ltd.

2.4.4.2 Rest of MMR

For rest of MMR, a detailed inventory of coastal feature has not been carried out yet. Hence it is strongly recommended to undertake a comprehensive study on the subject. Few of the prominent features are listed below.

Sr. No.	Name of the coastal feature	Remark/description
1	Arnala beach Source: http://www.mumbai77.com/city/939/beaches/arnala-virar/	The beach is located in the Virar region. 
2	Dharamtar creek Source: http://en.wikipedia.org/wiki/Dharamtar	• Located 2 km from Wadkhal village in Raigad and is at confluence of Amba river, Patalganga river and Karanja creek • It is used for services such as transportation of containers etc. 
3	Bassein creek Source: http://travelingluck.com/Asia/India/India+%28general%29/_1276745_Bassein+Creek.html#.U-sxEKNLcoM	Bassein creek is located in the Bassein village of Vasai taluka in Thane district.

Sr. No.	Name of the coastal feature	Remark/description
		
4	Bhayander creek Source: http://www.mumbai77.com/city/3118/information-about/bhayander-creek/	• Exactly below the Mumbai Western Railway Bridge between Naigaon & Bhayander lies the creek of Bhayander, well know as Bhayander ki khadi. • Famous for fishing & sand business • Widely used during Ganesh visarjan. 
5	Ulhas creek Source: http://en.wikipedia.org/wiki/Ulhas_River	Ulhas creek extends from Kalyan-Bhiwandi bridge in Kalyan till Versova bridge. 
6	Thane creek Source: http://en.wikipedia.org/wiki/Thane_Creek	• Lies between Ghobunder (section of Ulhas river flows through this region) and Gharapuri island • It has been recognized as important bird area by Bombay Natural History Society (BNHS)

Sr. No.	Name of the coastal feature	Remark/description
		• Recent water quality analysis report has shown increasing evidence of pollution. 
7	Uttan creek **Source:** Google earth	 It is located in Uttan village in Bhayender.
8	Vashi creek Source: Google earth	It is located from Vashi bridge to Gharapuri island, also a part of Thane creek. 

2.4.4.3 Creek/sea water quality information and assessment

In MMR, there are 23 creek WQM stations, under the NWMP (National Water Monitoring Programme), initiated by CPCB or SWMP (State Water Monitoring Programme) initiated by MPCB. The secondary water quality data of seafront and creeks was assessed for the years 2008-2013 and compared with the permissible standards stipulated by CPCB for SW-II category for commercial fishing, contact recreation and bathing water. Further, the WQI was also computed by TERI for the year 2012-13. The detailed assessment is presented below.

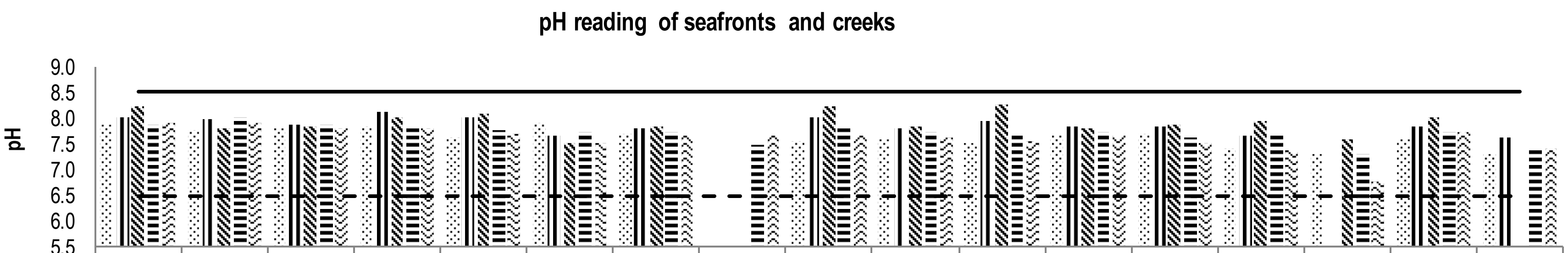
Parameter 1: pH

Permissible CPCB standard:

Between 6.5 and 8.5

Observation: The pH readings at all the creek WQM stations are within the permissible CPCB standards.

Note: The data for the WQM stations nos. 2810 and 2803 for the respective years 2008-11 and 2009-10 was not available for assessment.



	Arnala Sea 2805	Uttan Sea 2806	Varsova Beach 2169	Juhu Beach 2812	Shivaji Park 2811	Mahim creek 1318	Worli Seaface 2167	Haji ali 2810	Malabar Hill 2809	Charni Road Choupathy 2166	Nariman Point 2808	Gateway of India 2165	Airoli Bridge 2184	Vashi Bridge 2185	Panvel Creek 2803	Elephanta Island 1317	Kalwa Road Bridge 2793
2008-09	7.9	7.8	7.8	7.8	7.6	7.9	7.7		7.6	7.6	7.5	7.7	7.7	7.4	7.3	7.6	7.3
2009-10	8.0	8.0	7.9	8.1	8.0	7.7	7.8		8.0	7.8	7.9	7.9	7.9	7.7		7.8	7.6
2010-11	8.2	7.8	7.8	8.0	8.1	7.5	7.8		8.2	7.8	8.3	7.8	7.9	7.9	7.6	8.0	
2011-12	7.9	8.0	7.9	7.8	7.8	7.7	7.7	7.5	7.8	7.7	7.7	7.7	7.6	7.7	7.3	7.7	7.4
2012-13	7.9	7.9	7.8	7.8	7.7	7.5	7.7	7.7	7.7	7.6	7.6	7.7	7.5	7.4	6.8	7.7	7.4
Permissble limit	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5
Desirable limit	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5

Figure No. 2-61: pH reading of seafronts and creeks.

Source: MPCB

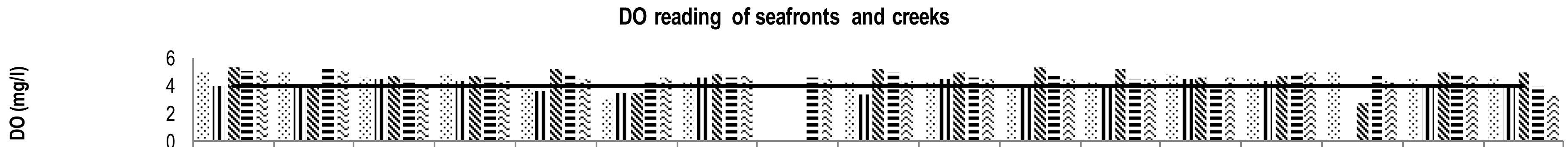
Parameter 2: Dissolved Oxygen (DO)

Permissible CPCB standard: 4 mg/l (minimum desirable standard)

Note: The data for the WQM stations nos. 2810 and 2803 for the respective years 2008-11 and 2009-10 was not available for assessment.

Observation:

The DO readings were found to be below the minimum desirable CPCB standards at Uttan (3.9 mg/l in the year 2009-11), Shivaji park (3.6mg/l in the year 2009-10), Mahim creek (3.1, 3.5 and 3.4 mg/l for the year 2008-09, 2009-10 and 2010-11 respectively), Malabar hill (3.3 mg/l in the year 2009-10), Nariman point (3.8 mg/l in the year 2009-10), Panvel creek (2.7 mg/l in the year 2010-11) and Kalwa bridge (3.8 mg/l in the year 2009-10). The possible reason for the exceedance may be due to higher organic waste content.



Sea/Creek water Sampling	Arnala Sea 2805	Uttan Sea 2806	Varsova Beach 2169	Juhu Beach 2812	Shivaji Park 2811	Mahim creek 1318	Worli Seaface 2167	Haji ali 2810	Malabar Hill 2809	Charni Road Choupathy 2166	Nariman Point 2808	Gateway of India 2165	Airoli Bridge 2184	Vashi Bridge 2185	Panvel Creek 2803	Elephanta Island 1317	Kalwa Road Bridge 2793
2008-09	5.0	4.9	4.6	4.9	4.0	3.1	4.2		4.4	4.4	4.0	4.3	4.9	4.5	5.1	4.5	4.6
2009-10	4.0	3.9	4.5	4.3	3.6	3.5	4.6		3.3	4.5	3.8	4.2	4.5	4.4		4.0	3.8
2010-11	5.3	3.9	4.7	4.7	5.2	3.4	4.8		5.2	5.0	5.3	5.2	4.6	4.7	2.7	5.0	5.0
2011-12	5.0	5.2	4.5	4.6	4.8	4.2	4.5	4.6	4.9	4.6	4.8	4.4	4.1	4.8	4.7	4.8	4.0
2012-13	5.1	5.1	4.1	4.4	4.5	4.6	4.7	4.5	4.3	4.5	4.5	4.5	4.7	4.9	4.4	4.7	3.3
Permissble limit	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0

Figure No. 2-62: DO reading of seafronts and creeks.

Source: MPCB

Parameter 3: Biochemical Oxygen Demand (BOD)

Permissible CPCB standard: 3 mg/l

Observation:

Note: The data for the WQM stations nos. 2810 and 2803 for the respective years 2008-11 and 2009-10 was not available for assessment.

The BOD readings at all the WQM stations exceeded the permissible CPCB standard. The possible reason for the exceedance may be untreated sewage discharge and the inefficiency of the STPs present in the region.

BOD reading of seafronts and creeks

Sea/Creek water Sampling	Arnala Sea 2805	Uttan Sea 2806	Varsova Beach 2169	Juhu Beach 2812	Shivaji Park 2811	Mahim creek 1318	Worli Seaface 2167	Haji ali 2810	Malabar Hill 2809	Charni Road Choupathy 2166	Nariman Point 2808	Gateway of India 2165	Airoli Bridge 2184	Vashi Bridge 2185	Panvel Creek 2803	Elephanta Island 1317	Kalwa Road Bridge 2793
2008-09	9.2	9.3	10.3	10.5	16.2	24.2	17.3		14.8	15.8	10.6	15.4	7.4	8.8	7.0	9.6	14.4
2009-10	14.2	14.8	11.5	13.0	15.3	10.0	12.1		15.4	13.2	14.8	12.8	10.8	12.3		11.3	10.7
2010-11	6.3	36.2	8.7	7.6	7.6	31.4	9.5		10.2	10.0	8.3	9.3	8.4	9.0	32.7	8.2	8.0
2011-12	11.8	11.1	13.0	13.1	11.2	13.1	12.0	9.8	10.6	12.7	12.5	12.5	27.4	10.2	9.3	12.0	14.7
2012-13	10.6	11.0	12.6	12.3	11.4	12.9	11.1	11.1	12.9	11.9	11.7	11.3	10.2	10.0	27.1	12.1	22.0
Permissble limit	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0

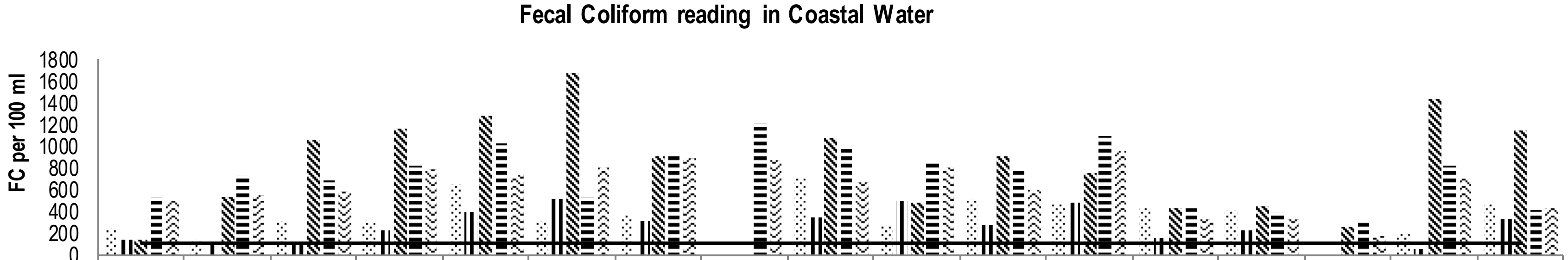
Figure No. 2-63: BOD reading of seafronts and creeks. Source: MPCB

Parameter 4 & 5: Fecal Coliform (FC)

Permissible CPCB standard: 100/100 ml (MPN)

Observation:

The FC readings at almost all the WQM stations (except 2 WQMS) exceeded the permissible CPCB standard. The possible reason for the exceedance may be untreated sewage discharge and the inefficiency of the STPs present in the region, indicating higher presence of human or animal waste.



	Arnala Sea 2805	Uttan Sea 2806	Varsova Beach 2169	Juhu Beach 2812	Shivaji Park 2811	Mahim creek 1318	Worli Seaface 2167	Haji ali 2810	Malabar Hill 2809	Charni Road Choupathy 2166	Nariman Point 2808	Gateway of India 2165	Airoli Bridge 2184	Vashi Bridge 2185	Panvel Creek 2803	Elephanta Island 1317	Kalwa Road Bridge 2793
	Sea/Creek water Sampling																
2008-09	240	137	308	296	649	309	383		699	281	510	471	434	409		190	460
2009-10	138	96	118	223	400	520	301		341	505	278	478	151	227		61	325
2010-11	132	529	1070	1157	1285	1680	900		1075	485	906	758	425	438	250	1444	1145
2011-12	535	729	684	830	1033	535	941	1213	976	856	780	1093	431	391	311	827	414
2012-13	491	543	579	784	731	798	883	877	670	813	596	964	334	320	168	698	423
Permissble limit	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Figure No. 2-64: FC reading of seafronts and creeks

Source: MPCB

Note: The data for the WQM stations nos. 2810 and 2803 for the respective years 2008-11 and 2009-10 was not available for assessment.

2.4.4.4 Water quality index (WQI) & recommendations

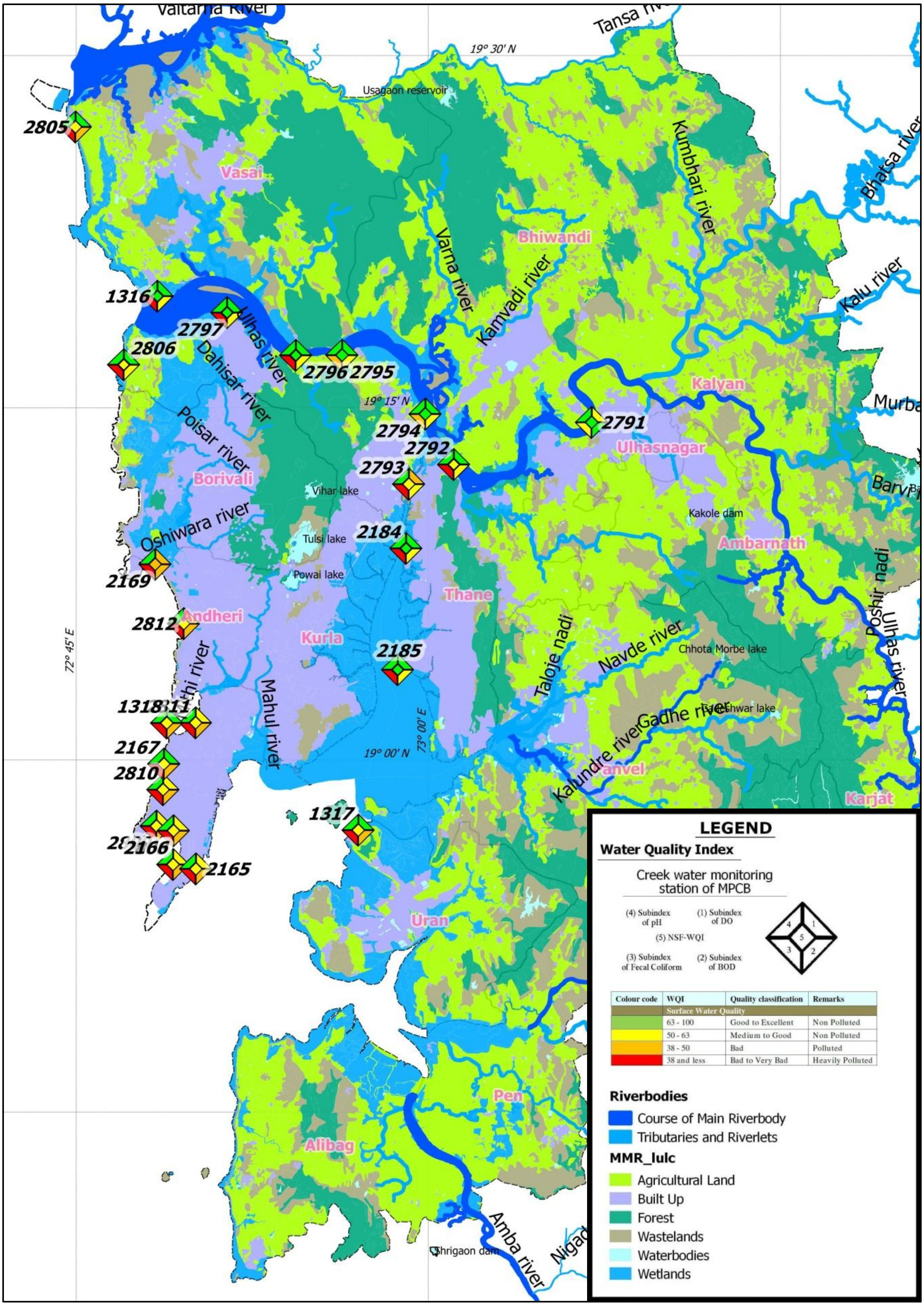
The water quality index was calculated for 24 water sampling locations. As seen in Table No. 2-45 and Map No. 0 25, the seafront/creek water quality during post monsoon was found to be good quality except at a sampling location near Oshiwara River *(WQMS 2169).* Whereas during pre monsoon, 21 WQMS *(87% of the sampling locations)* revealed bad water quality due to higher BOD and FC content.

Hence, it is strongly recommended to implement strategies to ensure that the creek water quality is in the acceptable range. The prevailing norms for improving and maintaining the creek water quality should be strictly followed and executed. Also it is recommended to have uniform distribution of WQMS to get an overview of the water quality of the entire coastline.

Table No. 2-45 WQI for sea/creek water in MMR

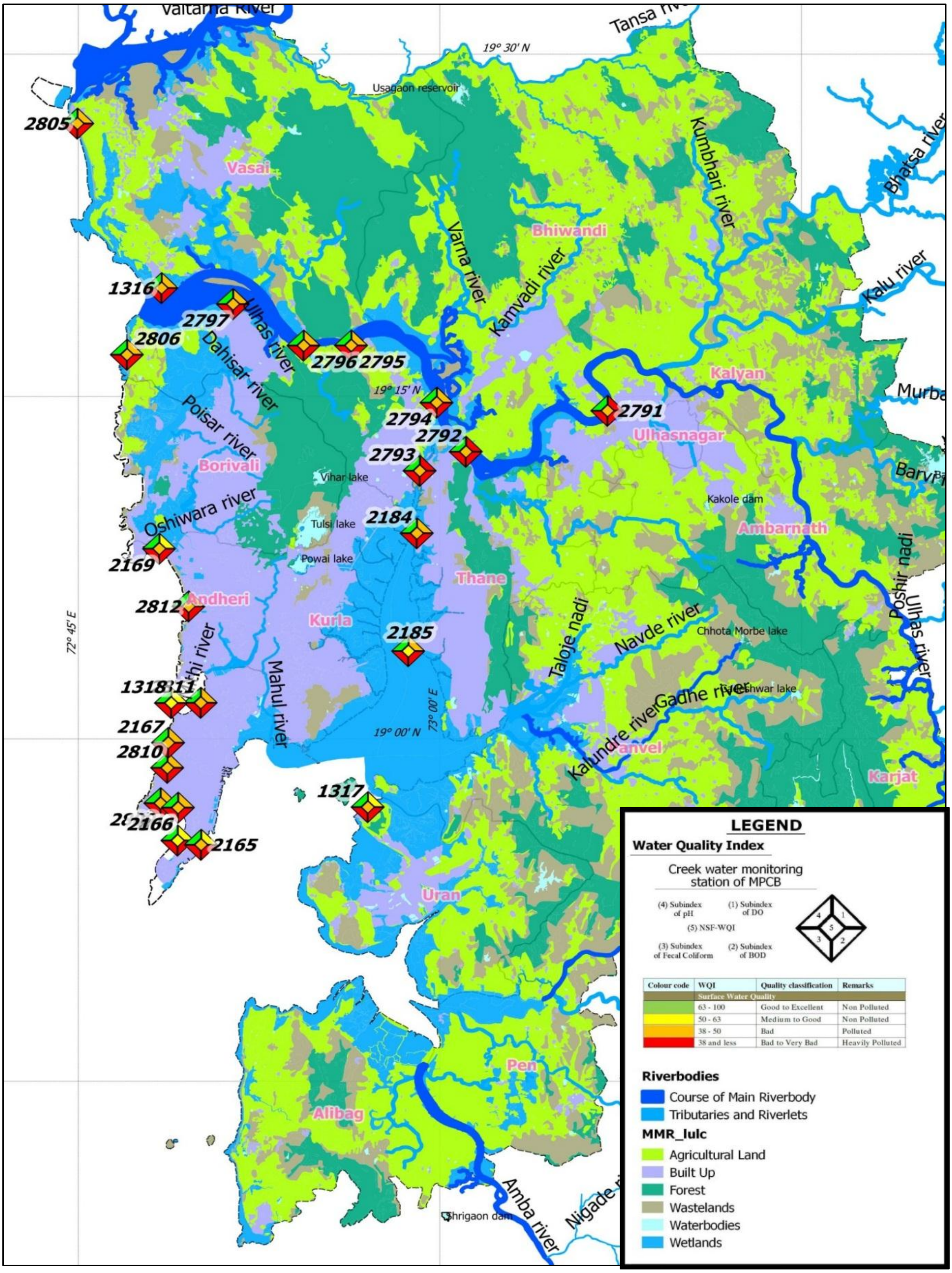
	WQI-DO	WQI-BOD	WQI-FC	WQI-pH	WQI
Total number of river water quality monitoring station- 24 No.					
Creek and Coastal water sampling stations					
Post monsoon period (June, 2012 to November, 2012)					
Good to excellent *(Green)*	14	2	0	24	**9**
Medium to good *(Yellow)*	8	10	1	0	**14**
Bad *(Orange)*	2	12	3	0	**1**
Bad to very Bad *(Red)*	0	0	20	0	**0**
Pre monsoon period (December, 2012 to May 2013)					
Good to excellent *(Green)*	0	0	0	24	**0**
Medium to good *(Yellow)*	5	0	0	0	**3**
Bad *(Orange)*	15	0	0	0	**21**
Bad to very Bad *(Red)*	4	24	24	0	**0**

Source: MPCB, MRSAC



Map No. 2-25 Creek water quality monitoring locations & its NSF-WQI for post monsoon period from June, 2012 to November, 2012

Source: MPCB, MRSAC



Map No. 2-26 Creek water quality monitoring locations & its NSF-WQI for pre monsoon period from December, 2012 to May, 2013

Source: MPCB, MRSAC

GroundWater Resources

2.5 Groundwater resources in MMR

In MMR municipal limits there are more than 5660 dug wells, 7511 tube wells, 1906 bore wells and 3715 hand pumps. The dependence of the region on these resources is to the tune of 293.35 MLD.

Groundwater is water that is found underground in cracks and spaces in soil, sand and rocks. The area where water fills these spaces is called the saturated zone. Groundwater also exists in cracks and fractures in crystalline rocks such as granite or limestone.[74] Groundwater accounts to 38.5 % of the total available fresh water resources in India which plays a major role in irrigation, rural water supply and even in meeting industrial and drinking water needs.

A unit of rock or an unconsolidated deposit or water bearing rocky formation is called an aquifer when it can yield a usable quantity of water. Whereas, the depth at which soil pore spaces or fractures and voids in rock become completely saturated with water is called the water table. That means the water table is the top of the saturated zone. The water beneath the water table is groundwater. The depth of water table varies according to location, season and long term climate variation.

Recharging of groundwater:

Groundwater recharge is the inflow of water to the groundwater system from the surface. Infiltration of precipitation and its movement to the water table is one form of natural recharge.[75] Groundwater is recharged naturally by rain and snow melt and to a smaller extent by surface water (rivers and lakes). Groundwater recharge is an important process for sustainable groundwater management.

Extraction of groundwater

The process, deliberate or inadvertent, of extracting groundwater from a source at a rate so in excess of the replenishment that the groundwater level declines persistently, threatening exhaustion of the supply or at least a decline of pumping levels to uneconomic depths is called as groundwater extraction.[76] Groundwater is open access common property natural resource and anyone can bore a well and pump out the water without limit. Most water is used for irrigation or drinking purposes. Groundwater is also extracted on large scale for industrial use and construction activities.

The groundwater is mainly extracted by forming an excavated structure that is a well in the ground. A **well** is an excavation or structure created in the ground by digging, driving, boring, or drilling to access groundwater in underground aquifers. The well water is drawn

74 http://www.oregongeology.org/sub/Water/groundwater.htm

75 http://www.water.gov.au/WaterAvailability/Whatisourtotalwaterresource/GroundwaterRecharge/index.aspx?Menu=Level1_3_1_6

76 http://www.eionet.europa.eu/gemet/en/concept/2417/

by a pump, or using containers. There are different kinds of wells such as dug wells, bore wells, tube wells and so on. **Dug wells** are open wells having comparatively bigger diameter which generally vary from 5 m – 15 m with the depth generally less than 25 m. The dug wells are constructed just beyond the water level. These wells are normally found in weathered hard rocks and in alluvial formation. **Bore wells** are of shallow and deep types. Shallow bore wells can be constructed where the water table exists at shallow depth in an unconsolidated sandy aquifer whereas deep bore wells are constructed for several meters and the depth may exceed more than 100 m. A **tube well** is a type of water well in which a long 100–200 mm (5 to 8 inch) wide stainless steel tube or pipe is bored into an underground deep aquifer. The lower end is fitted with a strainer. A pump fitted at the top lifts the water. The required depth of the well depends on the depth of the water table.

Issues with groundwater

Earlier in Mumbai, rainwater was the main source of water supply and it was collected in number of tanks like Mumba Devi, Manamala, Babula, Govalia, Gilder, Banganga, and so on. These tanks, wells and lakes were the main sources of water in earlier years. After the centralized water supply through pipe lines was regularized, these traditional water sources got neglected and now those are been misused for activities like idol emersion and dumping of solid waste.

According to Groundwater Survey & Development Agency (GSDA), the area occupied by phreatic aquifers (porous rock layers transmitting undergroundwater) is limited between the seacoast and hill ranges in Mumbai and scope for recharge from rainfall is limited.[77] In such cases a deep aquifers can yield water for meeting the growing demand and these can artificially be recharged with rainwater. However, wherever there is heavy withdrawal of bore well water, problem of seawater ingression is likely to arise and, hence, it is necessary to recharge the wells from which water is drawn. Industrial effluents, open drains and open defecation causes polluted water to seep into groundwater affecting its quality. Rainwater recharge can improve the deteriorating water quality and reduce salinity.

Further, government has no direct control over the groundwater use by millions of private well owners, both in rural and urban areas. In part, this is due to the absence of a systematic registering of wells with attached user rights and metering. In an indirect way, groundwater use is also sometimes limited through power shedding with limited hours of electricity supply, especially in rural areas. But in general there is no regulation on extraction of groundwater.

The following section elaborates on the groundwater sources in MMR, their types, average daily supply, groundwater quality data generated at different monitoring stations, water quality assessment, gaps and recommendations.

77 http://www.bcpt.org.in/webadmin/publications/pubimages/watersupply.pdf

2.5.1 Status of groundwater resources in MMR

The major available groundwater sources are dug wells, bore wells and tube wells / hand pumps. There are 5454 dug wells and 7511 tube wells in Greater Mumbai region (Figure No. 2-65). As per the Environmental Status Report of MCGM for the year 2011-12, total extraction of groundwater from these 12,965 wells was 259 MLD for Greater Mumbai city. Wheras in the rest of MMR, there are 3715 tube wells/hand pumps, 1960 bore wells and 206 dug wells from where 34.35 MLD of water is extracted daily. In all in the MMR region, 293.35 MLD of water is drawn from groundwater resources. At many places in coastal tehsils of Thane district, dug wells are converted into tube wells or bore wells as the water level has gone down. However, in coastal regions such activities may cause sea water intrusion in groundwater wells degrading quality of groundwater.

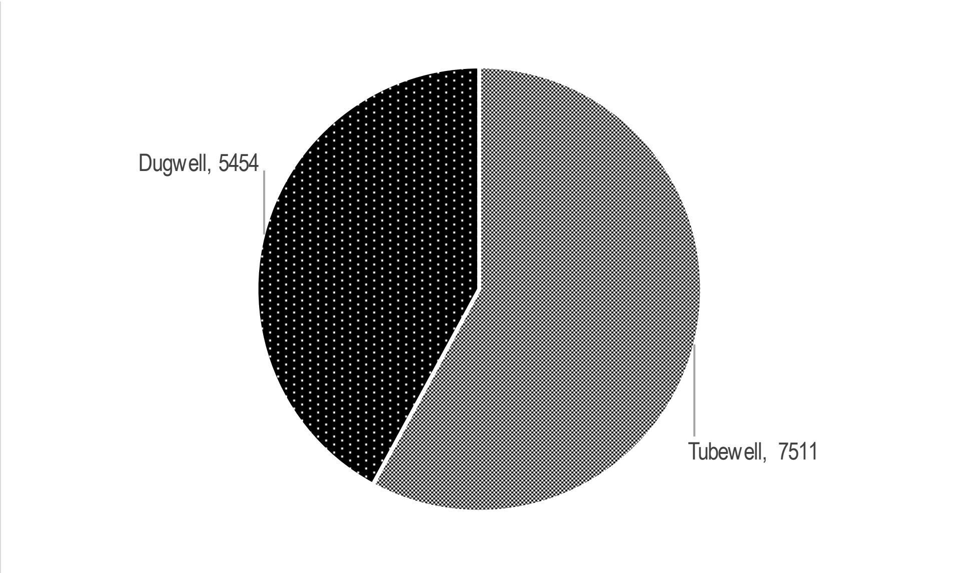


Figure No. 2-65: Number of dug and tube wells in Greater Mumbai

Source: MJP & ESRs

Major issue is pollution of groundwater as well as surface water due to dumping of sewage and industrial effluents. In addition to this various industrial effluents from oil refineries, reactors, fertilizers have polluted the groundwater. As a result the concentration of heavy metals in groundwater in the surrounding areas of creek has been observed beyond the prescribed limits. Groundwater exploitation for commercial purpose like construction purposes, hotel industry and for domestic purpose of the housing societies is carried out in entire district and the water is extracted from existing dugwells and borewells, even new borewells are also being drilled for this purpose.[78]

[78] http://cgwb.gov.in/District_Profile/Maharashtra/Greater%20Mumbai.pdf

According to recent decision taken by MCGM, it has asked large bulk consumers such as malls, multiplexes, five star hotels, the Mumbai Port Trust and the Railways to go in for bore-wells to take care of their non-potable water consumption. The MCGM is also planning to acquire nearly 1,000 private wells for supply of water to the city. Additionally MCGM has set aside nearly INR 10 crore for taking up the new bore well digging work in its year's fiscal exercise. The MCGM will also be spending INR 60 crore towards repair and cleaning of the 188 existing bore wells. About 8-10 million litres water is expected to be generated on a daily basis. This solution of MCGM to augment the supply of water would prove more hazardous. This will worsen the situation of groundwater. Already there is no regulation about extraction of groundwater and encouraging bulk users to access groundwater would facilitate the saline ingress3.[79]

Groundwater level trend (1998 – 2007)

Trend of water levels for premonsoon and postmonsoon periods for last ten years (1998-2007) have been computed for 4 National Hydrograph Network Stations (NHNS). Analysis of long term water level trend data indicates fall in water levels in all the 4 NHNS and it ranges between 0.11 (Church Gate) and 0.38 m/year (A.M.C. Colony). During postmonsoon period rise in water level of 0.09 m/year has been recorded at only 1 NHNS located at Mahroli (Chemur) while at 3 NHNS fall in water level have been recorded and it ranges between 0.02 (Colaba (Dandi)) and 0.26 m/year (A.M.C. Colony). Thus in major parts of the district, both during premonsoon.[80]

79 http://www.mumbaidp24seven.in/reference/Mumbai_Water_supply(Review_Report).pdf

80 http://cgwb.gov.in/District_Profile/Maharashtra/Greater%20Mumbai.pdf

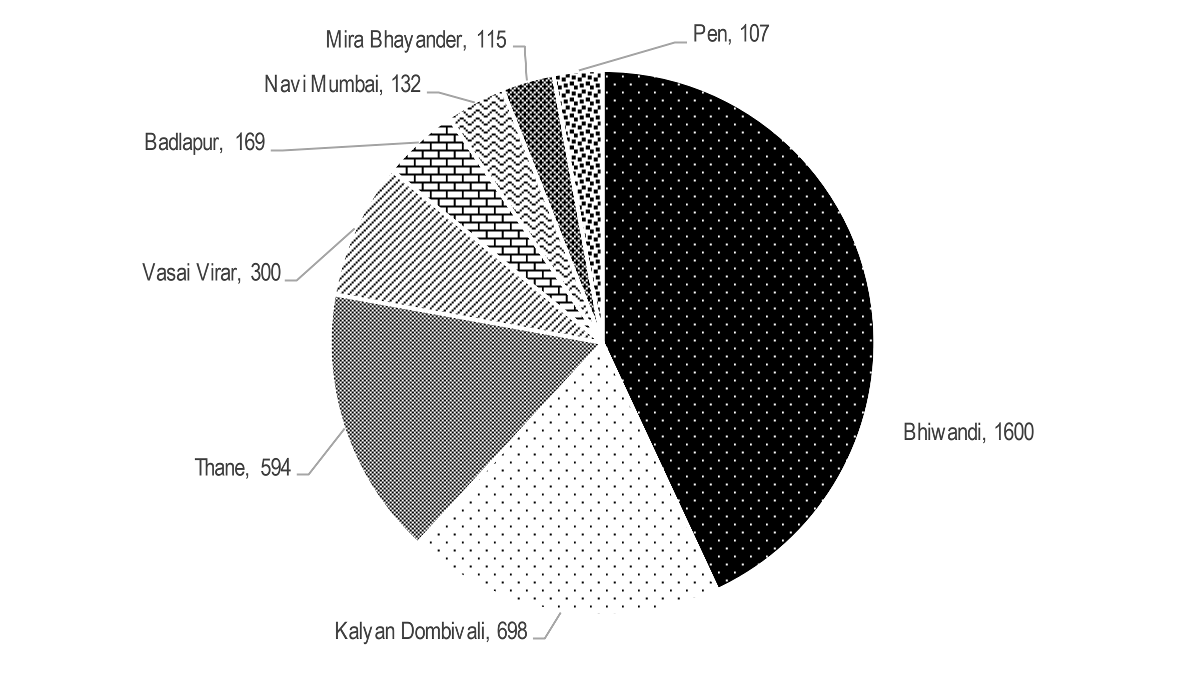


Figure No. 2-66: Number of Tube wells / hand pumps (3715) in rest of MMR Source: ***MMRDA***

Source: MMRDA

As seen in Figure No. 2-66, Bhiwandi area has the maximum number of tube wells (1600 wells). Water scarcity in summers may have posed the increase in number of tube wells to extract water from deeper aquifers in Bhiwandi. Further, Bhiwandi does not lie directly along the coastline so the extraction of water from deeper aquifer is possible. Also the water demand at Bhiwandi is high to support the large number of population (Population: 7, 11,000 and density per Sq.Km. 2371, as per 2011 census data). The water consumption in litres per capita per day in Bhiwandi area is 100 lpcd as against the standard of 135 lpcd. Hence to meet the water demand, the depandance on groundwater is observed. After Bhiwandi, Kalyan-Dombivali has the maximum number of tube wells (698 wells). The city has huge industrial as well as residential settlement. To support the increasing water demand and having limited options of water supply the usage of groundwater is being explored.

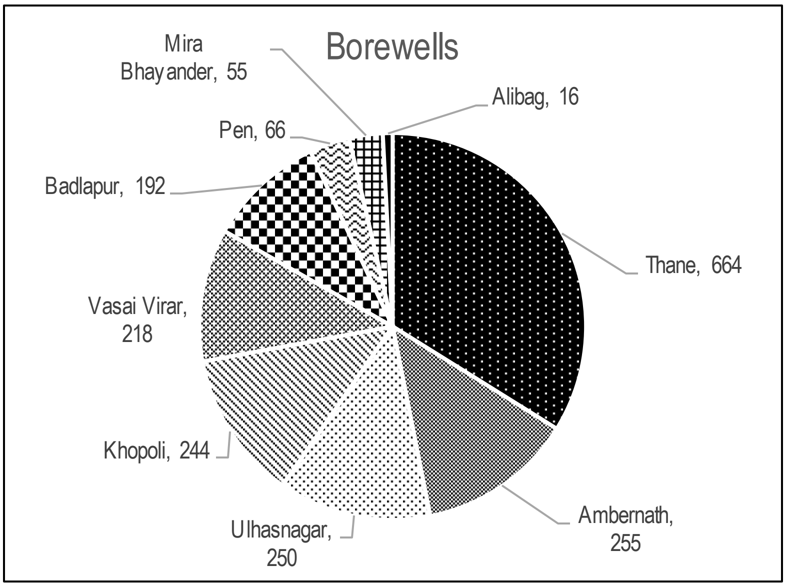


Figure No. 2-67: Number of Bore wells (1960) in rest of MMR

Source: MMRDA

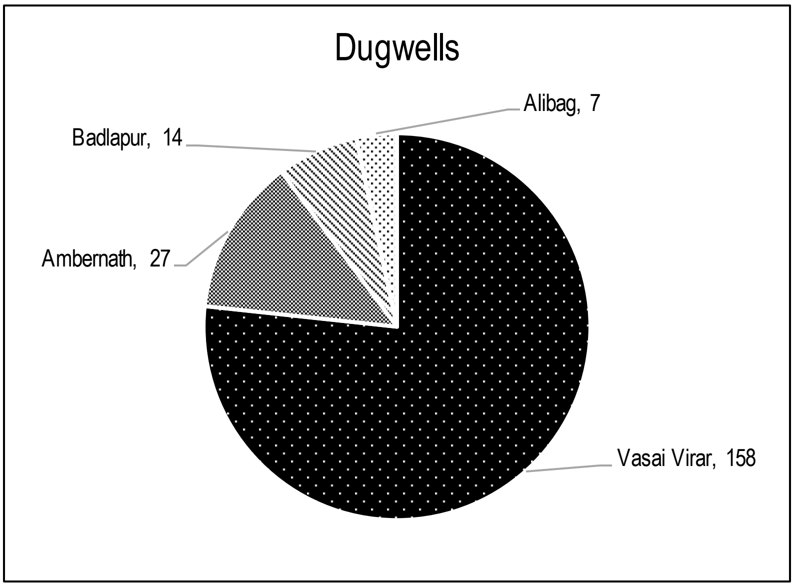


Figure No. 2-68 Number of Dug wells (206) in MMR

Source: MMRDA

The groundwater quality is monitored by CGWB, GoI and MPCB. In all there are 47 ground WQM stations in MMR (44 WQMS installed by CGWB and 3 by MPCB). The assessment revealed that 71% of the sampling locations showed good water quality whereas 9% showed poor water quality due to agricultural run-off, old or badly designed landfills, leakages from septic tanks.(For the remaining 20%, the secondary data was not available for assessment.) Further, 43% of the monitoring locations exhibited decreasing trend in the water level due to over extraction, especially the Vasai Virar and parts of Raigad district.

As seen in Figure No. 2-67 and Figure No. 2-68, Vasai Virar is a prominent coastal belt of Thane district having maximum number of dug wells. Being along the coastline the geological conditions of this area do not allow deepening of wells. However, at some locations some of the dug wells are converted into bore wells as the water table has lowered. The intensive water demand for agriculture, floriculture and horticulture is another reason for increasing dug wells. Also dug well is financially low profile technology to extract water.

Another possible reason for higest dug wells could be the per capita availability of water which is as low as 76.5 lpcd in the city (second lowest lpcd in the MMR).

2.5.2 Groundwater quality monitoring

Groundwater plays a key role in meeting the water needs of various user-sectors in India. With growing awareness, the dependability on groundwater as a sustainable resource in nation building reasserts the need for an organization like Central Groundwater Board (CGWB) which is vested with the responsibilities of assessing and managing the groundwater resources of the country through groundwater management studies, exploration, evaluation and monitoring of groundwater regime.

But unfortunately it has been getting polluted day by day due to different anthropogenic activities. So it is of paramount importance to conserve the water and prevent it from all sorts of pollution. There should be proper water investigation and management. This could be possible by continuous Water Quality Monitoring (WQM).[81] The following section elaborates on the status of the groundwater quality in MMR.

In MMR, groundwater quality is monitored by Central Pollution Control Board (CPCB) & CGWB and they have installed **44 WQMS** which regularly monitor the water quality as per the prescribed standards. In addition, MPCB also monitors the groundwater quality data and has installed **3 WQMS** in the region. However the data for all the parameters for these MPCB WQMS was not available and hence the assessment could not be carried out. CGWB periodically monitors 5 NHNS in the district, four times a year i.e. January, May (Premonsoon), August and November (Postmonsoon).

The details of the 44 water quality monitoring stations along with their geographic positions (Latitudes and Longitudes), constant depth, surface elevation, and groundwater quality rating has been tabulated in Table No. 2-46.

Table No. 2-46: WQMS installed by CPCB

Block name	Name	ID	Const_Dept	Surface_EL	Latitude	Longitude	Groundwater rating
Mumbai (Suburban)	A.M.C. Colony	C/BB-001	12.85	45.21	19.1353°	72.8872°	Excellent
Mumbai (Suburban)	Dahisar	C/BB-003	8.83	19.29	19.2556°	72.8714°	Good
Mumbai (Suburban)	Mahroli (Chemur)	C/BB-004	8.30	10.54	19.0389°	72.8944°	Good
Mumbai	Bombay (Church Gate)	C/BB-002	4.40	4.24	18.9319°	72.8311°	Good
Mumbai	Colaba	C/BB-005	5.04	4.21	18.8967°	72.8111°	Good

81 http://mpcb.gov.in/images/pdf/WQ_Report_hydalogy_dept.pdf

Block name	Name	ID	Const _Dept	Surface _EL	Latitude	Longitude	Groundwater rating
	(Dandi)						
Mumbai	Mahim	C/BB-006	5.80	2.04	19.0250°	72.8444°	Good
Alibag	Bilji (Umta)	C/RG-012	6.10	6.31	18.5347°	72.9833°	Excellent
Alibag	Nagaon	C/RG-033	7.30	17.99	18.6117°	72.9000°	Good
Alibag	Poynad	C/RG-032	7.71	14.94	18.6917°	72.9917°	Good
Karjat	Hudhre Budruk (Karjat	C/RG-010	6.70	47.34	18.9125°	73.3194°	Good
Karjat	Kadav	C/RG-019	4.60	0.00	18.9667°	73.4000	Not Available
Karjat	Neral	C/RG-018	4.20	38.35	19.0292°	73.3250	Excellent
Khalapur	Kargaon	C/RG-023	6.54	80.43	18.7264°	73.2986	Excellent
Khalapur	Khalapur	C/RG-036	7.20	71.69	18.8278°	73.2842	Excellent
Khalapur	Khopoli	C/RG-013	4.83	4.83	18.7833°	73.3333	Excellent
Panvel	Ajivali	C/RG-038	5.20	12.14	18.9528°	73.1500	Good
Panvel	Chinchwad	C/RG-014	9.49	46.23	18.9250°	73.1167	Excellent
Panvel	Kone	C/RG-002	8.49	18.24	18.9500°	73.1500	Not Available
Panvel	Navade	C/RG-031	5.30	0.00	19.0481°	73.1017	Excellent
Panvel	Sangurli	C/RG-040	75.00	18.76	18.9375°	73.1167	Not Available
Pen	Jite	C/RG-020	7.80	1.66	18.8139°	73.0875	Excellent
Pen	Vadkhal	C/RG-037	4.60	5.16	18.7333°	73.0500	Poor
Pen	Veshwi	C/RG-001	9.82	13.09	18.7500°	73.0333°	Good
Pen	Wadkhal	C/RG-015	8.58	0.00	18.7333°	73.0500°	Not Available
Bhiwandi	Ambadi	C/TN-029	7.30	23.70	19.4667°	73.1000°	Good
Bhiwandi	Angaon	C/TN-013	5.50	23.16	19.3667°	73.0833°	Poor
Bhiwandi	Padghe	C/TN-026	5.25	21.77	19.3625°	73.1722°	Good
Kalyan	Kolimb	C/TN-018	6.00	51.76	19.2833°	73.2667°	Excellent
Kalyan	Netivli	C/TN-044	9.50	17.25	19.2208°	73.1222°	Not Available
Thane	Bindarpada	C/TN-001	6.80	3.89	19.2833°	72.9500°	Excellent
Thane	Dahisar	C/TN-028	6.50	19.01	19.1111°	73.0639°	Good
Thane	Dahisar (New)	C/TN-055	7.95	19.29	19.2642°	72.8783°	Good
Thane	Diga	C/TN-034	2.25	0.00	19.1736°	73.0014°	Not Available
Thane	Shiravane	C/TN-031	5.20	20.55	19.0444°	73.0208°	Good
Ulhasnagar	Katolwadi (Mulgaon)	C/TN-039	7.00	61.63	19.1639°	73.3028	Excellent
Ulhasnagar	Navali	C/TN-056	6.82	0.00	19.1778°	73.1528°	Not Available
Vasai	Agashi	C/TN-046	7.30	9.92	19.4667°	72.7728°	Good

Block name	Name	ID	Const _Dept	Surface _EL	Latitude	Longitude	Groundwater rating
Vasai	Bramhanwadi	C/TN-047	4.45	11.05	19.4250°	72.7833°	Poor
Vasai	Giraj	C/TN-048	7.40	7.21	19.3792°	72.7917°	Excellent
Vasai	Khanivade	C/TN-003	5.00	3.47	19.4833°	72.8500°	Good
Vasai	Sakwar	C/TN-051	54.00	18.76	19.5375°	72.9292°	Not Available
Vasai	Sandor	C/TN-045	5.10	9.97	19.3478°	72.7861°	Poor
Vasai	Wafana	C/TN-035	8.75	16.15	19.3583°	72.8833°	Not Available
Vasai	Waliv	C/TN-041	8.20	16.80	19.4022°	72.8517°	Good

As seen in Figure No. 2-69, the result reveals that out of 44 monitoring points, 34 % i.e. 15 wells showed normal trend; 43% i.e. 19 wells exhibited decreasing trend and the data for remaining 23 % that is 10 wells was not available for assessment.

The map generated using GIS (Map No. 2-27) shows that almost along the coastline, water level in the wells showed normal trend. This could be because of the geological limitations to extract water from deeper aquifers, as beyond certain depth one starts getting salty water.

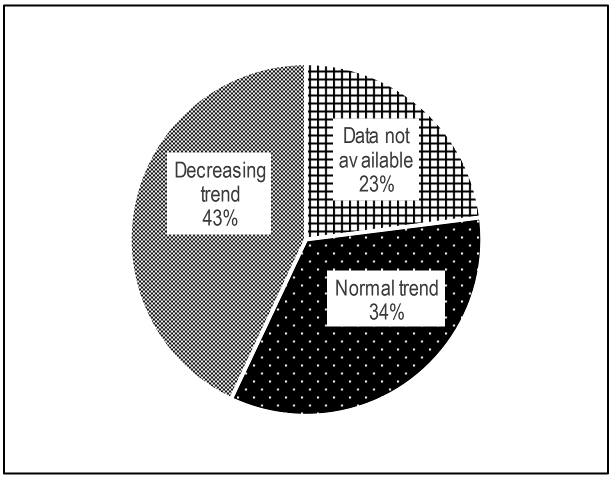


Figure No. 2-69: Status of groundwater quality in MMR

Vasai tehsil has maximum number of wells showing decreasing water level trend. The reason could be over extraction of water for increasing demand for agriculture, floriculture, horticulture and for increasing residential demands. Another reason could be that the municipal water supply may not be sufficient and therefore farmers have to depend on the groundwater. Decreasing trend of water level in Bhiwandi, Kalyan, Thane and Panvel may also be because of over extraction of groundwater to meet the water demand of the region.

2.5.3 Groundwater quality index (WQI)

The Dynamic Groundwater Resource of the country has been jointly established by State Groundwater Departments and Central Groundwater Board, based on the methodology recommended by Groundwater Estimation Committee-1997 (GEC-97).

The available data has been analyzed for finding Water Quality Index. Water quality data at groundwater locations being monitored under the network is evaluated against the water quality criteria and the monitoring locations in exceedance with respect to one or more parameters are identified as polluted, which requires action for restoration of water quality.

The WQI takes the complex scientific information and synthesizes into a single number between 0 and 100, by normalizing the observed values to subjective rating curves. Factors to be included in WQI model could vary depending upon the designated water uses and local preferences. Some of these factors include DO, pH, BOD, COD, total coliform bacteria, temperature, and nutrients (nitrogen and phosphorus), and so on.[82]

Calculation of WQI: This calculation is performed by using following notations

i – no. of the parameter
W i – unit weightage of ith parameter
S i – highest permitted value for ith parameter
Q i – subindex of ith parameter
O i – is the observed value of the ith parameter
Weightage of ith parameter is calculated by W i = k/S I ….. (1)
Where k is constant of proportionality.
The quality rating for each of the water quality parameters
Q i = O i x 100 / S i ….. (2)

Then, the water quality index is calculated as $WQI = \sum_{i=1}^{n} QiWi$

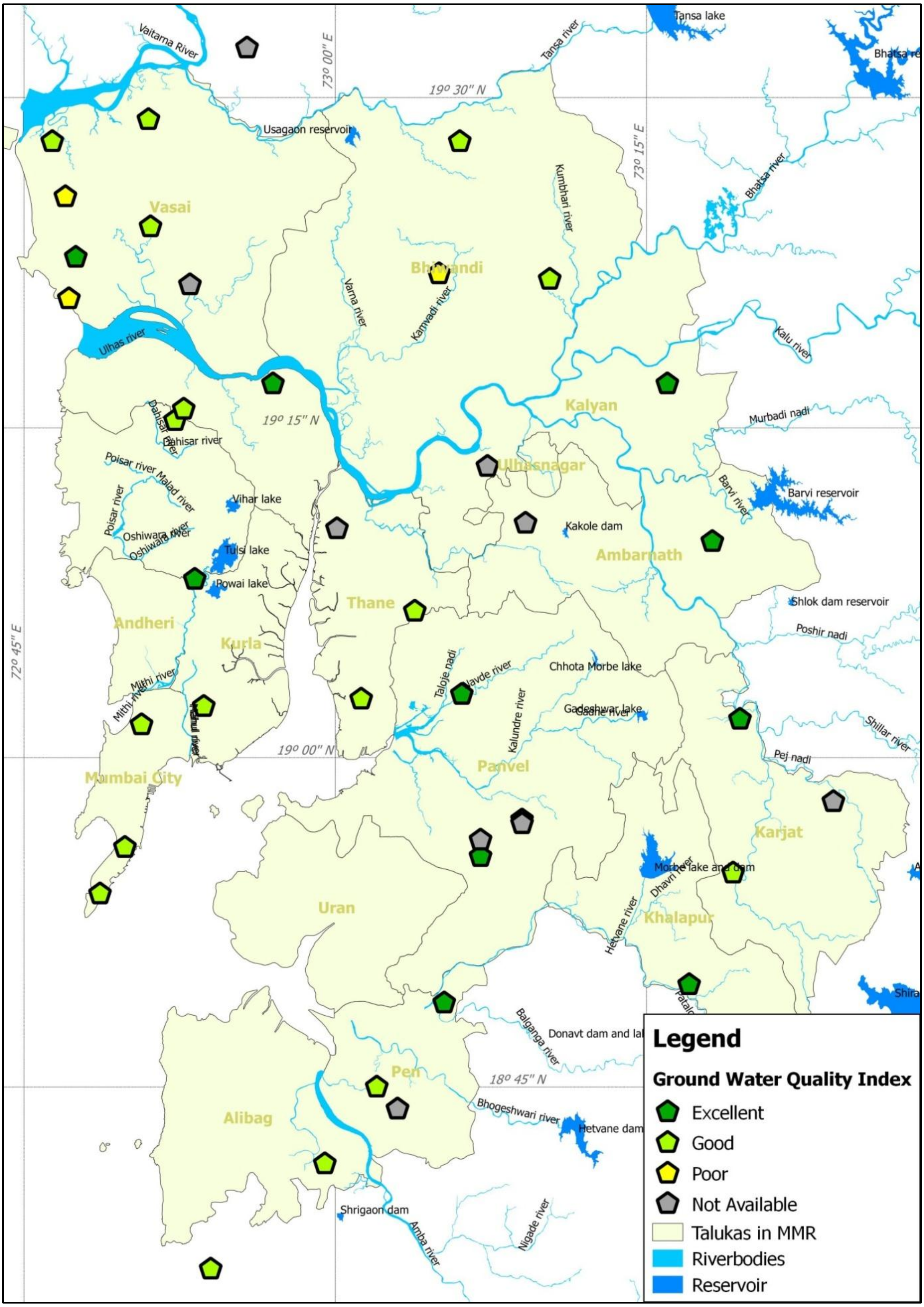
In this particular case of groundwater CPCB has given the rating as follows:

Table No. 2-47: WQI and CPCB rating

WQI	Rating
> 50	Excellent
50-100	Good
100-200	Poor
200-300	Very poor
< 300	Not suitable for drinking

Source: CPCB

82 http://globalskope.com/ijesr/122011/articles/ESR11010222.pdf



Map No. 2-27: Water quality index for groundwater in MMR

Source: Central Grounwater Board, 2011

As seen in Map No. 2-27 , 4 locations have been mapped where the status of water quality is bad. This status in perspective of groundwater quality index (WQI) is defined as "poor" quality and the WQI value is in between 100-200. At these locations, groundwater is not suitable for drinking purposes as EC and TDS are exceeding maximum desirable limits and also the data of last 4 years shows consistent increase in the values of EC and TDS at all 3 out of 4 locations.

In order to reduce the illness prevalence in the city, Brihanmumbai Corporation (BMC) and Government of Maharashtra (GoM) have discouraged the use of water from wells and ponds for domestic purpose in this area. As result, the dug well based water supply was completely neglected. However, being a financial capital of the country, the population growth in the city is very high as compared to other part of country. The supply of water from surface water sources fluctuates depending upon the rainfall during the year. Therefore, there is always the gap between demand and supply. In order to meet the shortfall in water supply, groundwater forms a supplementary source of supply for all purposes other than domestic.

2.5.4 Summary of recommendations for groundwater resources

Recommendation 1: Improve data availability

Government appointed/established groundwater management agencies, monitor and collect groundwater data. This data is very important for local, regional and state management decisions. However at regional level, holistic information is not available. Hence there is a clear need for collection of appropriate data and access to useful information across various government departments. Further, this data should also be made publicly available through the Department of Water Resources' (DWR). This shall encourage transparency in the entire system and generate data & information for better understanding of the groundwater resources in MMRDA and the state as a whole.

Recommendation 2: Mapping the groundwater resources and the water quality monitoring stations

A comprehensive map should be generated highlighting the groundwater resources and WQMS. Various subsequent maps like the water table level; watershed and so on should be generated at a regional level. These maps shall help MMRDA in planning strategies for increasing the water table levels and the required infrastructure.

Recommendation 3: Limit additional large scale pumping in areas where there is decreasing water trend

The private large scale pumping of groundwater in areas that are adversely impacted should be closely monitored by the authorities. In MMR, large quantum of groundwater is used for construction activities as well. However, there is no accountability of it. Hence this information should be available with MMRDA and there should be some strict action to limit over pumping of groundwater.

Recommendation 4: To improve the groundwater level by recharging the ground through rainwater harvesting.

43% of the monitoring wells exhibited decreasing trend in the water level. Further, MMR is highly depended on rainfall to generate source water; hence recharge should be accelerated through extensive rainwater harvesting.

Recommendation 5: The ULBs should take strict legal action for unauthorized digging of bore wells.

Recommendation 6: The ESRs should also document this data annually.

Recommendation 7: Authorities should tap other alternative sources rather than increasing budgetary allotments for increasing extraction of groundwater to meet the demands.

Water supply, sewerage and sanitation

2.6 Water supply, sewerage and sanitation

It is an obligatory duty of the ULBs (Urban Local Bodies) to provide water supply, sanitation and waste water disposal facilities to the citizens of the region. In India, 80% of the diseases are caused by water borne pathogens. Hence proper and safe water supply and sewage disposal is essential. In addition to health problems, inadequate sewage disposal causes severe environmental degradation. Recognising the growing importance of improving efficiency in delivery of basic services in cities, the Ministry of Urban Development has now adopted National Benchmarks in four key sectors—Water Supply, Sewerage, Solid Waste Management and Storm Water Drainage.

In MMR, the water demand is primarily met through surface water resources which include 4 major rivers namely Vaitarna, Ulhas, Patalganga, and Amba. These river basins constitute the Mumbai hydrometric area and are spread across a total catchment area of 5756 sq. km.

For all the sectors, emphasis has been laid on performance related to reach and access to quality service, and prevalence and effectiveness of the systems to manage the water supply networks. As financial sustainability is critical for continued effectiveness in service delivery, performance is measured on this aspect too. In the following sub section details about water supply, sewerage and sanitation are elaborated. A quick tabulated summary of the service level benchmarks has been provided below in Table No. 2-48 as per the latest data available.

Table No. 2-48 Summary of service level benchmarks

	Municipal Corporations								Municipal Councils								
Service level benchmarks	MCGM	NMMC	TMC	KDMC	BNMC	VVMC	MBMC	UMC	Alibaug	Ambernath	Karjat	Khopoli	Ku.BMC	Matheran	Panvel	Pen	Uran
	Service Level Benchmark – Water supply services																
Coverage of water supply connections (100%)	ND	94	92.2	40.2	80	78.5	91.1	89.9	89.3	97.6	64.3	59.5	87.7	79.9	50.5	83.1	98
Per capita available of water at consumer end (135 lpcd)	210	248	157	165	100	76.5	63.9	146	146	120	118	71.4	125.5	111.4	170	118	94.7
Extent of metering of water connections (100%)	ND	95.3	5.2	27	0	NA	75.9	1.8	17.8	84.7	NA	NA	92.8	87.2	3.9	4.6	13.9
Extent of Non-Revenue Water (20%)	ND	19.7	24.9	14.3	35	20.8	35.3	25.5	30.9	28.4	26.8	16.7	32.1	28.6	20.4	21.9	19.9
Continuity of water supply (24 hours)	2.7	16	5.6	4	3	2	1.4	3	2	4	1.5	5	4	2	1.5	1	1
Efficiency in redressal of customer complaints (80%)	ND	98.6	85.7	94.2	80	76.9	82.5	88.9	88.9	99.4	100	96.8	90.3	86.8	79.8	98.3	73.3
Quality of water supplied (100%)	94.1	97.4	96.3	99.9	99	98.1	96.8	100	93.7	93.9	100	100	99.6	100	99.3	100	89.8
Cost recovery in water supply services (100%)	ND	99	92.1	65.5	0	131	111	51.6	27	100.5	43.7	41.4	54.9	103.1	24.8	55.1	46.6
Efficiency in collection of water supply related charges (90%)	45.5	98.1	51.6	77.3	40	92.3	95.1	ND	81.8	91.7	53.8	84.4	9.6	42.3	ND	45.5	36.2
Coverage of WS connections in slums (100%)	ND	15.5	39.9	18	ND	0.6	25.6	ND	NA	64.1	20.2	0.7	10.1	ND	0	NA	11.5

Performance Legend:

Very good	Good	Fair	Average	Not available/No data

	Municipal Corporations								Municipal Councils								
Service level benchmarks	MCGM	NMMC	TMC	KDMC	BNMC	VVMC	MBMC	UMC	Alibaug	Ambernath	Karjat	Khopoli	Ku.B MC	Matheran	Panvel	Pen	Uran
	Service Level Benchmark - Sewerage and sanitation																
Coverage of Toilets (100%)	ND	99	99.4	87.2	89.2	86.5	73.3	61.1	71.5	92	90.6	94.8	66.8	61.4	91	91.2	92.1
Coverage of wastewater network services (100%)	ND	77.5	38.1	16.8	30	NA	9.5	14.7	NA	43	NA	NA	NA	NA	3.7	NA	NA
Collection efficiency of wastewater networks (100%)	67.6	89	21.8	17.7	40	NA	22.3	18.3	NA	90.1	NA	NA	NA	NA	0	NA	NA
Adequacy of wastewater treatment capacity (100%)	ND	89	21.8	17.7	13	NA	22.3	42.7	NA	0	NA	NA	NA	NA	NA	NA	NA
Extent of reuse and recycling of treated wastewater (20%)	ND	0.4	0	0	0	NA	0	0	NA	0	NA	NA	NA	NA	NA	NA	NA
Quality of wastewater treatment (100%)	ND	100	100	87.5	80	NA	100	ND	NA	0	NA	NA	NA	NA	NA	NA	NA
Efficiency in redressal of customer complaints (80%)	ND	100	91.5	99.9	70	90.4	90.7	94.5	85.5	98.3	100	100	85.8	100	69.3	86.7	100
Extent of cost recovery in wastewater management (100%)	149	141.8	246	65	70	ND	102	195	0	17.7	0	0	8.2	0	49.8	9.5	0
Efficiency in collection of sewerage charges (90%)	45.2	80	86.5	53.5	50	ND	ND	ND	NA	86.7	NA	NA	87	NA	78.1	29.2	NA
Coverage of individual toilets in slums (100%)	ND	0	2.1	3	ND	20.2	0	ND	NA	6.9	1.4	ND	5.4	ND	0	NA	5
Coverage of WW network services in slums (100%)	ND	0	ND	1.8	ND	NA	0	ND	NA	2.4	NA	NA	NA	NA	0	NA	NA

2.6.1 Water supply

The drinking water supply in MMR is primarily done using surface water which includes 4 major rivers. These four major rivers are Vaitarna, Ulhas, Patalganga, and Amba, which constitute the Mumbai hydrometric area and are spread across a total catchment area of 5756 sq. km as shown in Table No. 2-49. The total water resources available for utilization in the Bombay Hydraulic Area (BHA) are estimated as 7,869 MCM/year at 95% dependability and 10,439 MCM/year at 75% dependability. The water harnessed so far amounts to 2,969 MCM/year, while an additional amount of 292 MCM/year was planned to be utilized, which sum up to 3,261 MCM/year. The Municipal Corporation of Greater Mumbai (MCGM) has an installed capacity of water supply of 3,193 MLD. This comes from the lakes formed in three major catchment areas northwards of the city. Of this 100 MLD is delivered to Thane, leaving the balance 3,093 MLD for Mumbai.[83]

The region-wise source of water and the quantity of water that is supplied through various sources is also mentioned in the Table No. 2-49, Table No. 2-50 and its spatial representation in .

Table No. 2-49: Basin-wise break-up of water availability

Sr. No.	Name of Basin	Catchment Area In Sq.km	Water Availability		Irrigation requirement as planned (MCM)	Water available for Domestic & Industrial Use (MCM)
			75% Dependability	95% Dependability		
	1	2	3	4	5 (3-4)	6
1.	Vaitarna	1858	3130	2416	714	2416 (6,620 MLD)
2.	Ulhas	3205	6194	4681	1513	4681 (12,825 MLD)
3.	Patalganga	328	712	489	223	489 (1340 MLD)
4.	Amba	365	403	283	146	283 (775 MLD)
	Total	**5756**	**10439**	**7869**	**2596**	**7869 (21,560 MLD)**

Source: MMRDA

83 http://www.wesnetindia.org/fileadmin/newsletter_pdf/Dec06/Water_Resource_-_Mumbai.pdf

Table No. 2-50: Existing water supply sources in MMR

Sub-Region	Name of Dam / Source	Supply of water (MLD)
I. GREATER MUMBAI	1. Tansa	445
	2. Modak Sagar	450
	3. Upper Vaitarna	630
	4. Bhatsa	1850
	5. Vihar	60
	6. Tulsi	15
	Total	3450 MLD
	TOTAL: Net Supply after giving 120 MLD to local villages.	**3330 MLD**
II) REST OF MMR	1. Barvi	600
	2. Morbe	360
	3. Hetawane	150
	4. Dehrang	11
	5. Amba (Nagothane)	168
	6.Ulhas River (Bhivpura Tailrace 710+80+10)	800
	7.Tansa River (Shirgaon Bandhara)	10
	8. Usgaon	10
	9. Pelhar	10
	TOTAL	**2119 MLD**

Source: MMRDA

Map No. 2-28: Spatial representation of surface water resources in MMR

2.6.1.1 Demand and supply gap

The current water demand for the entire MMR which includes Greater Mumbai and rest of MMR is estimated to be 6725 MLD. This includes demands from domestic, industries, and irrigation sector. As against the demand, the amount of water that is been supplied is to the tune of 3330 MLD to Mumbai and 2119 MLD for rest of the MMR. This clearly indicates a deficit of 1276 MLD. [84] To address this issue, Government of Maharashtra appointed two committees to estimate the future water requirement upto 2031 and also to identify probable sources that could cater to the growing demand of the region. These region-wise water sources along with their yield are given in Table No. 2-51.

The present demand of the entire region is estimated to be 6725 MLD which includes demand from domestic, industries, and irrigation sector. As against this demand, the amount of water supplied is to a tune of 5449 MLD indicating a deficit of 1276 MLD.

Table No. 2-51: Identified water resources for entire MMR

Sr. No.	For Greater Mumbai		For Rest of MMR	
	Water Source	Estimated Yield (MLD)	Water Source	Estimated Yield (MLD)
1	Middle Vaitarna-	477	Shai	940
2	Gargai	455	Kalu	1140
3	Pinjal*	697	Poshir	740
4	Damanganga	2000	Pinjal *	533
Total		**3629**	Balganga	300
			Susari	200
			Total	**3853**
** Pinjal source is considered partly for Mumbai and partly for Rest of MMR*				

Source: MMRDA

2.6.1.2 Projected water demand & proposed water resources for MMR

Based on 2011 census total population of entire MMR is 23.13 Million. The projected total population for entire MMR by 2031 is estimated to be 34.07 Million. Consequently, the water demand would increase to 10657 MLD. To meet this requirement, sources have been identified and approximate cost has also been estimated. The details of the same are shown in Table No. 2-52. The Government of Maharashtra has taken initiative to plan and develop the water resources in such a way that the current deficit is reduced and future water requirement is also met. For the Greater Mumbai region, Municipal Corporation of Greater Mumbai (MCGM) has been allotted the work of planning and execution of the water works

[84] MMRDA

projects. For rest of the MMR, it was decided that MMRDA would plan and co-ordinate the development activities of the allocated water supply sources including distribution network for bulk supply of water to Urban Local Bodies (ULBs).

Table No. 2-52: Present water supply scenario and projected water demand for 2031

Sr. No.	Sub -Region	Present Demand (MLD)	Present supply (MLD)	Deficit (MLD)	Total water required by 2031 (MLD)	Identified Water Resources with probable yield (MLD)	Remarks
1	Greater Mumbai	4200	3330	870 (20.71 %)	6036	Mid.Vait - 477 Pinjal - 697	
2	Western Sub-Region: Mira-Bhayandar, Vasai-Virar, Navghar, Manikpur, Nallasopara and 76 villages	408	221	187 (45.83%)	852	Surya - 303, Susri - 200, Pinjal - 533	Estimated cost of construction of Shai + Kalu + Poshir dams
3	Eastern Sub-Region: Thane - Bhiwandi, Kalyan-Dombivali, Ambarnath, Kulgaon-Badlapur, Ulhasnagar	1344	1125	219 (16.29%)	2188	Shai - 940 Kalu - 1140	Estimated cost of distribution systems for bulk supply of Surya + Shai + Kalu + Poshir
4	New Mumbai	427	427	0	1073	Balganga - 300 Morbe - 450 Barvi - 957	Total yeild Surya 303 + Shai 940 + Kalu 1140 + Poshir 720 = 3103 MLD
5	Neral, Karjat and Khalapur + Panvel, Rasayani, Khopta and Uran	196	196	0	368	Poshir - 720	

Sr. No.	Sub -Region	Present Demand (MLD)	Present supply (MLD)	Deficit (MLD)	Total water required by 2031 (MLD)	Identified Water Resources with probable yield (MLD)	Remarks
6	Pen + Alibag	150	150	0	140		
Total		**6725**	**5449**	**1276**	**10657**		**~ Estimated cost 4731.04 Cr.**

Source: MMRDA

2.6.1.3 Performance assessment comparison of ULBs[85]

1. Coverage of water supply connections

Definition: Total number of households in the service area that are connected to the water supply network with direct service connections, as a percentage of the total number of households in that service area. Service area implies a specific jurisdiction in which service is required to be provided.

Rationale for the Indicator: The minimum level acceptable standard for water supply service should be a household level water supply connection, i.e. direct piped connection within the household. Water provision to households (urban poor or otherwise), at common public stand posts cannot be considered as an acceptable or long term permanent service provision standard. Hence the benchmark value for this indicator should be 100%.

85 Handbook on service level benchmarking, MoUD, GoI

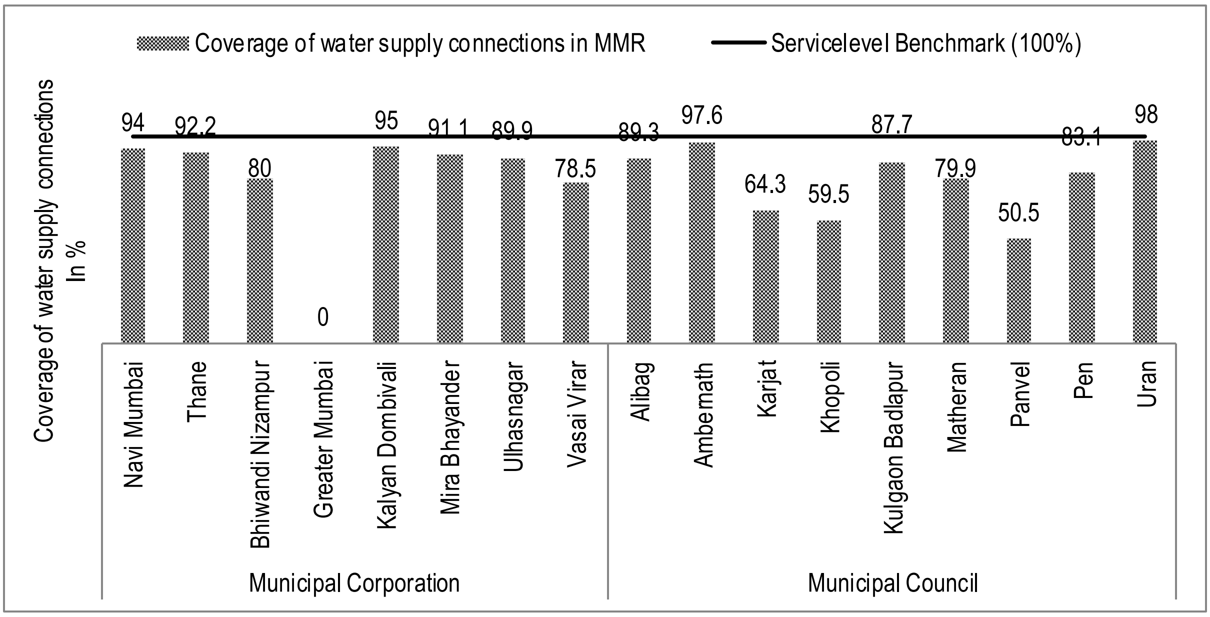


Figure No. 2-70: Coverage of water supply connections across the ULBs in MMR (2011-12)

Source: http://www.pas.org.in

Observations: As seen in Figure No. 2-70; none of the ULBs meet the service level benchmark (SLB) of 100%. As far as Municipal Corporations are concerned, Navi Mumbai, Thane, Kalyan Dombivali, Mira Bhayander and Ulhasnagar had or have service coverage above 90%; whereas Bhiwandi Nizampur and Vasai Virar have 80 and 78.5% coverage respectively in the year 2011-12. The data for Greater Mumbai was not available; hence it shows 'Zero'.

With respect to Municipal Council, Ambernath and Uran (98%) were very close to the SLB. Whereas Alibag, Kulgaon Badlapur, Matheran and Pen were in the range of 83 to 89% and the poorest performance was by Karjat (64%), Khopoli (59.5%) and Panvel (50.5%) respectively.

2. Per capita supply of water

Definition: Total water supplied to consumers expressed by population served per day

Rationale for the Indicator: This frequently used performance indicator provides an overall indication of the adequacy of the water supply to meet the needs of the citizens in the city. Per capita water supplied, expressed in LPCD and indicates the adequacy of the municipal water supply system in being able to source, treat water to potable standards and supply it into the distribution system. Therefore, the benchmark value for the indicator is 135 lpcd. The key limitation of this indicator is that it provides information on a city wide basis, and does not reveal intra city variations.

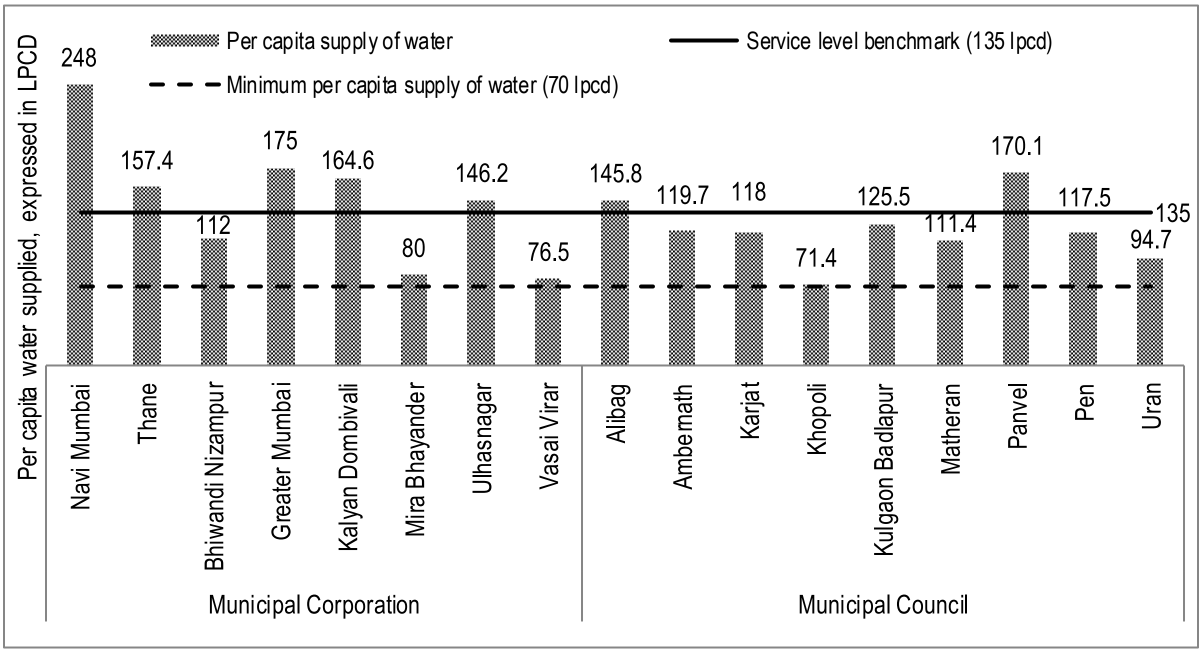


Figure No. 2-71: Per capita supply of water by ULBs in MMR (2011-12)

Source: http://www.pas.org.in

Observations: As seen in Figure No. 2-71; among all the Municipal Corporations, Navi Mumbai, Thane, Greater Mumbai, Kalyan Dombivali, Ulhasnagar meet the SLB, whereas Bhiwandi Nizampur, Mira Bhayander and Vasai Virar are below the SLB of 135 lpcd. However, they supply the minimum per capita supply of water i.e. 70 lpcd.

In case of Municipal councils, Alibag, and Panvel meet the SLB, whereas the rest of the councils i.e. Ambernath, Karjat, Khopoli, Kulgaon Badlapur, Matheran, Pen and Uran supply the minimum per capita water.

3. Extent of metering of water connections

Definition: The total number of functional metered water connections expressed as a percentage of the total number of water supply connections. Public stand post connections should also be included.

Rationale for the Indicator: While water is a basic need, the supply of potable water to citizens at their doorstep involves significant cost in building, operating and maintaining a system todo so. In a water supply system, the quantum of service provided to citizens is directly measurable, and therefore it is necessary that all the water supplied to all categories of consumer's should be metered. Metering will also induce efficiency in use of water, reveal physical and administrative leakages in the system, and enable high-end consumers to be charged for consuming more. Therefore, to introduce a volumetric- based tariff structure for water charges, metering all connections is essential. It is, therefore, important to monitor this indicator, the benchmark value for which is 100%.

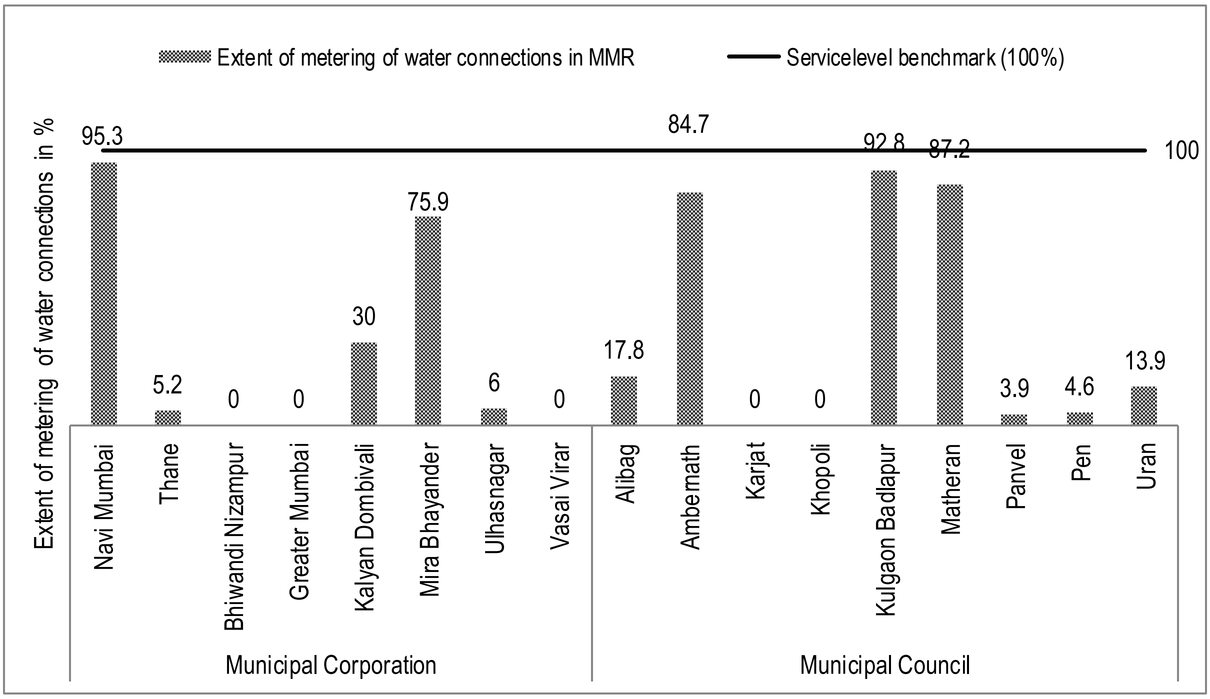


Figure No. 2-72: Extent of metering of water connections done by the ULBs in MMR (2011-12)

Source: http://www.pas.org.in

Observations: As seen in Figure No. 2-72; none of the ULBs meet the SLB. Navi Mumbai, Mira Bhayander, Ambernath, Kulgaon Badlapur and Matheran have some metering systems in place, hence their SLB range from 75 to 95%. Hence it is essential to meter all connections, especially for Bhiwandi Nizampur, Vasai Virar, Karjat and Khopoli.

The data for Greater Mumbai was not available; hence it shows 'Zero'.

4. Extent of non-revenue water (NRW)

Definition: This indicator highlights the extent of water produced which does not earn the utility any revenue. This is computed as the difference between the total water produced (ex-treatment plant) and the total water sold expressed as a percentage of the total water produced. NRW comprises:

- Consumption which is authorized but not billed, such as public stand posts;
- Apparent losses such as illegal water connections, water theft and metering inaccuracies; and
- Real losses which are leakages in the transmission and distribution networks.

Rationale for the Indicator: The reduction in NRW to acceptable levels is vital for the financial sustainability of the water utility. NRW can be reduced through appropriate technical and managerial actions, and therefore monitoring NRW can trigger such corrective measures. The reduction of real losses can be used to meet currently unsatisfied demand or to defer future capital expenditures to provide additional supply capacity. The reduction of NRW is desirable not just from a financial standpoint, but also from the economic and environmental benefits' point of view. The benchmark value for NRW may be considered at 20%, the levels achieved by most well-performing utilities in developed countries. NRW is also influenced by factors outside the control of the water utility such as the topography of the city, age of the network, length of the network per connection and water use per capita.

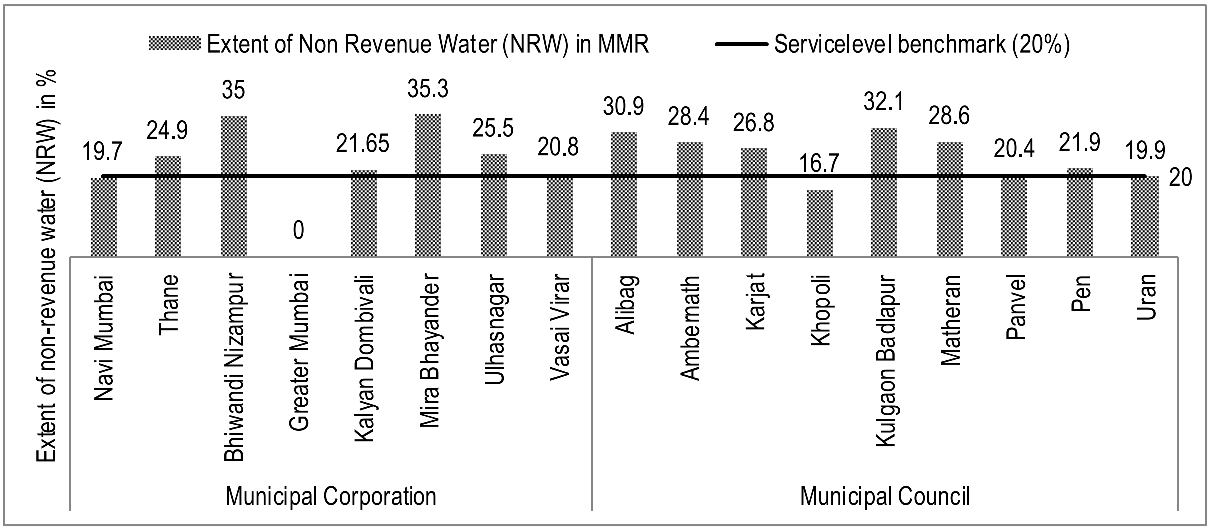


Figure No. 2-73: Extent of Non-Revenue Water (NRW) in MMR (2011-12)

Source: http://www.pas.org.in

Observations: The extent of NRW is expected to be below 20%. As seen in Figure No. 2-73; none of the ULBs meet the SLB except for Khopoli. In Bhiwandi Nizampur and Mira Bhayander the extent of water produced which does not earn any revenue is the maximum among all the ULBs and is in tune to 35% and above.

The data for Greater Mumbai was not available; hence it shows 'Zero'.

5. Continuity of water supply

Definition: Continuity of supply is measured as the average number of hours of pressurised water supply per day. Water pressure should be equal to or more than a head of 7 metre (m) at the ferrule point/meter point for the connection (7 m head corresponds to the ability to supply to a single-storey building).

Rationale for the Indicator: Almost no Indian city has a continuous (24x7) water supply system. From a citizen's perspective, it is desirable to have round-the-clock water supply daily, as it eliminates the need to provide and manage household/establishment level storage, and other resultant inconveniences. Water utilities in most Indian cities provide intermittent and limited number of hours of supply, as a means to manage inadequate supply. A number of cities are undertaking substantial investments to improve this service level. It is, therefore, critical to monitor this indicator on a city-wide basis and move towards the benchmark value of 24 hours.

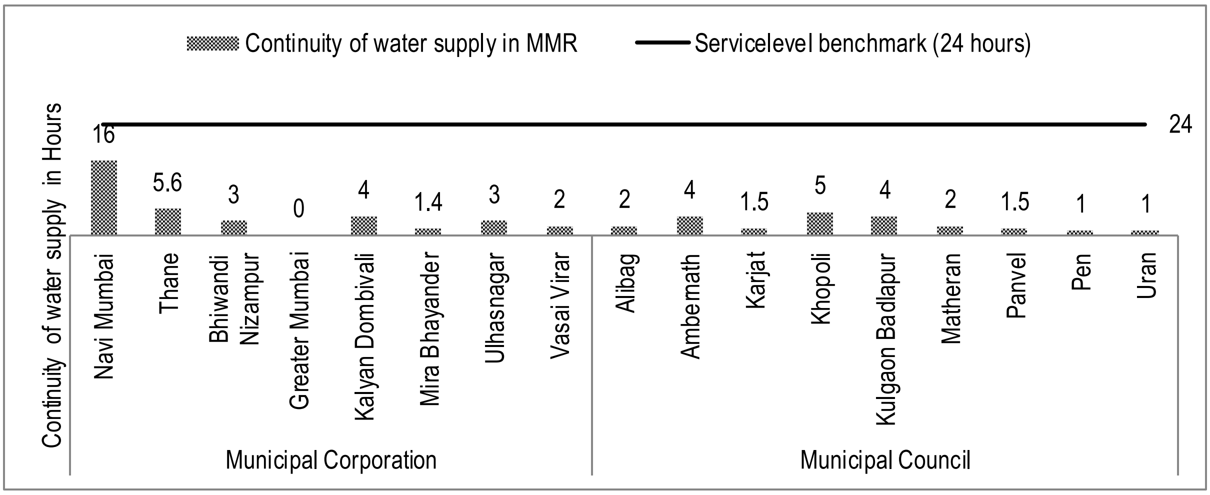


Figure No. 2-74: Continuity of water supply by the ULBs in MMR (2011-12)

Source: http://www.pas.org.in

Observations: Continuity of water supply in MMR is extremely poor. As seen in Figure No. 2-74; none of the ULBs meet the SLB. Among all, Navi Mumbai has a better performance of supplying water for 16 hours per day, rest all the ULBs need to have more systems in place to meet the SLB of 24 hour water supply.

The data for Greater Mumbai was not available; hence it shows 'Zero'.

6. Quality of water supplied

Definition: The percentage of water samples that meet or exceed the specified potable water standards, as defined by the Central Public Health and Environmental Engineering Organisation (CPHEEO). The sampling regimen should meet standards and norms laid down

Rationale for the Indicator: The quality of water supplied is an important performance indicator as other service delivery indicators. Poor water quality can pose serious public health hazards. Water-borne diseases are quite common in Indian cities, particularly among the urban poor. Although, in most cases, the source of water that causes such diseases/epidemics is not the municipal piped water supply, it is very important to monitor the supply. Therefore, this performance indicator must be regularly monitored, the benchmark value for which is 100%.

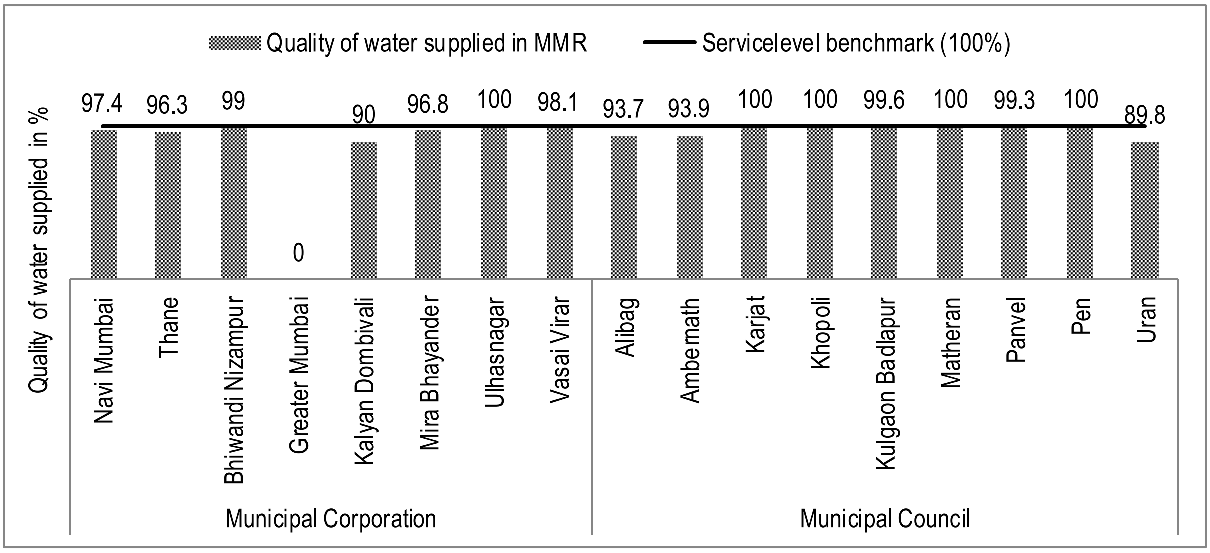


Figure No. 2-75: Quality of water supplied by the ULBs in MMR (2011-12)

Source: http://www.pas.org.in

Observations: As seen in Figure No. 2-75; Ulhasnagar, Karjat, Khopoli, Matheran, Panvel and Pen meet the SLB of 100%; whereas the rest of the ULBs are above 90%. The data for Greater Mumbai was not available; hence it shows 'Zero'.

7. Efficiency in redressal of consumer complaints

Definition: The total number of water supply- related complaints redressed within 24 hours of receipt of complaint, as a percentage of the total number of water supply- related complaints received in the given time period.

Rationale for the Indicator: It is important that, in essential services such as water supply, the ULB/water utility has effective systems to capture customer complaints/grievances, escalate them internally for remedial action and resolve them. While many ULBs/utilities have put in place systems to capture complaints, much more work needs to be done to put in place back-end systems for satisfactory resolution of those complaints on time. As water supply is an essential service, the benchmark time for redressal is 24 hours or the next working day. It is, therefore, important to monitor this indicator. The benchmark value for this indicator will depend on a number of factors such as the size of the city, age of the network, etc. The benchmark value for this indicator may be set at 80 %.

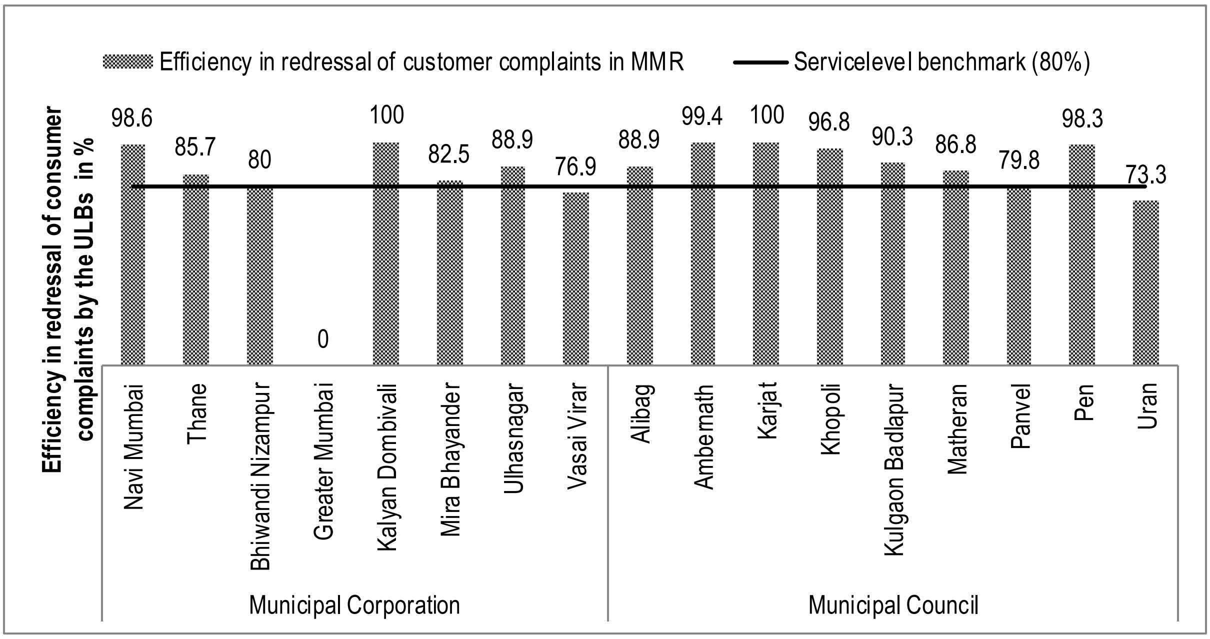


Figure No. 2-76: Efficiency in redressal of consumer complaints by the ULBs in MMR (2011-12)

Source: http://www.pas.org.in

Observations: As seen in Figure No. 2-76; all the ULBs meet the SLB, except Vasai Virar and Uran. The possible reasons for not meeting the SLB may be because of inadequate staff strength or poor technical expertise to resolve the problem. The data for Greater Mumbai was not available; hence it shows 'Zero'.

8. Cost recovery in water supply services

Definition: The total operating revenues expressed as a percentage of the total operating expenses incurred in the corresponding time period. Only income and expenditure of the revenue account must be considered, and income and expenditure from the capital account should be excluded.

Rationale for the Indicator: Financial sustainability is critical for all basic urban services. In services such as water supply, benefits received by the consumers are more direct and can be quantified. Therefore, through a combination of user charges, fees and taxes, all operating costs may be recovered. Therefore, this indicator is critical for measuring overall cost recovery, the benchmark value for which is 100 %. Cost recovery objectives provide a basis for tariff fixation, enable setting targets for revenue mobilization and cost control in the delivery of water supply services.

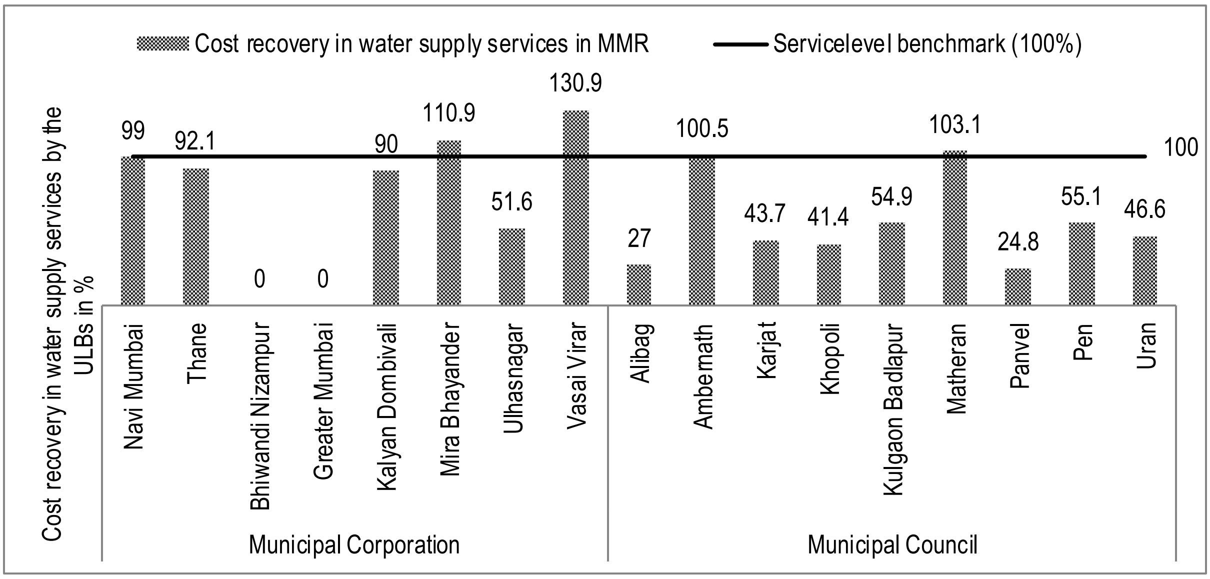


Figure No. 2-77: Cost recovery in water supply services by the ULBs in MMR (2011-12)

Source: http://www.pas.org.in

Observations: As seen in Figure No. 2-77; cost recovery in water supply services by ULBs is relatively fair in MMR. Navi Mumbai, Mira Bhayander, Vasai Virar, Ambenath and Matheran meet the SLB. Thane and Kalyan Dombivali's performance has been above 90% for the year 2011-12. The ULBs having performance percentage less that 55% need s serious improvement to achieve financial sustainability.

The data for Greater Mumbai was not available; hence it shows 'Zero'.

9. Efficiency in collection of water supply related charges

Definition: Efficiency in collection is defined as current year revenues collected, expressed as a percentage of the total operating revenues, for the corresponding time period.

Rationale for the Indicator: For a water utility, it is not just enough to have an appropriate tariff structure that enables cost recovery objectives but also efficient collection of revenues that are due to the utility. It is also important that the revenues are collected in the same financial year, without allowing for dues to get accumulated as arrears. It is, therefore, critical to monitor this indicator. The benchmark value for collection efficiency may be considered at 90 %, since it is possible that about 10% of the dues may be delayed to the next year.

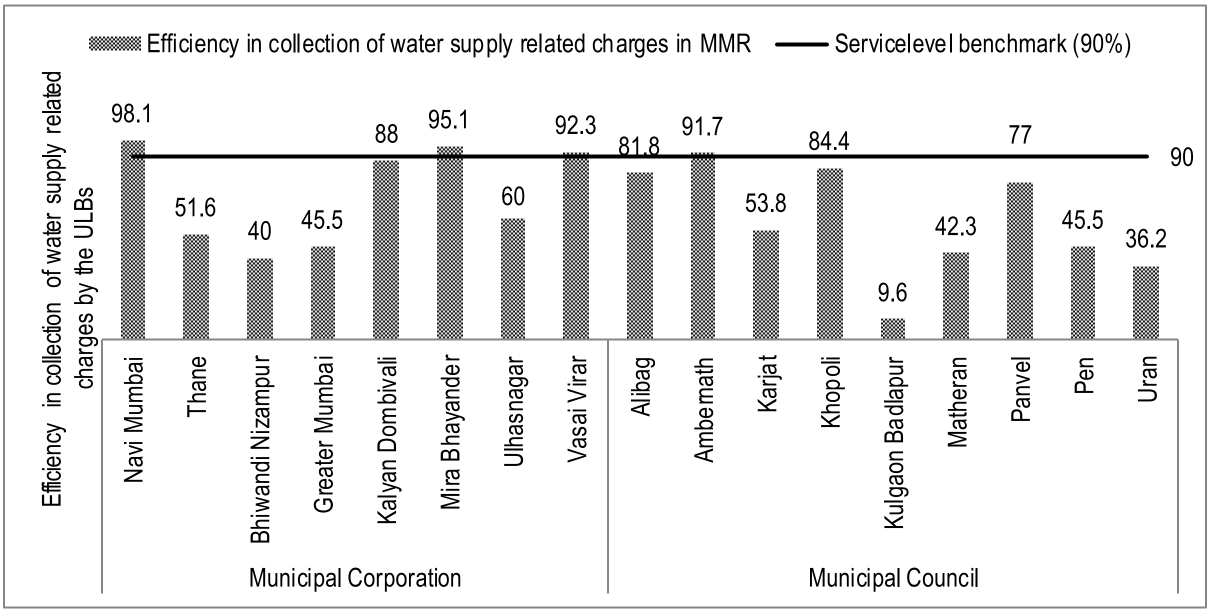


Figure No. 2-78: Efficiency in collection of water supply related charges by the ULBs in MMR (2011-12)

Source: http://www.pas.org.in

Please note that the data for Greater Mumbai is for the year 2008-09 and Panvel for the year 2010-11.

Observations: As seen in Figure No. 2-78; only Navi Mumbai, Mira Bhayander, Vasai Virar and Ambernath meet the SLB. Whereas in Kalyan Dombivali, Alibag and Khopoli the collection efficiency of water supply related charges is above 80%. Almost 50% of the ULBs do not have a proper mechanism to collect water related charges and the poorest performance was recorded at Kulgaon Badlapur.

Situation Analysis and Reform Agenda[86]

- Out of the gross available water supply of 3, 193 MLD, the losses through leakages and other sources make the net available water supply 2,320 MLD, which also includes 600 MLD water supply for non-domestic purposes i.e., industry and commerce. The average gross per capita water supply is 260 litres and the net water available for domestic use is about 155 litres per capita per day (lpcd). The net available water supply higher than the Bureau of Indian Standards (IS) norm of urban water supply (135 lpcd) does not reveal why there are good number of private water suppliers and why bottled water is much in vogue. The spatial, temporal and sectoral coverage of water is still missing i.e., some parts of the city do not receive water; some of them receive it intermittently; and some sectors have more privilege in accessing it than others. Given the shortfalls in service delivery, it is imperative to address them through (a) restructuring of the operations, as in corporatization, (b) outsourcing to bulk water supply agencies and (c) institutional unbundling to address policy and tariff issues through different institutional mechanisms. Moreover, there are other regional issues in water management at metropolitan level, for addressing which a regional water agency needs to be constituted.

86 http://www.wesnetindia.org/fileadmin/newsletter_pdf/Dec06/Water_Resource_-_Mumbai.pdf

- The Municipal Corporation of Greater Mumbai (MCGM) is not only service provider but also water resource developer and monitoring agency. These functions need to be unbundled and transferred to external agencies and pollution control boards/ community organizations respectively. The losses arising from leakage through water supply distribution system amount to almost 25%, which is very high in spite of the MCGM, attempts to reduce it to 15%. Also, current water supply network infrastructure is very old and not periodically maintained. Auditing and accounting practices have to be instituted to check for the losses and attempts have to be made to reduce the same, through appropriate technologies of leak detection. This is also tied to the corporatisation of the MCGM in several aspects.
- Tariff structure reforms are required. Current tariff structures do not promote water conservation and cross-subsidy through industrial use is very high. Water has the characteristics of public good that necessitate generating greater consumption benefits, the necessity and luxury nature of it need to be distinguished through water pricing. Instead of levying a flat tariff for domestic as well as other uses, MCGM should use telescopic pricing with high water consumption beyond the threshold point of bare necessity level. Proper and full metering of individual water connections and a different mechanism for charging slum households need to be placed before this, but the tariffs should not be rather attached to measures like annual ratable value of property. Water resource budgeting has to be planned more carefully and charges levy automated using IT and financial accounts need to be kept separate and be in line with modern practices like accrual based accounting

2.6.2 Sewerage and sanitation

Sewage is waste matter from domestic or industrial establishments that is carried away in sewers or drains for dumping or conversion into a form that is not toxic[87] and sewerage refers to the infrastructure that conveys sewage. It encompasses components such as receiving drains, manholes, pumping stations, storm overflows, and screening chambers of the combined sewer or sanitary sewer. Sewerage ends at the entry to a sewage treatment plant or at the point of discharge into the environment.[88]

In MMR, 4753 MLD of waste water is generated, out of which only 59% is treated to some extent (either primary or secondary).

Sewage treatment is the process of removing contaminants from wastewater and household sewage, both runoff (effluents), domestic, commercial and institutional. It includes physical, chemical, and biological processes to remove contaminants. Its objective is to produce an environmentally safe fluid waste stream (or treated effluent) and a solid waste (or treated sludge) suitable for disposal or reuse (usually as farm fertilizer). Using advanced

87 http://www.collinsdictionary.com/dictionary/english/sewage
88 http://en.wikipedia.org/wiki/Sewerage

technology it is now possible to re-use sewage effluent for drinking water, although Singapore is the only country to implement such technology on a production scale.[89]

The following sub section elaborates on the performance of the ULBs in the waste water sector and the quantity of waste water generated in the region.

2.6.2.1 Waste water in MMR (Residential sector)

In MMR, 2776 MLD of waste water is generated in Greater Mumbai and 1143 MLD from rest of the region. Thus the total quantity of waste water produced is **3290 MLD** as shown in Table No. 2-53

Table No. 2-53: Waste water generated in MMR

ULBs	Waste water generated in MLD
Greater Mumbai	2776
Navi Mumbai	245
Thane	270
Kalyan Dombivali	192
Bhiwandi Nizampur	88
Vasai Virar	104
Mira Bhayander	68
Ulhasnagar	68
Alibag	3.6
Ambernath	44.39
Karjat	4
Khopoli	6.16
Kulgaon Badlapur	20.4
Matheran	1.096
Panvel	21.424
Pen	5.24
Uran	2.9
Total	**3920.21**

Source: Latest ESRs & City Sanitation Plan

89 http://en.wikipedia.org/wiki/Sewage_treatment

2.6.2.2 Performance assessment comparison of ULBs[90]

1. **Coverage of sewage network services**

Definition: This indicator denotes the extent to which the underground sewerage (or sewage collection) network has reached out to individual properties across the service area. Properties include those in the categories of residential, commercial, industrial and institutional. The service area implies a specific jurisdiction in which service is required to be provided.

Rationale for the Indicator: Last mile access to sewage networks is a key to improvement in service levels of sewage management. In many Indian cities, sewage also flows through open drains/storm water drains, posing serious public health hazards. Also, the coverage of sewage network services is very low across most Indian cities. With substantial investments in this area being taken up in programmes such as JNNURM, it would be important to monitor this indicator to observe the impact being made on the ground. Therefore, it is important to measure this parameter. Its benchmark value is 100%.

Observations: As seen in Figure No. 2-79; none of the ULBs meet the SLB of 100%. Among all the ULBs, Navi Mumbai has the highest performance percentage of 77.5 and rest are below 50%.

The data for Greater Mumbai, Vasai virar, Alibag, Karjat, Khopoli, Kulgaon Badlapur, Matheran, Pen and Uran was not available; hence it shows no value.

Coverage of toilets

Definition: This indicator denotes the extent to which citizens have access to a toilet (whether individual or community) in a service area. The toilets would include those in the category of residential, commercial, industrial and institutional properties. The service area implies a specific jurisdiction in which the service is required to be provided.

Rationale for the Indicator: Last mile access to toilets is key to improvement in service levels of sanitation facilities. In many Indian cities, there is inadequate access to toilet facilities. Therefore, it is important to measure this parameter. The benchmark value for this indicator is 100 %. Substantial investment in this area is being taken up under the Basic Services to the Urban Poor (BSUP) component of JNNURM as well as the Integrated Low Cost Sanitation (ILCS) scheme.

Observations: As seen in Figure No. 2-79; Navi Mumbai, Thane, Ambernath, Karjat, Khopoli, Panvel, Pen and Uran have performance percentage above 90%; whereas the rest of the ULBs are in the range of 60 to 85%.

The data for Greater Mumbai was not available; hence it shows no value.

[90] Handbook on service level benchmarking, MoUD, GoI

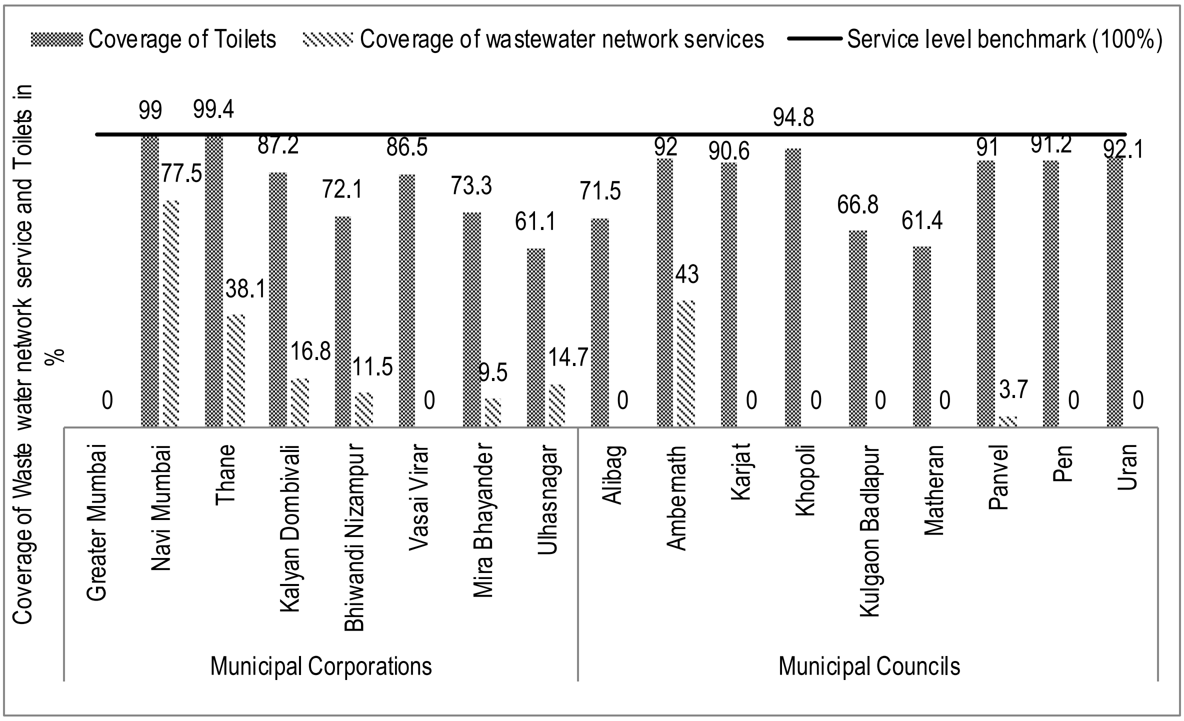


Figure No. 2-79: Coverage of Waste water network service and Toilet in MMR (2011-12)

Source: http://www.pas.org.in

Site visit observation:

In Kalyan Dombivali, there are open sewage drains (as shown in Picture No. 2-39) which may lead to serious health and environment problems. Hence it is recommended to have closed drains for transporting/disposing sewage.

Picture No. 2-39: Open sewage drains in Kalyan Dombivali area

Photo credit: TERI

2. Collection efficiency of the sewage network

Definition: This indicator is measured as the quantum of wastewater collected as a percentage of normative sewage generation in the ULB. Wastewater generation is linked to the quantum of water supplied through piped systems, and other sources such as bore wells, when they are very extensively used. Data should be collected daily for an entire month, so as to measure the quantities per month. While daily variations may be normalised, monthly variations may exist on account of seasonal variations. Data should be aggregated from multiple points across the ULB.

Rationale for the Indicator: While the performance indicator for coverage provides an idea of infrastructure available for access to sewage networks, the effectiveness of the system in capturing the sewage may not be adequate. Therefore, the performance indicator related to collection efficiency signifies the effectiveness of the network in capturing and conveying it to the treatment plants. Thus, it is not just adequate to have an effective network that collects sewage, but also one that treats the sewage at the end of the network. The benchmark value for this indicator is 100 %.

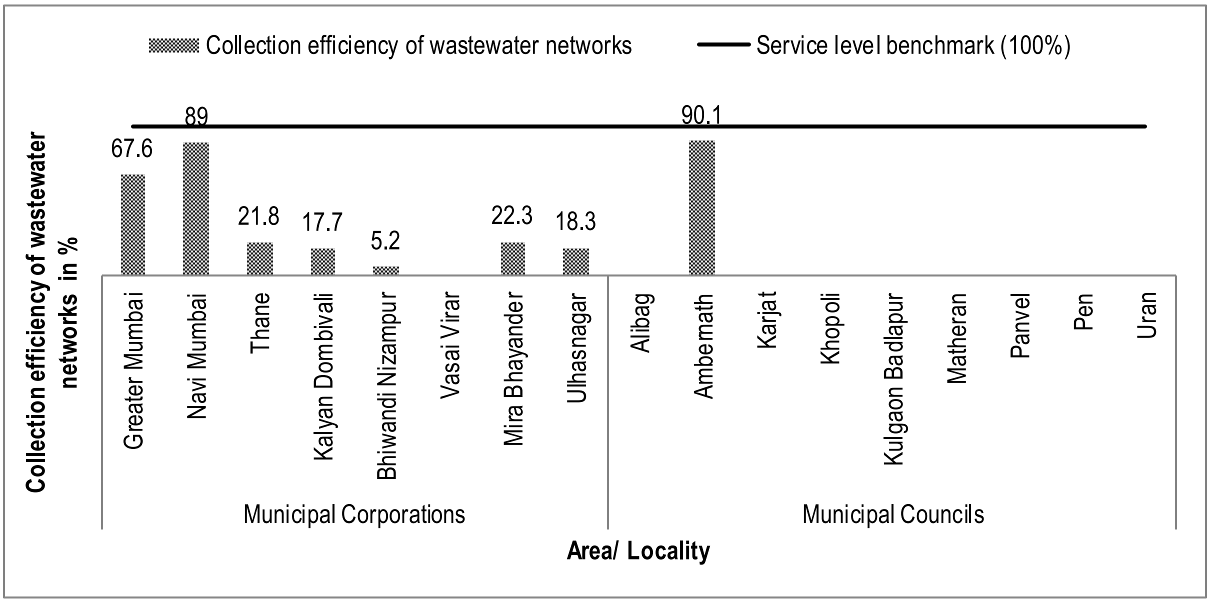


Figure No. 2-80: Collection efficiency of wastewater networks in MMR (2011-12)

Source: http://www.pas.org.in

Observations: As seen in Figure No. 2-80; none of the ULBs meet the SLB. Only Greater Mumbai, Navi Mumbai and Ambernath are above 65%, whereas rest of the Municipal corporations are below 22%.

The data for Vasai Virar, Alibag, Karjat, Khopoli, Kulgaon Badlapur, Matheran, Panvel, Pen and Uran was not available; hence it shows no value.

3. **Adequacy of sewage treatment capacity**

Definition: Adequacy is expressed as secondary treatment (that is, removing oxygen demand as well as solids, normally biological) capacity available as a percentage of normative wastewater generation, for the same time period.

Rationale for the Indicator: Most Indian cities have inadequate capacity for treatment of sewage that is generated in their cities. Significant investments are under way in creating such capacities through programmes such as JNNURM. This indicator will highlight the adequacy of available and operational sewage treatment capacity. The benchmark value for this indicator is 100 %.

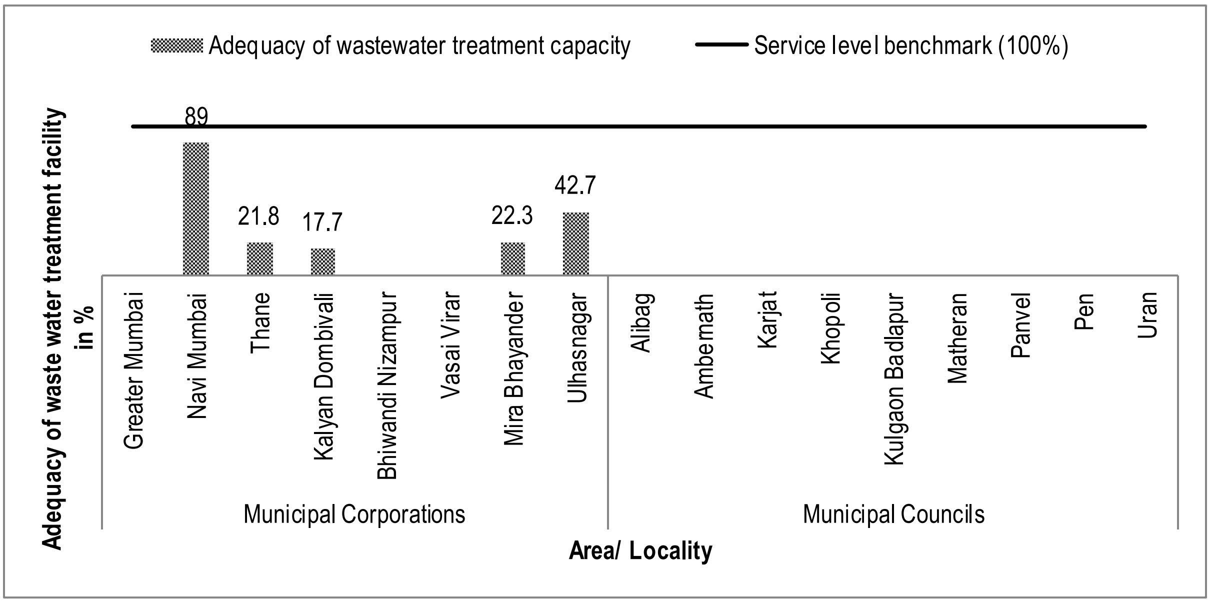


Figure No. 2-81: Adequacy of waste water treatment facility in MMR (2011-12)

Source: http://www.pas.org.in

Observations: As seen in Figure No. 2-81; the data for this performance indicator was missing across all the municipal councils and 3 municipal corporations namely Greater Mumbai, Bhiwandi Nizampur and Vasai Virar. Of the data available it was observed that only Navi Mumbai has performance percentage of 89, whereas the remaining corporations it is below 43%.

4. **Quality of sewage treatment**

Definition: Quality of treatment is measured as a percentage of wastewater samples that pass the specified secondary treatment standards, that is, treated water samples from the outlet of STPs are equal to or better than the standards lay down by the Government of India agencies for secondary treatment of sewage. While the samples are collected at the STP outlet and results should be computed per STP, this indicator should be reported at city/ULB level.

Rationale for the Indicator: For sustainable sewage management, it is not just enough to have the infrastructure to collect and convey the sewage, or the installed capacity to treat it. It is important that the treated water that is discharged back into water bodies, or used for other purposes such as irrigation, meets the laid down environmental standards. It is therefore important to monitor this indicator. Its benchmark value is 100%.

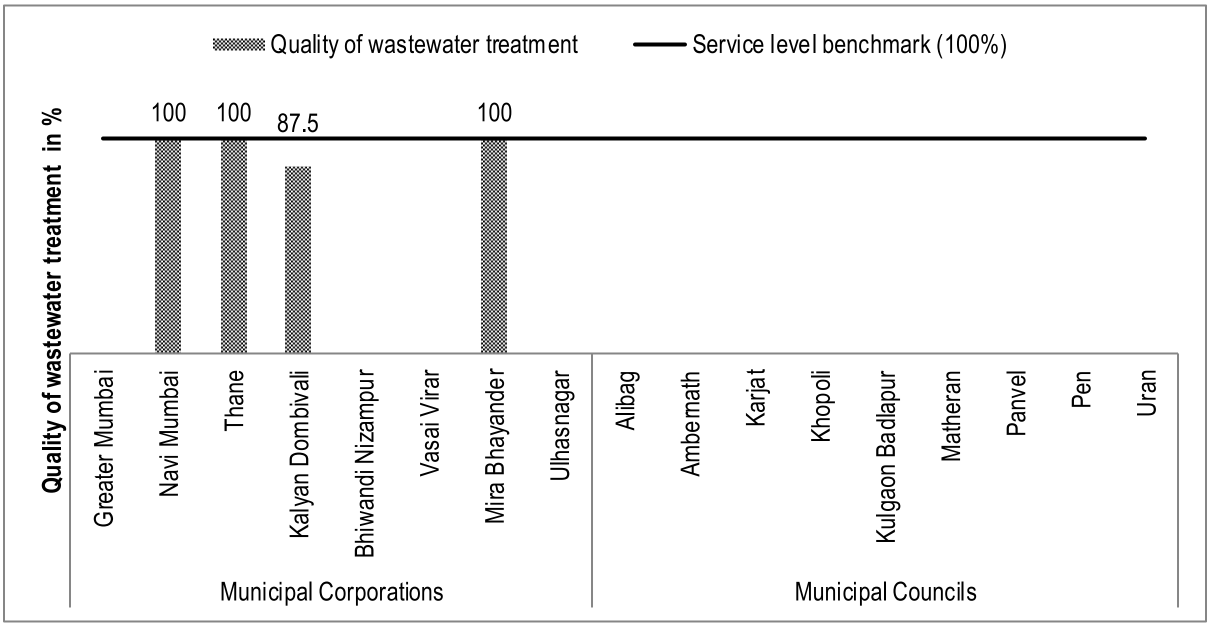


Figure No. 2-82: Quality of wastewater treatment in MMR

Source: http://www.pas.org.in

Observations: As seen in Figure No. 2-82the data for this performance indicator was missing across all the municipal councils and 4 municipal corporations namely Greater Mumbai, Bhiwandi Nizampur, Vasai Virar and Ulhasnagar. Of the data available it was observed that Navi Mumbai, Thane and Mira Bhayander meet the SLB of 100, whereas in Kalyan Dombivali it is 87.5%.

5. Extent of reuse and recycling of sewage

Definition: The percentage of wastewater received at the treatment plant that is recycled or reused after appropriate treatment for various purposes. This should only consider water that is directly conveyed for recycling or reuse, such as use in gardens and parks, use for irrigation, etc. Water that is discharged into water bodies, which is subsequently used for a variety of purposes, should not be included in this quantum.

While measurements are done at STP inlets and outlets, the indicator should be reported at the city/ULB level as a whole.

Rationale for the Indicator: For sustainable water management, it is desirable that sewage is recycled or reused after appropriate treatment. Effluent water can be directly reused in a number of areas such as used in parks and gardens, supplied for irrigation purposes for farmland on the city periphery, etc. To maximise this reuse, it is important that this indicator is measured and monitored. Its benchmark could be 20 %.

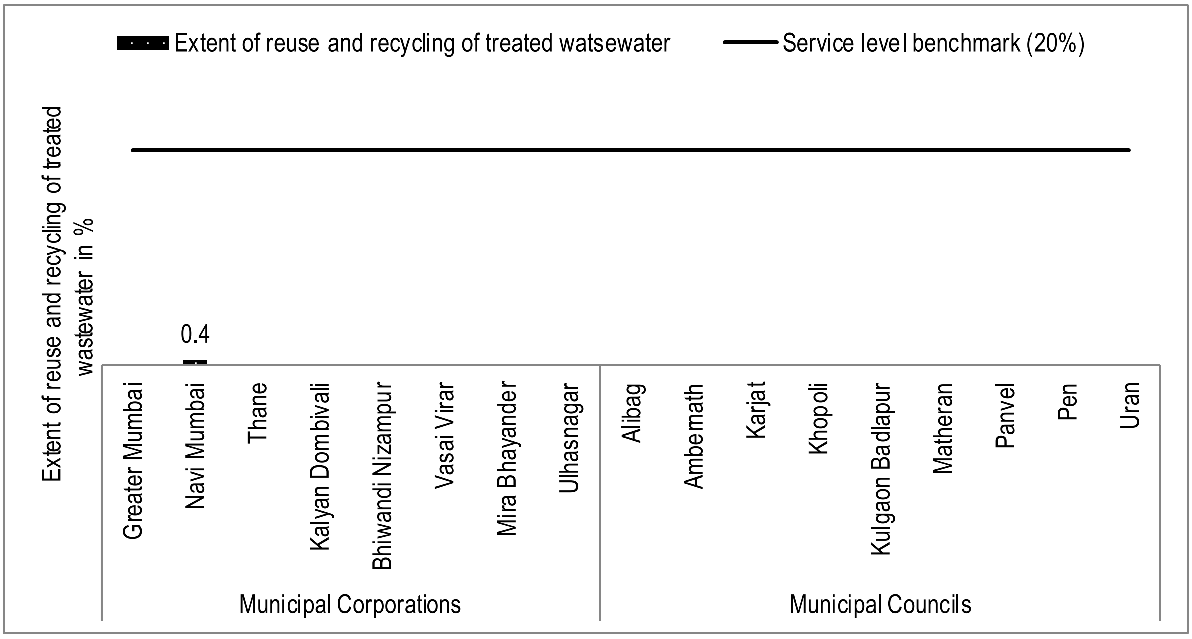


Figure No. 2-83: Extent of reuse and recycling of treated wastewater in MMR

Source: http://www.pas.org.in

Observations: As seen in Figure No. 2-83; the data was missing across all the ULBs except Navi Mumbai where the percentage of reuse and recycle of treated wastewater is 0.4 as against 20%.

6. Efficiency in redressal of consumer complaints

Definition: The total number of sewage-related complaints redressed within 24 hours of receipt of complaints, as a percentage of the total number of sewage related complaints received in the given time period.

Rationale for the Indicator: It is important that in essential services such as sewage, the utility has effective systems to capture customer complaints/grievances, escalate them internally for remedial action and resolve them. While many ULBs/utilities have put in place systems to capture complaints, much more work needs to be done to put in place back-end systems for satisfactorily resolving those complaints on time. As sewage treatment is an essential service, the benchmark time for redressal is 24 hours or the next working day. It is therefore important to monitor this indicator. The benchmark value for this indicator will depend on a number of factors such as the size of the city, age of the network, etc. The benchmark value for this indicator may be set at 80 %.

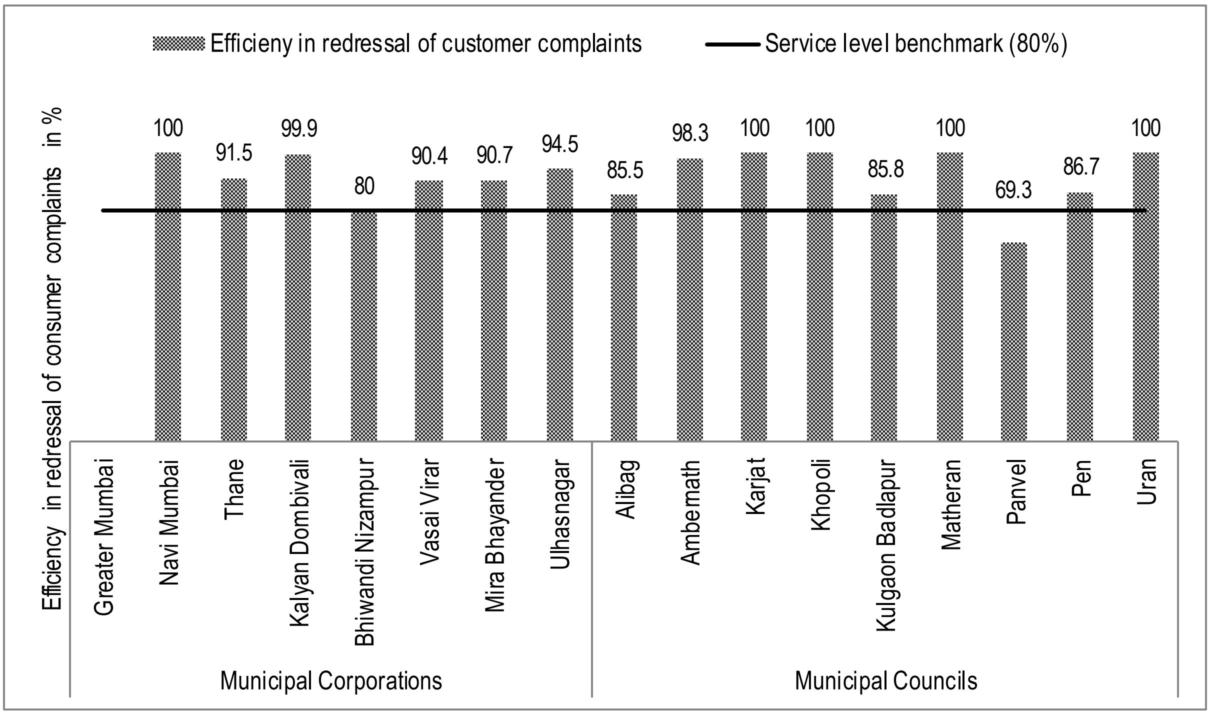


Figure No. 2-84: Efficiency in redressal of consumer complaints in MMR

Source: http://www.pas.org.in

Observations: As seen in Figure No. 2-84; all the ULBs meet the SLB, except Panvel where the performance percentage is 69%. The data for Greater Mumbai was not available, hence it shows no value.

7. Extent of cost recovery in sewage management

Definition: The extent of cost recovery is expressed as wastewater revenues as a percentage of wastewater expenses, for the corresponding time period.

Rationale for the Indicator: Financial sustainability is a critical factor for all basic urban services. In services such as sewerage management, some benefits are received directly by the consumers, and some benefits accrue indirectly through a sustainable environment and public health benefits. Therefore, through a combination of user charges, fees and taxes, all operating costs may be recovered. Therefore, the indicator is critical for measuring overall cost recovery, the benchmark value for which is 100 %.

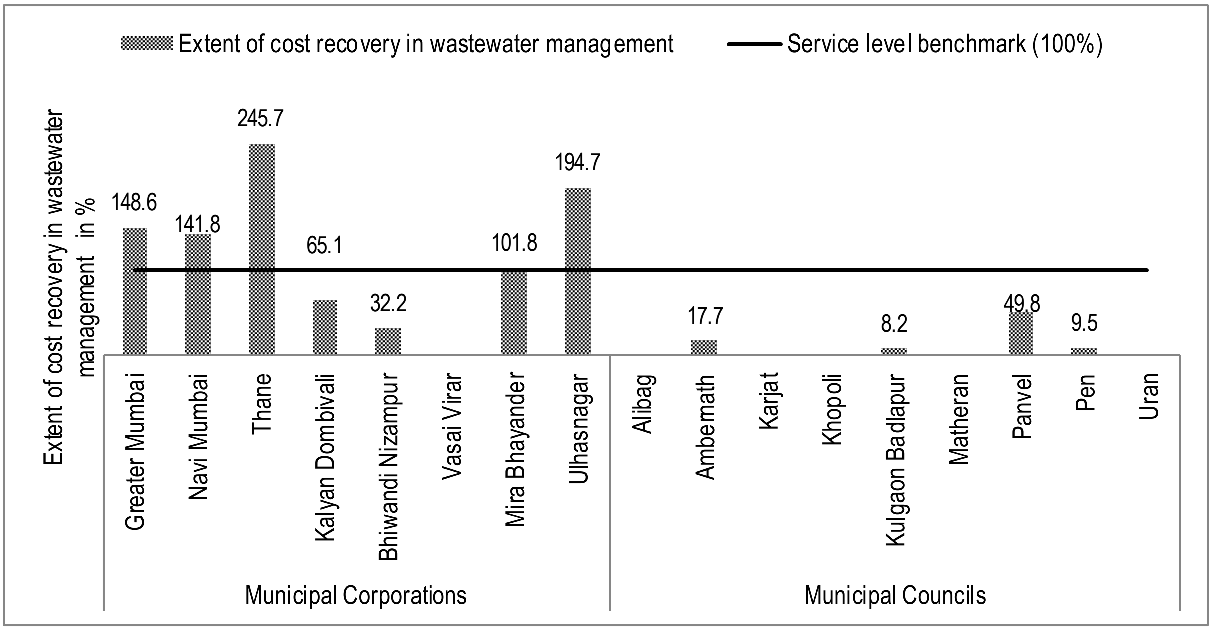


Figure No. 2-85: Extent of cost recovery in wastewater management in MMR (2011-12)

Source: http://www.pas.org.in

Observations: As seen in Figure No. 2-85; only Greater Mumbai, Navi Mumbai, Thane, Mira Bhayander and Ulhasnagar meet the SLB. Whereas in Kalyan Dombivali, Bhiwandi Nizampur, Ambernath, Kulgaon Badlapur, Panvel and Pen the extent of cost recovery in wastewater management is below 65%. For rest of the ULBs the data was not available.

8. Efficiency in collection of sewage charges

Definition: Efficiency in collection is defined as current year revenues collected, expressed as a percentage of the total operating revenues, for the corresponding time period.

Rationale for the Indicator: For a utility, it is not just enough to have an appropriate tariff structure that enables cost recovery objectives, but also efficient collection of revenues that are due to the utility. It is also important that the revenues are collected in the same financial year, without allowing for dues to get accumulated as arrears. It is therefore critical to monitor this indicator. The benchmark value for collection efficiency may be considered at 90 %, since it is possible that about 10 % of the dues may be delayed to the next year.

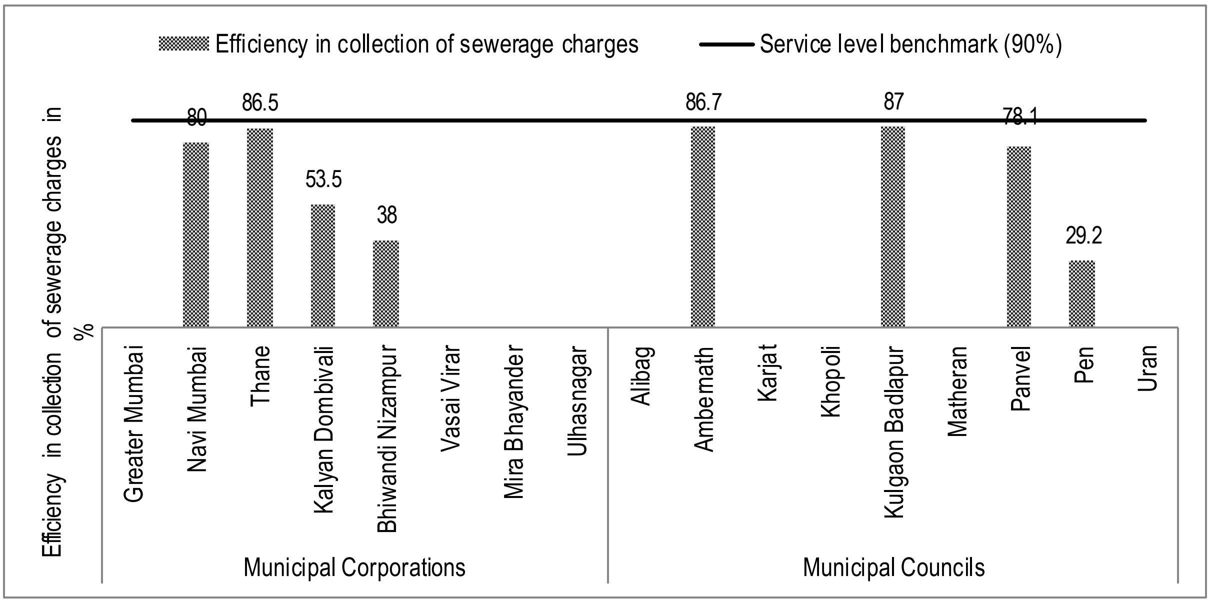


Figure No. 2-86: Efficiency in collection of sewerage charges in MMR

Source: http://www.pas.org.in

Observations: As seen in Figure No. 2-86; Navi Mumbai, Thane, Ambernath, Kulgaon Badlapur and Panvel are close to the SLB ranging between 78 to 87%; whereas in Kalyan Dombivali, Bhiwandi Nizampur, and Pen it is 54, 38 and 29% respectively.

For rest of the ULBs data was not available hence it shows no value.

2.6.2.3 Waste water in MMR (Industrial sector)[91]

In MMR, there are 16,558 industries. Out of which, 52% of industries (8622) fall in the water polluting category of industries as shown in **Table No. 2-54**. Approximately 834.52 MLD of effluent is generated by these water polluting industries.

Table No. 2-54: Waste water generated from industrial sector of MMR

Sr. No.	Region	Total no. of industries	Water polluting industries	Effluent quantity (MLD)
1	Mumbai	2992	386	593.58
2	Navi Mumbai	2999	1376	66.83
3	Thane	4393	3391	40.27
4	Kalyan	4291	2965	49.84
5	Raigad	1883	504	84
	Total	16558	8622	**834.52**

Source: MIDC annual report 2011-12

91 Statistical report 2011-12, MPCB

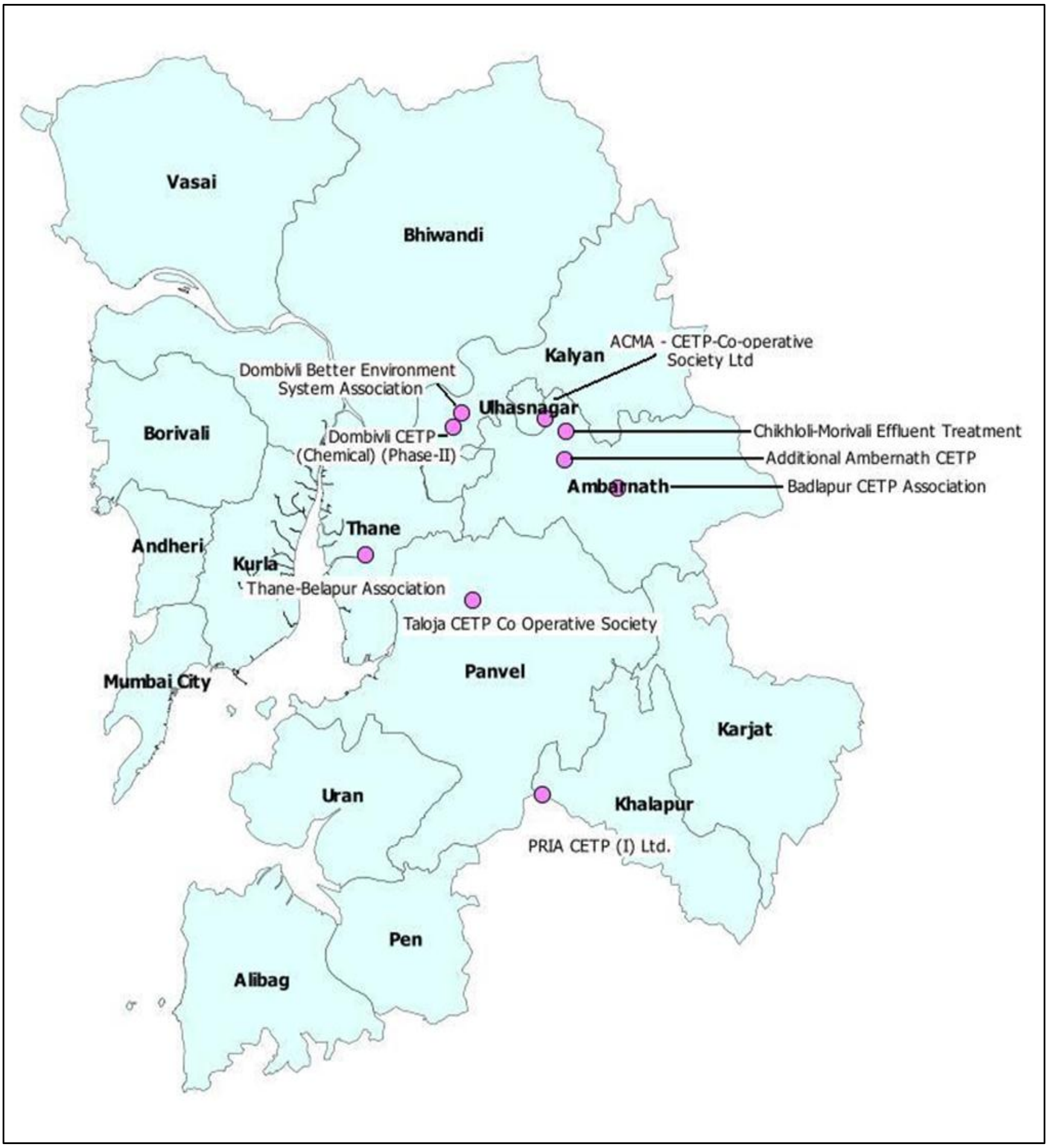
As far as the adequacy of treatment facility at these water polluting industries is concerned, 88% of the industries have adequate treatment facility to treat their effluent. Whereas 8% of the industries have partial treatment facility and 4% of the industries do have treatment facility as shown in Table No. 2-55.

Table No. 2-55: Adequacy of treatment facility in industrial sector of MMR

Sr. No.	Region	Industries having adequate treatment/disposal facilities	Industries having partial treatment/disposal facilities	Industries having no treatment/disposal facilities
1	Mumbai	204	99	83
2	Navi Mumbai	1018	358	0
3	Thane	3340	51	0
4	Kalyan	2679	1	285
5	Raigad	358	146	0
	Total	**7599** **(88%)**	**655** **(8%)**	**368** **(4%)**

Source: MIDC annual report 2011-12

Altogether, there are 9 CETPs (Common Effluent Treatment Plant) installed in the region as shown in Map No. 2-29. For the waste water quality assessment parameters like pH, BOD, COD, TAN and O&G were considered. The average values at the inlet and outlet for the year 2011-2012 were analyzed. The Additional Ambernath CETP is presently not functional, hence the qualitative parameters are not mentioned below.



Map No. 2-29: Spatial representation of CETPs in MMR

Source: Google Earth

Qualitative assessment of effluent from the industrial sector of MMR[92]

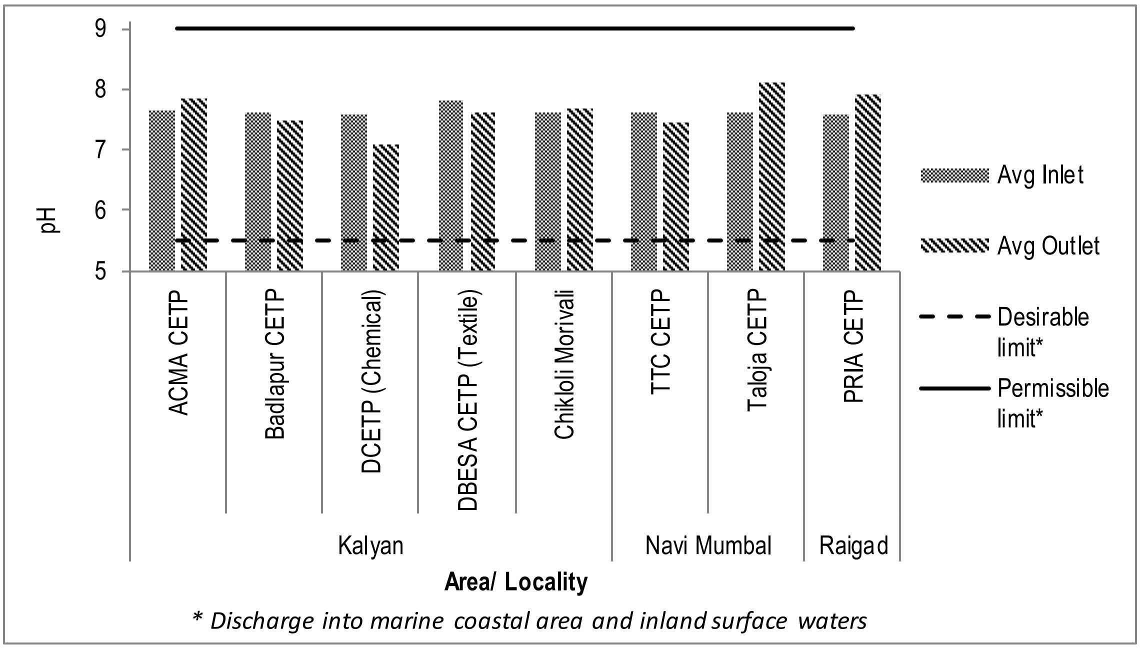


Figure No. 2-87: pH value of CETPs of MMR (2011-12)

Source: MIDC annual report 2011-12

Observations: As seen in Figure No. 2-87; the pH value for all the CETPs are well within the permissible limit of CPCB.

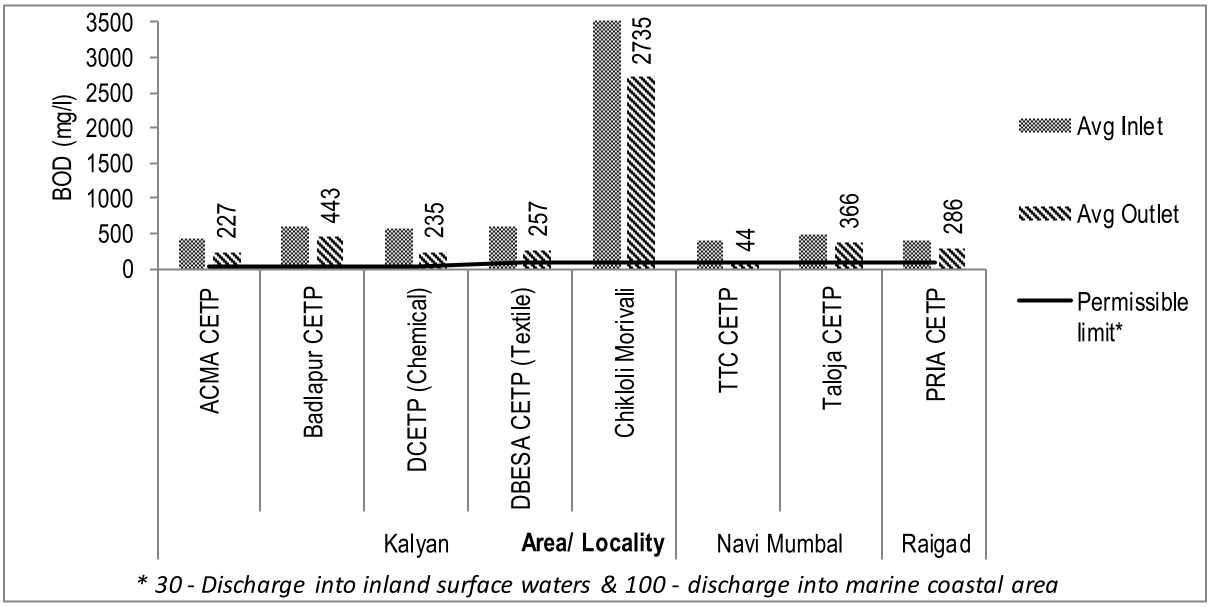


Figure No. 2-88: BOD value of CETPs of MMR (2011-12)

Source: MIDC annual report 2011-12

92 http://mpcb.gov.in/relatedtopics/pdf/CETP%20Standards.pdf

Observations: As seen in Figure No. 2-88; the BOD value at all the CETPs exceeds the permissible limit of CPCB, except at Thane Belapur Association. The possible reasons for higher BOD value may be the inefficiency of the CETPs to function.

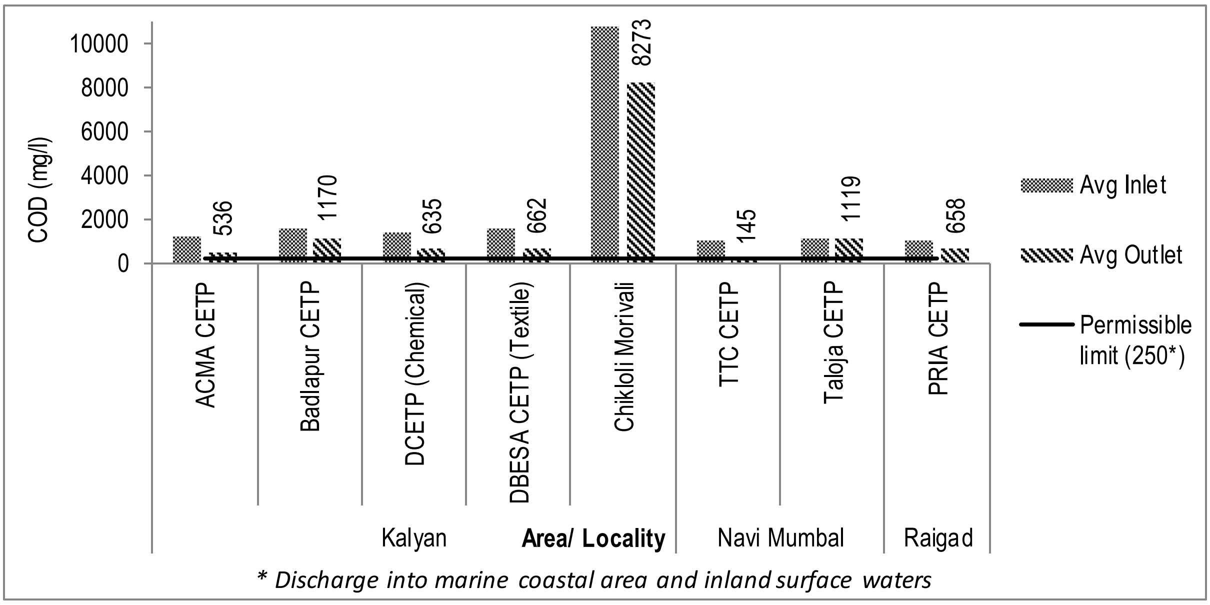


Figure No. 2-89: COD value of CETPs of MMR (2011-12)

Source: MIDC annual report 2011-12

Observations: As seen in Figure No. 2-89; the COD values at all the CETPs exceed the permissible limit of CPCB. The possible reasons for higher COD value may be the inefficiency of the CETPs to function.

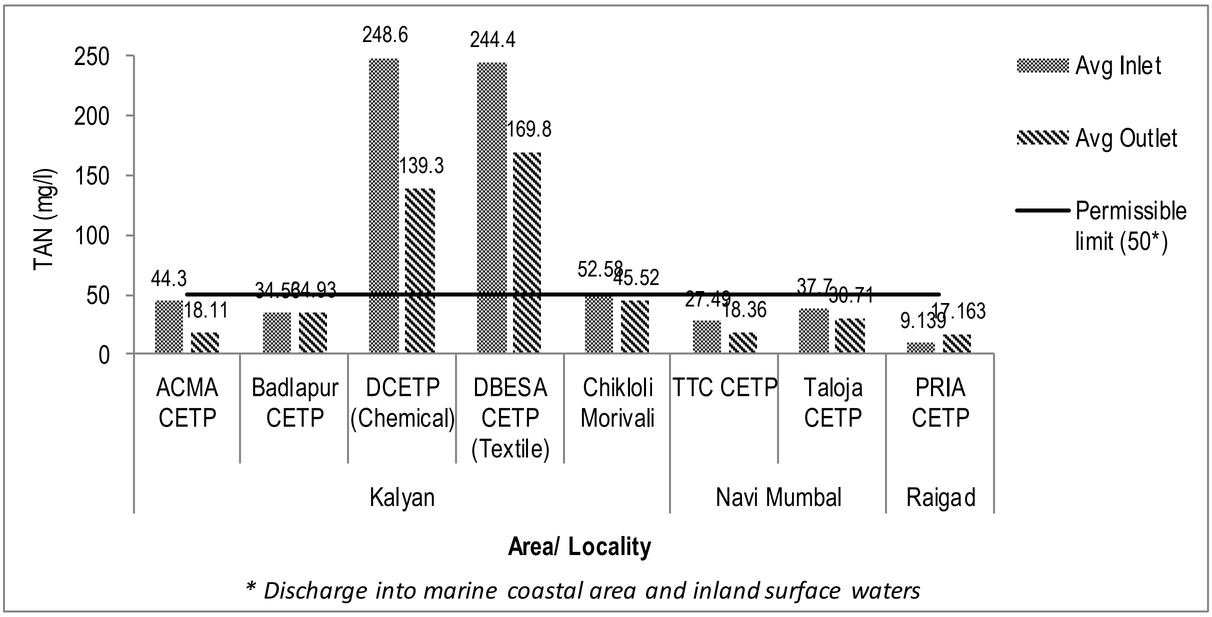


Figure No. 2-90: TAN value of CETPs of MMR (2011-12)

Source: MIDC annual report 2011-12

Observations: As seen in Figure No. 2-90; the TAN values at all the CETPs meet the permissible limit of CPCB, except DCETP and DBESA CETP.

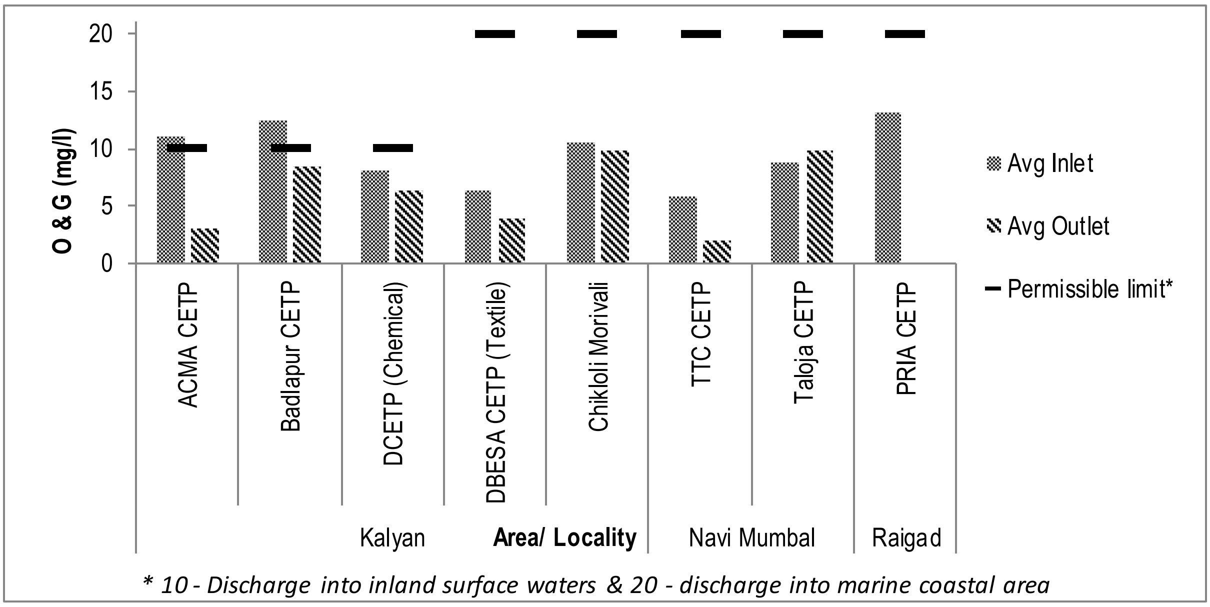


Figure No. 2-91: O & G value of CETPs of MMR (2011-12)

Observations: **The O&G value at all the CETPs meet the permissible limit of CPCB.**

Source: MIDC annual report 2011-12

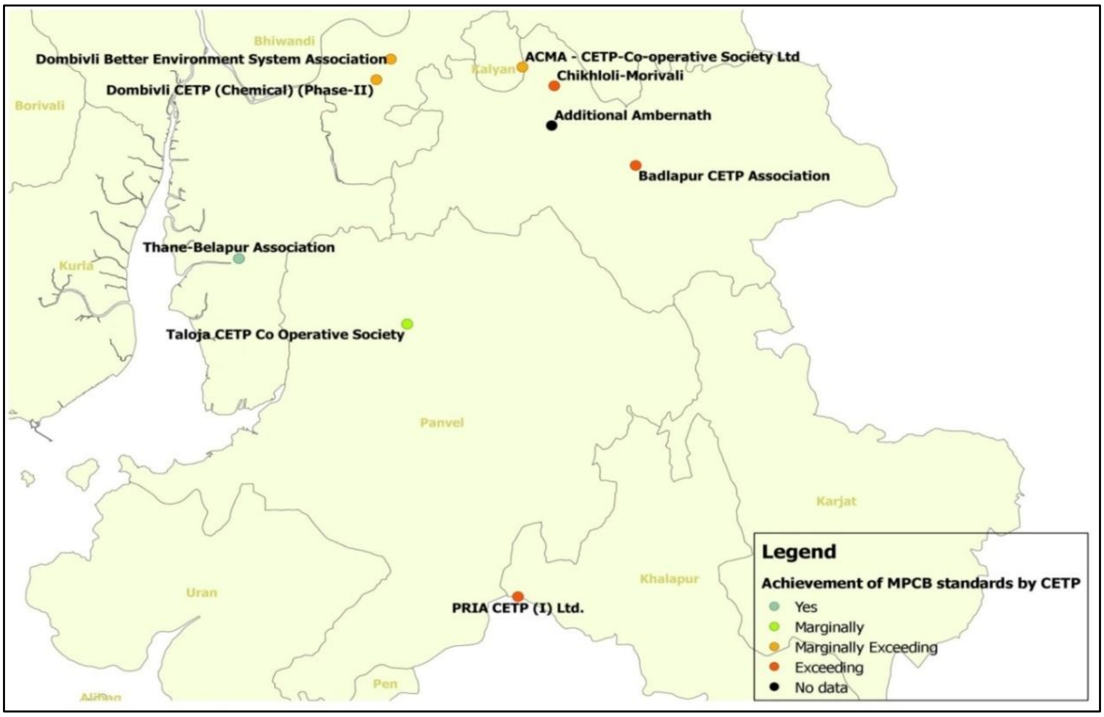
Table No. 2-56: Summary of the status of the waste water quality in MMR (2011-12)

Sr. No	Name of the CETP	Commissioning year	Designed capacity (MLD)	Actual effluent load (MLD)	Permissible MPCB standards
1	PRIA CETP, Patalganga, Raigad	June-2004	15	15	Exceeding
2	Taloja CETP Co-op society	10 MLD- Dec-1999 & 12.5 MLD- Feb-2008	22.5	16	Marginally exceeding
3	Thane Belapur Association	12 MLD- Dec-1997 & 15 MLD Mar-2006	27	26.5	Compliant
4	Badlapur CETP association	2004	8	8	Exceeding
5	Additional Ambernath CETP	1996	7	2.1	Not in operation.
6	ACMA, CETP Co-op society	June-1999	0.25	0.1	Marginally exceeding

Sr. No	Name of the CETP	Commissioning year	Designed capacity (MLD)	Actual effluent load (MLD)	Permissible MPCB standards
7	Dombivali better environment	2001	16	15	Marginally exceeding
8	Chikholi- Morivali effluent treatment	2006	0.8	0.3	Exceeding
9	Dombivali CETP	1999	1.5	1.5	Marginally exceeding

Source: MIDC annual report 2011-12

It is observed from Table No. 2-56 that only 1 CETP is complying with the MPCB standards, whereas 4 CETPs marginally exceed and 4 CETPs exceed the MPCB standards. The spatial representation of the wastewater quality is shown in Map No. 2-30.



Map No. 2-30: Spatial representation of the waste water quality at CETPs in MMR (2011-12)

Source: MIDC annual report 2011-12

2.6.3 Summary of recommendations for water supply and sewerage

TERI's study has clearly identified the gaps and shortcomings in the existing pattern of data recording and the infrastructure available for water supply, sanitation and sewerage. The region is fast growing and densely populated, hence providing basic service becomes utmost important.

Recommendation 1: Documention and recording of the data as per nationally accepted format.

While some ULBs had the most up-to-date data, there were ULBs where old or no data was available for analysis. This data gap is one of the major constrain in studying the entire region in totality. Further, lack of standard format for data collection is another major concern. Training should be given to the concerned personnel and standard code of practice should be employed.

Recommendation 2: Dedicated team for quality control

Contamination of water occurs during transmission. Extensive checking of water quality at the consumer end or ward-wise is not done and should be promoted. Also high level of unaccounted-for water (UFW) needs to be fixed.

Recommendation 3: Revsiting the tariff structure

For residential sector in Navi Mumbai, water and sewerage charges are the same. This is as usual scenario, where the consumers are billed as per their usage. In order to encourage optimum utilization of water resource, it is recommended to levy tax proportionate to the quantity of sewage generated by unit holders. In such a case, the ULBs could also supply water free of cost.

Recommendation 4: Increasing water supply infrastructure to ensure uniformity in supply of water

In MMR, variable supply to various areas in MMR needs attention to bring in the uniformity. Also there is a need for augmentation of dams and reservoirs around the region. The sources have been identified and planning has been done. However time-bound and systematic execution needs attention.

Recommendation 5: Having more & efficient waste water treatment facility in the region

Industrial sector:-

In MMR, there are 40% of the industries which do not have adequate waste water treatment facility. This infrastructural gap needs immediate attention. Industries should either treat their wastewater to tertiary level or minimize their waste discharges to ensure that it can be absorbed by the rivers. Further, heavy penalty should be levied on industries violating the CPCB/MPCB norms.

Residentail sector:-

Only 75.26% of the total wastewater generated in the region is treated to some extent (Either primary or secondary). Hence it is recommended to treat 100% of the wastewater generated in the region to an extent of tertiary treatment followed by biological treatment before its recycling.

Environmental Status Report of Mumbai Metropolitan Region

Section
3 Air Quality

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3.1 Introduction

Owing to influence of growing urbanization and industrialization a lot of undesired elements have been added to ambient air's composition especially due to anthropogenic activities. This change in the composition of pure air is termed as "Air Pollution". An air pollutant has been defined as any solid, liquid or gaseous substance (including noise) present in the atmosphere in such concentration as may be or tend to be injurious to human beings or other living creatures or plants or property or environment.

Combustion of fossil fuel in vehicles, power plants and industries to meet the energy requirements are exert tremendous pressure on the atmosphere, thereby deteriorating the air quality and exposing citizens to great health risks. Moreover construction activities, road dust re-suspension owing to movement of vehicles and quarrying activities constantly disperse particulate matter. Apart from these, burning of domestic fuel and use of DG (diesel generator) sets has further aggravated the problem, globally.

Fossil fuel usage in transport, industries and power plants the major source of air pollution

In a developing country like China, three main economic zones have more than 200 hazy days per year, which primarily results from the rapid industrialization and urbanization which provide 30% of the overall sulphur dioxide, nitrogen oxides and dust emissions in China. In order to treat the issue, the government has formulated regulations, standards and policies to reduce air pollutants. They have planned to build a national air quality monitoring network across 190 Chinese cities by the end of the year 2013. The network will publicize real-time air-quality monitoring data, which will offer a scientific basis for us to control air pollution and increase the determination of local governments to push forward the treatment measures[1].

United Kingdom is also actively involved in controlling the air pollution and improving the air quality status. The government has taken strong actions to manage and improve air quality driven by European (EU) legislation. The 2008 ambient air quality directive (2008/50/EC) sets legally binding limits for concentrations in outdoor air of major air pollutants that impact public health such as particulate matter (PM10 and PM2.5) and nitrogen dioxide (NO_2)[2].

Similarly, MMR being the most urbanised region in the country is under tremendous stress of air pollution with its air quality exceeding the permissible limits of NAAQS (National Ambient Air Quality Standards) over the years. Rapid population growth in MMR, growth in mobility demands, demands for power, transport requirements within and from the nearby regions have all led to emissions of air pollutants in MMR. As per the GBD (Global Burden of Disease) report[3], Ulhasnagar and Badlapur topped the levels of SOx and NOx concentrations among those 190 cities in terms of air pollution. SO_2, NOx and RSPM are the major concerns in the region and scientific assessment is crucial to have a baseline of pollution levels in MMR. Hence, having an appropriate knowledge of state of air quality in the region is required to plan strategic development.

[1] http://www.china.org.cn/china/NPC_CPPCC_2013/2013-03/16/content_28261889.htm

[2] http://uk-air.defra.gov.uk/air-pollution/uk-eu-policy-context

[3] http://www.healtheffects.org/International/HEI-India-GBD-PressRelease021313.pdf

The source of Air pollutants could be both natural as well as anthropogenic. An elaborate enlisting of the sources (natural and anthropogenic) and the harmful effects on humans is provided in Annex 8. USEPA (United States Environmental Protection Agency) has identified 6 major air pollutants which are enlisted below in Table No. 3-1 along with their anthropogenic sources and effects on human health. In addition to USEPA, CPCB (Central Pollution Control Board) Government of India, also regards the pollutants mentioned in the above table as major air pollutants in the Indian context.

Table No. 3-1: Major air pollutants, their sources and their effects on humans

Pollutants	Sources	Effects	Annual Standards[4]
Oxides of Nitrogen (NOx)	Combustion processes (heating, power generation, and vehicles)	• Bronchitis in asthmatic children. • Reduced lung function	40 µg/m³
Particulate Matter (PM2.5, PM10)	Vehicles, industrial sources, domestic fuel burning, road dust re-suspension,	• Cardiovascular and respiratory diseases, • Lung cancer, • ALRI (Acute Lower Respiratory Infections)	PM2.5 40 µg/m³ PM10 60 µg/m³
Carbon monoxide (CO)	Incomplete fuel combustion (as in motor vehicles)	• Reduces the oxygen carrying capacity of blood, • Causes headaches, nausea, and dizziness • Can lead to death at high levels	2 µg/m³ (for 8 hours)
Sulphur dioxide (SO_2)	Burning of sulphur-containing fuels for heating, power & vehicles.	• Affects respiratory system and lung function. Coughing, mucus secretion, asthma and chronic bronchitis. • Causes acid rain.	50 µg/m³
Lead (Pb)	Petrol and industry (such as smelting, and paint works).	• Affects brain development of children, • At very high doses leads to poisoning, • May lead to brain and organ damage.	0.5 µg/m³
Ozone (O_3) Tropospheric	Formed by the reaction of NOx and (VOCs) in sunlight	• Breathing problems, asthma, reduce lung function.	100 µg/m³ (for 8 hours)

Source: US Environment Protection Agency and Central Pollution Control Board, GoI

[4] Annual standards by *Central Pollution Control Board, 2009*. Annual Arithmetic Mean of 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals. The annual average and 8 hourly average values recorded at a location should not exceed the prescribed standards.

3.1.1 Policy initiatives: India

Air quality laws govern the emission of air pollutants into the atmosphere or the quality of air inside buildings. Air quality laws are often designed specifically to protect human health by limiting or eliminating airborne pollutant concentrations and address broader ecological problems, such as limitations on chemicals that affect the ecosystem The major policy and legal initiatives taken in India having implications over air pollution are discussed below:

3.1.1.1 Air (Prevention and Control) Act

Government of India enacted the Air (prevention and control pollution) Act 1981. The act prescribes to combat air pollution by prohibiting the use of polluting fuels and substances as well as by appliances that give rise to air pollution. Under this Act, the central government is empowered to take measures necessary to protect and improve the quality of the environment by setting standards for emissions and discharges; regulating the location of industries; management of hazardous wastes, and protection of public health and welfare.

Since the 1970s environmental legislation in India has been taking serious initiatives to tackle the issue of air pollution.

3.1.1.2 Auto Fuel Policy

In the 2003, MoPNG (Ministry of Petroleum and Natural Gas), Government of India has enunciated an Auto Fuel Policy, to address the issues of vehicular emissions, vehicular technologies and auto fuel quality in a cost-efficient manner while ensuring the security of fuel supply. The main objective of the policy is to adopt such vehicular emission standards that will be able to make a decisive impact on air quality. The Policy provides a road map for reduction in vehicular emission norms for new vehicles as well as for reduction of pollution from in-use vehicles.

3.1.1.3 National Environment Policy

The government recognised the importance of early action to combat air pollution and formulated the National Environment Policy (NEP)-2006 which, enumerates the following specific actions that need to be taken to control air pollution:

- Strengthening the monitoring and enforcement of emission standards for both point and non-point sources
- Preparing and implementing action plans for major cities relying on a judicious combination of fiats and incentive-based instruments
- Formulating a national strategy for urban transport

3.1.2 Regulatory Framework

Regulatory efforts include identifying and categorizing air pollutants, setting limits on acceptable emissions levels, and dictating necessary or appropriate mitigation technologies. In India there exists a regulatory framework at the national level which operates under the Ministry of Environment and Forests, Government of India.

3.1.2.1 Central Pollution Control Board

The CPCB (Central Pollution Control Board), statutory organisation, was constituted in September, 1974 under the Water (Prevention and Control of Pollution) Act, 1974. Further, CPCB was entrusted with the powers and functions under the Air (Prevention and Control of Pollution) Act, 1981. CPCB serves as a field formation and also provides technical services to the Ministry of Environment and Forests of the provisions of the Environment (Protection) Act, 1986. Principal Functions of the CPCB, under the Air (Prevention and Control of Pollution) Act, 1981, is to improve the quality of air and to prevent, control or abate air pollution in the country.

3.1.2.2 Maharashtra Pollution Control Board

To implement the activities of CPCB at the state level, State pollution control boards were established. The Maharashtra State government in 1981 adopted the Water (Prevention and Control of Pollution) Act 1974 and under this MPCB (Maharashtra Pollution Control Board) was established in the year 1981. MPCB has established 12 regional and 42 sub-regional offices across the state to check and regulate the pollution level with necessary control measures. The main functions of MPCB are as follows

- To plan comprehensive program for the prevention, control or abatement of pollution and secure executions thereof,
- To collect and disseminate information relating to pollution and the prevention, control or abatement thereof,
- To inspect sewage or trade effluent treatment and disposal facilities, and air pollution control systems and to review plans, specification or any other data relating to the treatment plants, disposal systems and air pollution control systems in connection with the consent granted,
- Supporting and encouraging the developments in the fields of pollution control, waste recycle reuse, eco-friendly practices etc.
- To educate and guide the entrepreneurs in improving environment by suggesting appropriate pollution control technologies and techniques
- To create public awareness about clean and healthy environment and attending the public complaints regarding pollution.

The Air (Prevention & Control of Pollution) Act 1981 was adopted by the state of Maharashtra in 1983 and the MPCB is functioning as the state board under section 5 of this Act. Following this MPCB has taken many initiatives to control, prevent and monitor air quality in the state of Maharashtra.

3.1.3 Ambient Air Monitoring

Detection and measurement of constituents of the atmosphere (ambient air) is becoming increasingly important. Careful planning of measurements is essential to arrive at correct results of the measurement. One of the major factors which influence the representation of data collected is the location of monitoring stations. Monitoring stations are set up keeping in view a large number of parameters. Such a planning requires consideration of various parameters involved in making the measurements, namely, objective, physical access, security, various human and environmental agencies affecting the emission, transport and dispersion of the constituents and their ultimate fate. Hence detection and monitoring of the ambient air needs to be done scientifically and hence standard guidelines have been developed for its monitoring. The Indian Standards and CPCB guidelines followed in India are discussed below.

3.1.3.1 Indian Standards

The Bureau of Indian Standards (BIS) has released the revised Indian Standard (Indian Standards: 5182 (Part 14), 2000) titled "Methods for Measurement of Air Pollution Part 14 Guidelines for Planning the Sampling of Atmosphere" in the year 2005. The standard takes into consideration large number of parameters in setting up monitoring stations. It has been prepared with a view to present broad guidelines to be followed in establishing a monitoring network so as to optimize the efforts. The objectives and situations most likely to be encountered in the country have been considered in detail in these standards.

CPCB initiated the NAMP (National Air Quality Monitoring Program) in 1984 with seven AAQMS.

3.1.3.2 CPCB guidelines for Ambient Air Monitoring

Under the Air (Prevention and Control of Pollution) Act, 1981, CPCB initiated National Ambient Air Quality Monitoring programme in the year 1984 and the network of monitoring stations has been extended throughout the country. To maintain a uniformity for carrying out ambient air quality monitoring including selection of monitoring stations, number and distribution of monitoring stations, selection of pollutants, measurement methods, sampling duration and frequency etc. The guidelines have been prepared on the basis of experience gained over the years in ambient air quality monitoring.

3.1.3.3 National Air Monitoring Program

CPCB initiated National Ambient Air Quality Monitoring (NAAQM) programme in the year 1984. Subsequently, expanding the network to have representation of various regions in the country, various stations under the programme were established nationwide. The program was subsequently renamed as National Air Quality Monitoring Programme (NAMP). In the year 2010-11 CPCB is executing NAMP for generating air quality database at 456 air quality monitoring stations throughout the nation covering 190 cities in 26 States and 4 union territories.

However, at state level the data from few NAMP sites is not easily available to state pollution control boards. Also the network under NAMP is not adequate at times to represent larger states. To further strengthen the network of AAQM (Ambient Air Quality Monitoring) stations at state level, MPCB (Maharashtra Pollution Control Board) has installed monitoring stations under SAMP (State Air Monitoring Program). Also there are proposals under SAMP and NAMP to further expand the AAQM network in the state of Maharashtra including MMR. As on March 2013, there are 25 AAQMS in MMR Table No. 3-2.

3.1.3.4 Standards for pollutant concentration

Standards have been released by CPCB under the Air (Prevention and Control) Act called as National Ambient Air Quality Standards (NAAQS) with the following objectives:

- To indicate the levels of air quality necessary with an adequate margin of safety to protect the public health, vegetation and property;
- To assist in establishing priorities for abatement and control of pollutant level;
- To provide uniform yardstick for assessing air quality at national level;
- To indicate the need and extent of monitoring programme.

The revised National Ambient Air Quality Standards Table No. 3-1 were notified on 18 November 2009. A copy of the Gazette is attached as Annex 9.

3.2 Approach and Methodology

Regular air quality monitoring and assessment in MMR is carried out by the AAQMS installed by Central Pollution Control Board and Maharashtra Pollution Control Board. Also the CPCB and NEERI have carried out detailed assessment of the source apportionment for the city of Mumbai. However a comprehensive status report encompassing the major parameters for the MMR region has not been developed. Hence this is the first of its kind report which is been developed at regional scale of Mumbai Metropolitan Region. A specific and customised methodology was developed for interpretation and analysis of the guidelines released by CPCB were referred and adopted. The step wise methodology for the study is discussed in the following section.

3.2.1 Review of CPCB guidelines

Guidelines for Ambient Air Quality Monitoring, released by CPCB in the year 2003-04 under National Ambient Air Quality Monitoring Series have been used to analyze the ambient air quality monitoring network in MMR. The Revised National Ambient Air Quality Standards[5] (NAAQS), notification dated 18th November 2009, as per the gazette released by CPCB (Appendix C) have been considered to compare the violation of the pollutant concentrations monitored at various monitoring stations.

3.2.2 Setting up of the physical boundaries for study area

The study has been developed as per the data available from the monitoring sites within the jurisdiction of MMR. There are a few sources like industrial belts at Tarapur and Roha, power plant at Dahanu which lie outside MMR jurisdiction. They have not been considered for the study as they are relatively far from the MMR boundaries and more detailed study, through source apportionment, emission inventory, meteorological assessment, air quality modelling and so on is required to study the impact of these sources in the air quality of MMR.

3.2.3 Analysing existing monitoring network

The coverage of existing monitoring network and monitoring protocol followed by each station in the network has been studied. The spatial coverage of the monitoring network has assessed with the help of GIS (Geographical Information System) and protocol followed by different monitoring agencies in the region has been compared with standard protocol given by the CPCB. After this, gaps in the existing air quality monitoring infrastructure in the region have been identified and the number of stations required to augment the identified gaps have been estimated based on the guidelines released by CPCB.

3.2.4 Selection of pollutants

SO_2 (Sulphur Dioxide), NOx (Nitrogen Oxides) and RSPM (Respirable Suspended Particulate Matter) have been considered for determining the air quality of MMR. These are

[5] http://cpcb.nic.in/National_Ambient_Air_Quality_Standards.php

the three air pollutants identified under NAMP for regular monitoring at all the sites as a standard practice. Hence only these pollutants have been considered for the analysis.

As per CPCB, the SPM (Suspended Particulate Matter) are bigger coarse particles which settle down fast and do not reach the respiratory tract. Therefore they have less adverse effect on health and not been included in the revised standard under NAMP from 2012[6] and not considered in the present study.

3.2.5 Site selection and trend analysis

After analysing the coverage and scientific accuracy of data generated by monitoring network in the region, station-wise trend analysis is being carried out for stations which follow the standard monitoring protocol. Only the AAQMS under pollution control boards (MPCB and CPCB) have been considered for the analysis.

The sites which monitored a minimum of 85+ observations in a year have only been considered for the annual averages to depict the concentration of a pollutant at a station or a region for the trend and status of that pollutant.

3.2.6 Site survey of polluted sites

Based on the trend analysis, two stations having worst air quality (sites exceeding the permissible limits were shortlisted for the survey) were identified and a reconnaissance survey was carried out at these stations to identify the potential sources of air pollution. A specific questionnaire was developed for the field visits. The findings of the survey have been elaborated in the section 4.2.1 of this report.

3.2.7 Review of case studies and regional initiatives

Literature review was carried out to quantify the impact of air pollution on human health, vegetation and infrastructure in the region. Thereafter, list of initiatives taken by government in response to the problem of air quality was prepared.

3.2.8 Secondary Data Collection

Air Quality in MMR is regularly monitored under the, SAMP (State Air Monitoring Program) by CPCB and MPCB. The ULB's (Urban Local Bodies) either have their own monitoring stations or monitor the air quality of specific locations within their jurisdiction through air sampling. Under the Air (prevention and control of pollution) Act 1981 industries also monitor the ambient air quality and stack emissions. All the above sources were approached to collate information on air quality to have a representation of the region. Literature review, personal interaction, and access to database were the main ways to collect the information and data sets for the study. A brief gist of the same is provided below

3.2.8.1 Stations regulated under Monitoring Programs

- MPCB publishes data online for its monitoring stations under NAMP and SAMP. The data range is flexible and is accessible on their website. The data sets for the stations in MMR have been digitized in a spread sheet and used for the analysis.

[6] http://cpcb.nic.in/upload/NewItems/NewItem_192_NAAQSTI.pdf

- Three monitoring stations under NAMP, located at Parel, Worli and Kalbadevi in Mumbai are monitored by NEERI (National Environmental Engineering Research Institute). They submit their data directly to CPCB. This data was collected from NEERI in hard copies and then digitized for further analysis.

- The online published reports by CPCB and data sets from these reports were referred for the purpose of the study. The Guidelines for Ambient Air Quality published by CPCB were referred to compare the existing monitoring network in MMR as against the recommended minimum number of stations.

3.2.8.2 Stations regulated by Urban Local Bodies

- The A class cities in Maharashtra publish an annual Environmental Status Report. This report documents the data on air quality in their municipal limits. Out of the 10 A class cities in MMR 9 of them publish an annual ESR. Ulhasnagar Municipal Corporation is an only exception which does not document an ESR. The ESR's of all the ULBS were collected to procure data for the air quality monitoring in their jurisdiction.

3.2.8.3 Stations regulated by Industries

- Air pollution prone industries in MMR monitor ambient air quality while submitting their environmental statement to MPCB. However many a times this monitoring is not consistent and is not at par with the national guidelines which is to be considered as annual averages. Hence, agencies which have CAAQMS (Continuous Ambient Air Quality Monitoring Stations) in their premises were approached personally and through MPCB to procure the data from their monitoring stations.

Specific Recommendation

The data for air quality monitoring by the various agencies is not easily available online except for data from MPCB. Also there is no single point repository for the data recorded by the various agencies. More specifically

- ULBs provide data as annual averages for the air quality monitored by them and don't give details regarding number of observations, time frames and other details. There is no uniformity in collation of data, its availability and its representation.
- 3 monitoring stations viz. the AAQMS at Parel, Kalbadevi and Worli are regulated by NEERI under NAMP and the data is deposited with CPCB. This data is not available with MPCB and also it is not available online.
- The data recorded by the AAQMS of the Industries is shared with MPCB but it is not available on line.
- It is recommended to establish a single window/ point repository to provide centralized data, in a uniform format, pertaining to air quality generated by various agencies like CPCB, MPCB, NEERI, ULBs, Transport Department and Industries. The data could be updated periodically or may be made available as real time data as may be applicable.

3.2.9 Data Compilation

The data thus collected from the various agencies has been digitized in a spread sheet format and been used for the analysis. The complete digitized data sets has been provided in a CD (Compact Disk) enclosed along with this report as Annex 10.

3.2.10 Stakeholder Consultations

Given the complexity of the region and involvement of diverse stakeholders, a lot of personal interaction was required to explain the requirements of the project and procurement of the expected data in a desired format. Since, various agencies maintain data in various formats, specific and target oriented questionnaires were developed and circulated while requesting the data. The mode of correspondence and the list of the agencies approached is enlisted below in Table No. 3-2.

Table No. 3-2: List of stakeholders approached to procure data for Air Quality assessment

Organizations/Officials Approached	Mode of correspondence
National Environmental Engineering Research Institute (NEERI)	
Scientist G and Head, Mumbai Zonal Laboratory	Email
Principal Scientist, Mumbai Zonal Laboratory	Telephonic conversation
Maharashtra Pollution Control Board (MPCB)	
Member Secretary - MPCB	Letter, Email and personal meeting
Technical Secretary- MPCB	Personal meeting
Jt-Director (APC)	Personal meeting
Scientific Officer - MPCB	Personal meeting
Statistical Officer - MPCB	Personal meeting
RO- Navi Mumbai- MPCB	Personal meeting
RO- Raigad - MPCB	Telephonic interaction
RO-Thane - MPCB	Telephonic interaction
RO-Kalyan - MPCB	Telephonic interaction
Urban Local Bodies	
Municipal Corporation of Greater Mumbai	Personal visits and correspondence
Thane Municipal Corporation	Personal visits and correspondence
Navi Mumbai Municipal Corporation	Personal visits and correspondence
Kalyan Dombivali Municipal Corporation	Personal visits and correspondence
Vasai Virar Municipal Corporation	Personal visits and correspondence
Bhiwandi Municipal Corporation	Personal visits and correspondence
Mira Bhayandar Municipal Corporation	Personal visits and correspondence
Ulhasnagar Municipal Corporation	Personal visits and correspondence
Ambernath Municipal Council	Personal visits and correspondence
Panvel Municipal Council	Personal visits and correspondence
Industries	
Jawharlal Nehru Port Trust	Mails, personal visits, telephonic conversations
Bombay Port Trust	Mails, personal visits, telephonic conversations
MAHAGENCO	Mails, personal visits, telephonic conversations
TATA Power	Mails, telephonic conversations
Bharat Petroleum Corporation Limited	Mails, telephonic conversations
Hindustan Petroleum Corporation Limited	Mails, telephonic conversations
Rashtriya Chemicals and Fertilizers	Personal visit, Mails, telephonic

Organizations/Officials Approached	Mode of correspondence
	conversations
Gharda Chemicals	Mails, telephonic conversations
Oil and Natural Gas Corporation	Mails, telephonic conversations
Maharashtra Industrial Development Corporation	
Advisor to MIDC	Personal Interaction
RO- MIDC Thane	Personal Interaction
RO-MIDC Mahape	Personal Interaction
AE (E&M)	Personal Interaction
Regional Transport Office (RTO)	
Jt. Commissioner - RTO	Fax, email

Specific Recommendation

There is a major data gap or lack of communication between the various stakeholders which further translates into lacuna for technical know - how on the data base management. It was observed that there are two AAQMS, regulated one each by NEERI and MCGM. They are located in close vicinity (

Map No. 3-1) at Worli, However both the stations showed very diverse readings of the same region. The annual average value of SO_2 recorded by MCGM in 2011-12 was 14µg/m^3 as against that monitored by NEERI which were around 5µg/m^3 for the same year.

Hence the specific recommendation for the same:

1. Spatial maps of the air quality monitoring stations should be made available, updated and circulated amongst the stakeholders.
2. There should be multiple monitoring stations of different agencies at very critical locations such as Saki Naka, Amar Mahal, Andheri, Sion, Bandra junction and so on to facilitate cross verification of the data. Also in case of system failures, parallel set up help avoid any data gaps.
3. Periodic interactions between the concerned personnel monitoring the air quality should be encouraged. Trainings and refreshers courses for the field

3.3 Status of AAQM Infrastructure in MMR

3.3.1 Monitoring Network

Ambient air quality monitoring network is designed to get spatial and temporal variation of ambient air concentrations addressing a wide range of pollutants that are considered relevant for evolving a strategic management plan. Monitoring locations are selected to represent different land use categories like kerbside, residential, industrial, commercial etc. were selected so as to capture air quality levels under different activity profiles. Sometimes, one background location (away from all the sources and in upwind direction) is also included. Population density, meteorology, major polluting sources, transport network, topography and so on are the main criteria for the design of air quality monitoring network. In addition, due consideration is given to security aspects as well as availability of power supply while choosing the sites. After the Air (Prevention and control of pollution) Act, 1981, CPCB initiated NAAQM (National Ambient Air Quality Monitoring) programme in the year 1984. Subsequently, expanding the network to have representation of various regions in the country, various stations under the programme were established nationwide. The program was subsequently renamed as NAMP (National Air Quality Monitoring Programme).

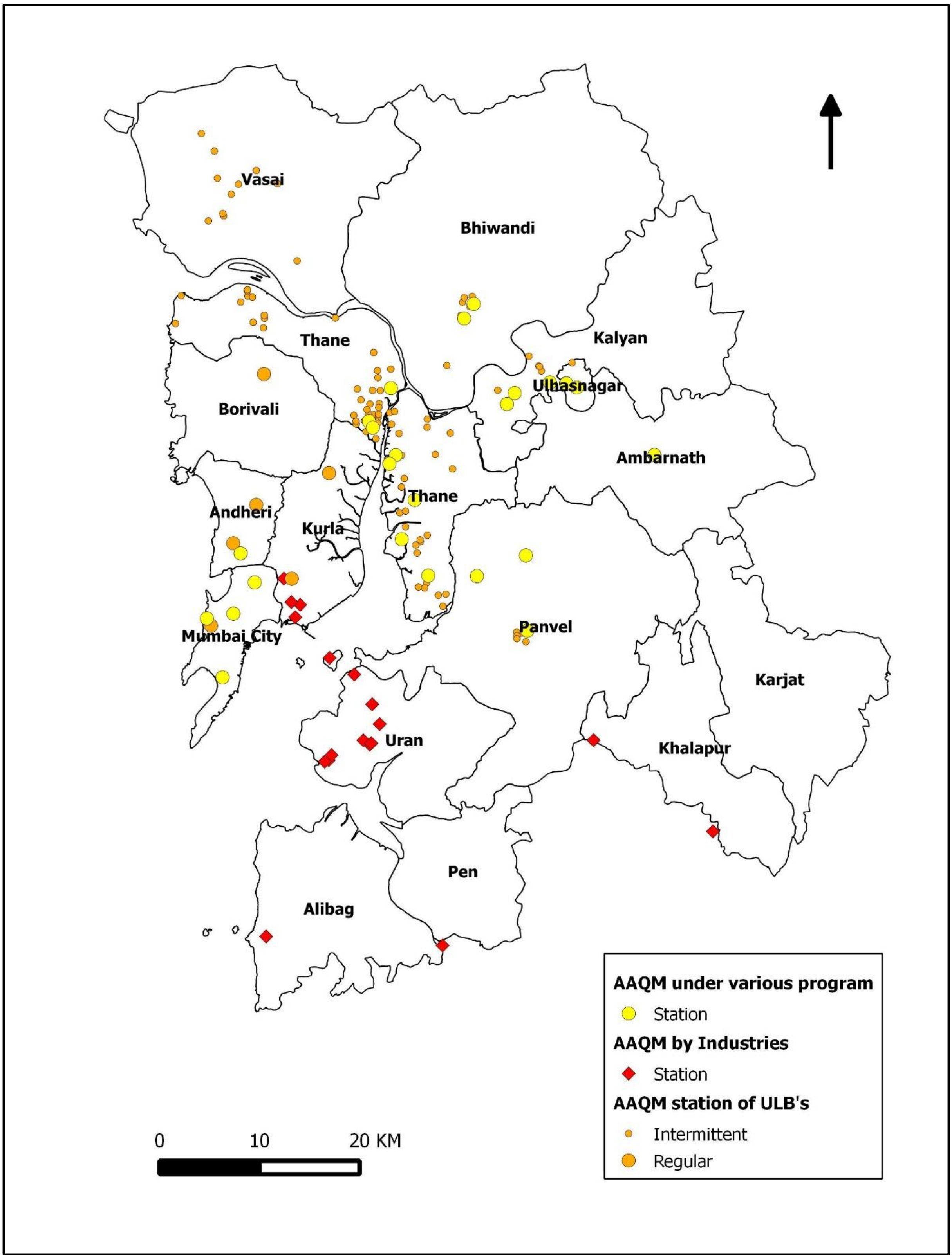
3.3.2 Existing monitoring network in MMR

There are three types of agencies (Pollution control boards (MPCB & CPCB), Industries and ULB's) which monitor air quality in MMR. Pollution control board has total 25 monitoring stations (including both MPCB and CPCB). A total of 11 industries in MMR have CAAQMS within their premises and ULB's have 123 stations where ambient air quality is been monitored. The industries are required to monitor and report their air quality status on regular basis to MPCB. This is mandatory for red category industries.

Although, ULB's have highest number of stations in the region, the frequency of monitoring at all these stations (except for Municipal Corporation of Greater Mumbai) is either once in a month or two or three times in a year, which is very low as compared to the frequency of sampling prescribed by CPCB (Twice in a week). So despite of having greater coverage, data collected from these stations do not represent the state of air quality due to low sampling frequency.

While in case of monitoring carried out by pollution control boards and industries, frequency is either twice in a week or continuous sampling is carried out. Despite of higher sampling frequency, monitoring data generated by industries is not reliable as sometimes calibration of the equipment is not carried out properly.[7] Comprehensive details about the monitoring network in the region are given in the Table No. 3-3 and detailed data related to each station is provided in Annex 11. Also, Map No. 3-1 pesented below shows the spatial distribution of monitoring network run by various agencies in the region. The details of the stations and the parameters monitored by the stations have been provided in the Table No. 3-4, Table No. 3-5 and Table No. 3-6 presented below.

[7] *Source: Discussion with MPCB officials*



Map No. 3-1: Network of Ambient Air Quality Monitoring Stations in MMR

Source: MPCB, and ESR of ULB's and GIS map from MRSAC

Table No. 3-3: Summary of ambient air monitoring stations in MMR

Agencies	Regularity	Name of Program	Type					No of Stations
			Resi.	Comm.	Indus.	Sen.	Traffic Junctions	
Pollution Control Board	Regular	CAAQMS	4	-	-	-	-	4
		NAMP	8	3	6	-	-	17
		SAMP	-	2	1	1	-	4
ULB's	Regular*		5	-	1	-	3	9
	Intermittent		31	17	0	-	61	114
Industries	Regular		-NA-	-NA-	11	-	-	11
	Intermittent		-	-	-	-	-	Air pollution prone industries
Total								**159**

Source: MPCB, and data collection for the project

Note: Resi: Residential; Comm: Commercial; Indus: Industrial; Sen: Sensitive
Out of all the ULB's regular Monitoring (twice a week each site) is done only By MCGM

<u>Specific Recommendation</u>

ULB's like MCGM, TMC and NMMC have better infrastructure, laboratories and efficient systems to monitor air quality. As a practice these ULB's regularly monitor air quality data within their corporation However, the frequency of monitoring is either far less than the minimum of 104 equally distributed monitoring observations required for considering annual average (Annex 9).

This infrastructure could be re-structured and be linked with the SAMP (State Air Monitoring Program) and shall help the monitoring to be in sync with the national guidelines. It shall enable regularise the monitoring at a given location and to enable appropriate representation and analysis for the region. They already have infrastructure to carry of the monitoring but the same should be used more efficiently and effectively.

Table No. 3-4: Details of monitoring stations under NAMP and SAMP in MMR (2012-13)

Sr. No.	Program/Type/Station Name	Implementing Agency	Commission Date	Frequency Of Monitoring
	CAAQMS (Continuous Ambient Air Quality Monitoring Station)			
	Residential			Daily
1	Bandra	M/S Chemtrols Engineering Ltd., Mumbai	May, 2007	
2	Navi Mumbai- Airoli	N.M.M.C / M/S Chemtrols Engineering Ltd., Mumbai	December,2008	
3	Navi Mumbai- Vashi	N.M.M.C / M/S Chemtrols Engineering Ltd., Mumbai	October, 2006	
4	Sion	Maharashtra Pollution Control Board (MPCB)	June, 2004	
	NAMP (National Air Monitoring Program)			
	Commercial			2 Days In A Week
5	Navi Mumbai- Airoli Datta Meghe	Karmaveer Bhaurao Patil College, Vashi	April, 2006	
6	Thane- Naupada	Thane Municipal Corporation	July, 2005	
7	Kalbadevi	National Environmental Engineering Research Institute (NEERI)		
	Industrial			
8	Ambernath	Maharashtra Pollution Control Board (MPCB)	December, 2005	
9	Dombivali - Phase II MIDC	Maharashtra Pollution Control Board (MPCB)		
10	Navi Mumbai- Mahape	Karmaveer Bhaurao Patil College, Vashi	April, 2006	
11	Navi Mumbai- Taloja	Karmaveer Bhaurao Patil College, Vashi	April, 2006	
12	Thane- Balkum/Kolshet	Thane Municipal Corporation	July, 2005	
13	Parel	National Environmental Engineering Research Institute (NEERI)		
	Residential			
14	Badlapur	C.H.M.College, Ulhasnagar	June, 2006	
15	Navi Mumbai- Kharghar	Karmaveer Bhaurao Patil College, Vashi	April, 2006	
16	Navi Mumbai- Nerul	D Y Patil College, Nerul		
17	Panvel	Karmaveer Bhaurao Patil College, Vashi	April, 2006	

Sr. No.	Program/Type/Station Name	Implementing Agency	Commission Date	Frequency Of Monitoring
18	Thane- Kopri	Thane Municipal Corporation	February, 2006	
19	Ulhasnagar - CHM college	C.H.M.College, Ulhasnagar	June, 2006	
20	Ulhasnagar - Powai Chowk	C.H.M.College, Ulhasnagar	June, 2006	
21	Worli	National Environmental Engineering Research Institute (NEERI)	1990	
	SAMP (State Air Monitoring Program)			
	Commercial			2 Days In A Week
22	Bhiwandi - Prematai Hall	Bhiwandi Municipal Corporation	April, 2011	
23	Kalyan	Bhiwandi Municipal Corporation	April, 2011	
	Industrial			
24	Dombivali - MIDC Office	C.H.M.College, Ulhasnagar	May, 2012	
	Sensitive			
25	Bhiwandi - I. G. M Hospital	Bhiwandi Municipal Corporation	April, 2011	

Source: As per communication and interaction with MPCB for the project

Parameters monitored under CAAQMS, NAMP and SAMP are as follows:

CAAQMS : SO_2, NOx, RSPM, SPM, CO, BTX (Benzene, Toulene, Xylene), O_3 (Ozone Tropospheric)

NAMP and SAMP : SO_2, NOx, RSPM, SPM

Table No. 3-5: Details of monitoring stations under Urban Local bodies in MMR (2012-13)

Sr. No.	ULBs	No. of stations	Types					Frequency Of Monitoring	Pollutants Monitored
			Resi	Comm	Indu	Traffic	Landfill site		
1.	BNMC	6	-	1	-	5	-	Intermittent	RSPM, SOx, NOx
2.	KDMC	7	-	3	-	3	1	Intermittent	SO2, NOX, NH3, SPM, CO, RSPM
3.	MBMC	11	1	2	-	8	-	Intermittent	RSPM, Sox, NOx
4.	MCGM	9	5	-	1	3	-	Twice in a week/ Thrice in a week at traffic junction	SO2, NOx, NH3, SPM, Lead, Nickel,Benzo(a), Pyrene
5.	NNMC	18	10	0	0	7	1	Intermittent	SO2, NOX, NH3, H2S, RSPM
6.	TMC	34	-	-	-	32	2	Once in a Month	SO2, NOX, NH3, H2S, RSPM
7	VVMC	32	-	-	-	-	-	Intermittent	
8	Panvel M.Cl	6	3	2	-	1	-	Intermittent	SO2, NOX, RSPM

Source: Environmental Status Reports of respective ULB's and personal interactions with the concerned officials

Note: Resi: Residential; Comm: Commercial; Indus: Industrial; Sen: Sensitive
Out of all the ULB's regular Monitoring (twice a week each site) is done only By MCGM

Table No. 3-6: Details of monitoring stations regulated by Industries in MMR (2012-13)

Sr. No.	Industries	Region	No of CAAQMS	Parameters Monitored	Frequency Of Monitoring
1	Rashtriya Chemicals and Fertilizers	Trombay, Chembur	4	Sox, NOx, $PM_{2.5}$, PM_{10}, CO, SPM	Continuous
2	Bharat Petroleum Corporation Limited	Trombay, Chembur	3	Sox, NOx, $PM_{2.5}$, PM_{10}, CO, SPM	Continuous
3	Hindustan Petroleum Corporation Limited	Trombay, Chembur	3	Sox, NOx, PM_{10}, CO, SPM	Continuous
4	TATA Power	Trombay, Chembur	-	Sox, NOx, $PM_{2.5}$, PM_{10}, CO, SPM	Continuous
5	Oil and Natural Gas Corporation	Uran	3	SO_2, NOx, PM_{10}, $PM_{2.5}$, CO	Continuous
6	Jawharlal Nehru Port Trust	Uran	4	SO_2, NOx, PM_{10} , SPM	2 Days In A Week
7	MAHAGENCO	Uran	3	SO_2, NOx, SPM	2 Days In A Week
8	Reliance Industries limited	Patalganga	-	-	-
9	Bhushan steel	Khopoli		SO_2, NOx, SPM	Once in a Month
10	ISPAT	Dharamtar, Alibag	3	Sox, NOx, $PM_{2.5}$, PM_{10}, CO, SPM	Continuous
11	Rashtriya Chemicals and Fertilizers	Thal, Alibag	2	Sox, NOx, $PM_{2.5}$, PM_{10}, CO, SPM	Continuous

Note: Jawharlal Nehru Port Trust conducts ambient air monitoring at Elephant caves once in a month.

Source: As per communication and interaction with MPCB for the project

3.3.3 Gaps in Existing Infrastructure

Although the Ambient air quality in MMR is monitored at various locations, there are many gaps in monitoring in terms of number of monitoring sites, regular and scientific monitoring and so on. It is evident from the spatial analysis presented in Map No. 3-1 that a major area in MMR is not covered under the regular monitoring sites. Also there are very few sites in the region which are monitored regularly under the monitoring programs. Mumbai city, Kalyan, Dombivali and Bhiwandi have already been identified by MPCB where more stations are required for air quality monitoring. The following section presents the gap in the existing monitoring infrastructure and the suggestions to strengthen the same. The gaps in the existing infrastructure have been analysed in the following 3 sections.

3.3.3.1 Frequency of Monitoring

As per CPCB guidelines, a minimum of 2 monitoring reading in a week, evenly distributed across all the seasons needs to be recorded to represent a region. Hence, 104 monitoring readings at a given location are required for the readings to be considered as annual average. An analysis of the number of readings at different monitoring stations under monitoring program of the pollution control board in MMR is presented in Figure No. 3-1. It may be noted that the stations at Parel, Kalbadevi and Worli under NAMP have recorded less number of observations as against the minimum number of observations required.

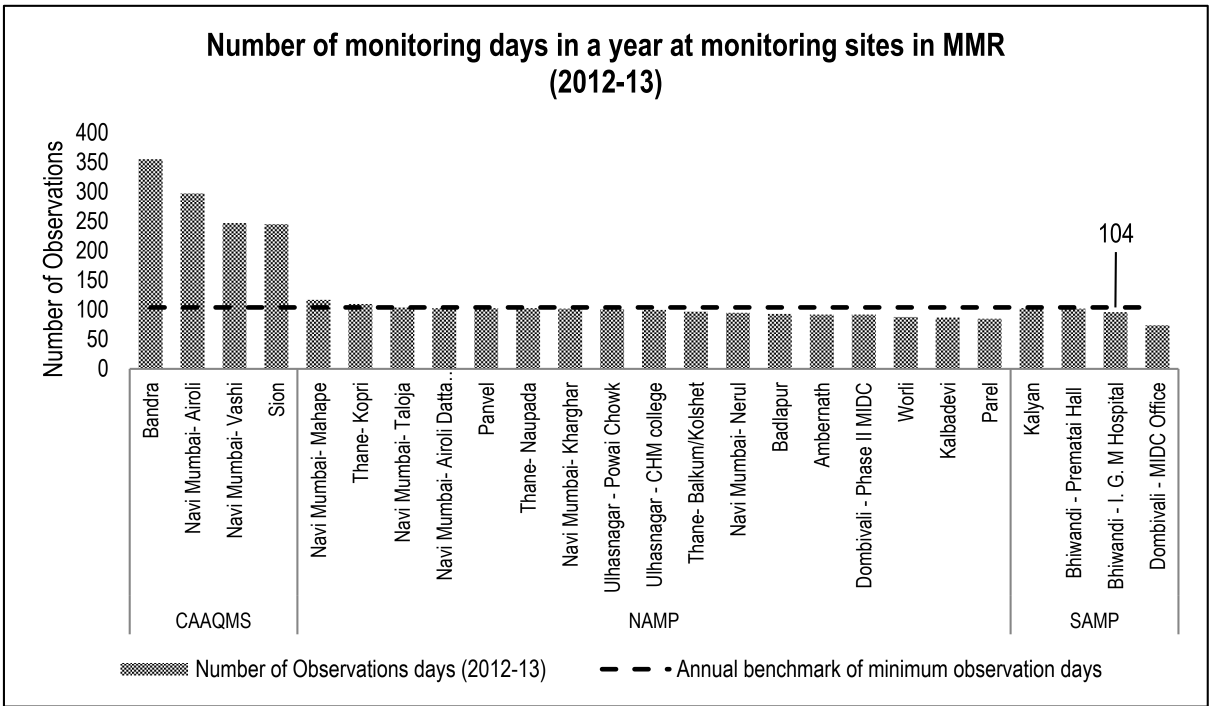


Figure No. 3-1: Number of monitoring days at various monitoring stations in MMR (2012-13)

Source: As per number of observation posted MPCB's website and as per data received from NEERI for stations of Worli, Kalbadevi and Parel

As seen in Table No. 3-7, the number of monitoring days is significantly less at many stations (represented by red shadow) in MMR indicating that the frequency of monitoring needs to be regularised at all the locations. The stations which did not meet the annual benchmark observations of 104 have been highlighted in red. However for the analysis, sites with observations of minimum 85+ days in a year have been considered.

Table No. 3-7: Number of annual observations recorded by AAQMS under NAMP & SAMP in MMR

Monitoring Station	Number of days of Monitoring in respective Fiscal Year					
	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13
CAAQMS						
Bandra	231	334	339	349	353	355
Navi Mumbai- Airoli	-	80	335	343	250	297
Navi Mumbai- Vashi	251	287	329	290	186	247
Sion	283	82	236	259	200	245
NAMP						
Navi Mumbai- Mahape	98	88	105	90	69	117
Thane- Kopri	111	103	97	117	123	110
Navi Mumbai- Taloja	101	107	100	106	93	104
Navi Mumbai- Airoli Datta Meghe	101	107	103	100	97	103
Panvel	119	106	102	100	97	103
Thane- Naupada	104	100	112	122	123	103
Navi Mumbai- Kharghar	94	94	111	105	95	102
Ulhasnagar - Powai Chowk	98	98	89	96	102	101
Ulhasnagar - CHM college	53	92	88	99	102	100
Thane- Balkum/Kolshet	96	94	80	21	45	97
Navi Mumbai- Nerul	105	113	104	96	98	95
Badlapur	104	102	84	94	95	93
Ambernath	101	26	Nil	Nil	Nil	92
Dombivali - Phase II MIDC	96	25	Nil	Nil	Nil	92
Worli	-	26	97	100	94	88
Kalbadevi	-	25	77	93	93	87
Parel	-	23	93	98	94	85
SAMP						
Kalyan	-	-	-	-	82	103
Bhiwandi - Prematai Hall	-	-	-	-	103	102
Bhiwandi - I. G. M Hospital	-	-	-	-	26	96
Dombivali - MIDC Office	-	-	-	-	-	74

Source: As per number of observation posted MPCB's website and as per data received from NEERI for stations of Worli, Kalbadevi and Parel

3.3.3.2 Number of monitoring stations

As discussed in the earlier section one may note that although there are many monitoring sites in MMR but the frequency of monitoring is not regular to represent annual average for that site. Although the ULB's together monitor around 123 stations but frequency of monitoring at all of these stations (except stations operated by MCGM) is well below the sampling frequency prescribed by CPCB. Hence, for determining the lacuna in number of monitoring stations, the stations with regular monitoring have been considered.

Population growth leads to air pollution owing to anthropogenic activities. At the same, given the health impacts of air pollution on human health, higher population will indicate higher incidence of exposure to air pollution. Hence, while determining/estimating the minimum number of AAQMS in MMR population has been considered as critical indicator.

As seen in Table No. 3-8, IS (Indian Standards) guidelines have given pollutant specific calculation to estimate the minimum recommended number of AAQMS per unit population for a study area. Number of monitoring station required to effectively monitor the air quality in MMR are estimated on the basis of IS guidelines. The numbers have been determined on the basis of population in that particular taluka, which is presented in Annex 12.

Table No. 3-8: Pollutant wise recommended minimum number of AAQMS for a population range

Pollutant	Population of Evaluation Area	Minimum No. of AAQ Monitoring Stations
SPM	<1,00,000 1,00,000- 10,00,000 10,00,000 – 50,00,000 >50,00,000	4 4+0.6 per 1,00,000 population 7.5 + 0.25 per 1,00,000 population 12 + 0.16 per 1,00,000 population
SO_2	<1,00,000 1,00,000- 10,00,000 10,00,000 – 1,00,00,000 >1,00,00,000	3 2.5+0.5 per 1,00,000 population 6+0.15 per 1,00,000 population 20
NO_2	<1,00,000 1,00,000- 10,00,000 >10,00,000	4 4+0.6 per 1,00,000 population 10
CO	<1,00,000 1,00,000- 50,00,000 >50,00,000	1 1+0.15 per 1,00,000 population 6+0.05 per 1,00,000 population
Oxidants	-do-	-do-

Source: Indian Standards: 5182 (Part 14), 2000

As per the calculations, a minimum of **160 AAQM stations** are required in MMR to have appropriate analysis and representation of the region data. At present there are 159 sites where air quality is monitored in MMR, however only at **42 sites the air quality is monitored regularly**. As seen in Figure No. 3-2, Vasai, Pen and Karjat have no AAQM stations with regular monitoring. Kurla and Thane talukas have the highest population of around 38 lakhs and require highest number of AAQM stations i.e. 17 stations each.

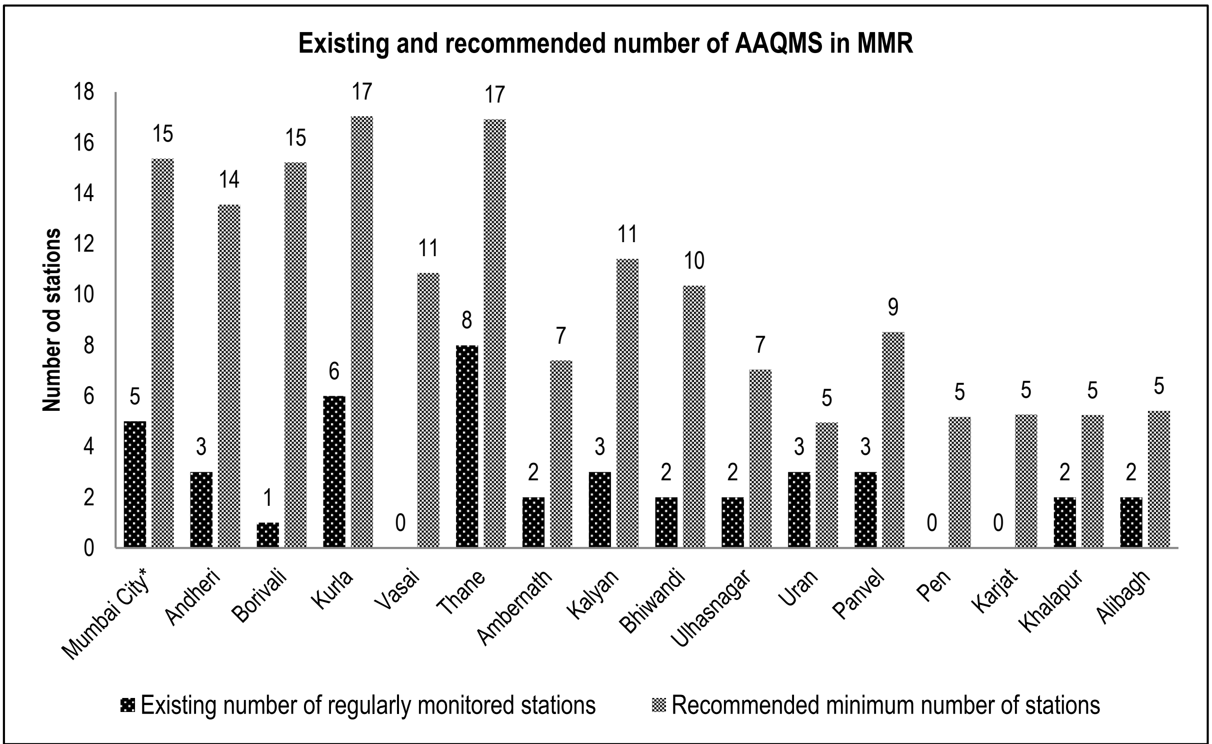
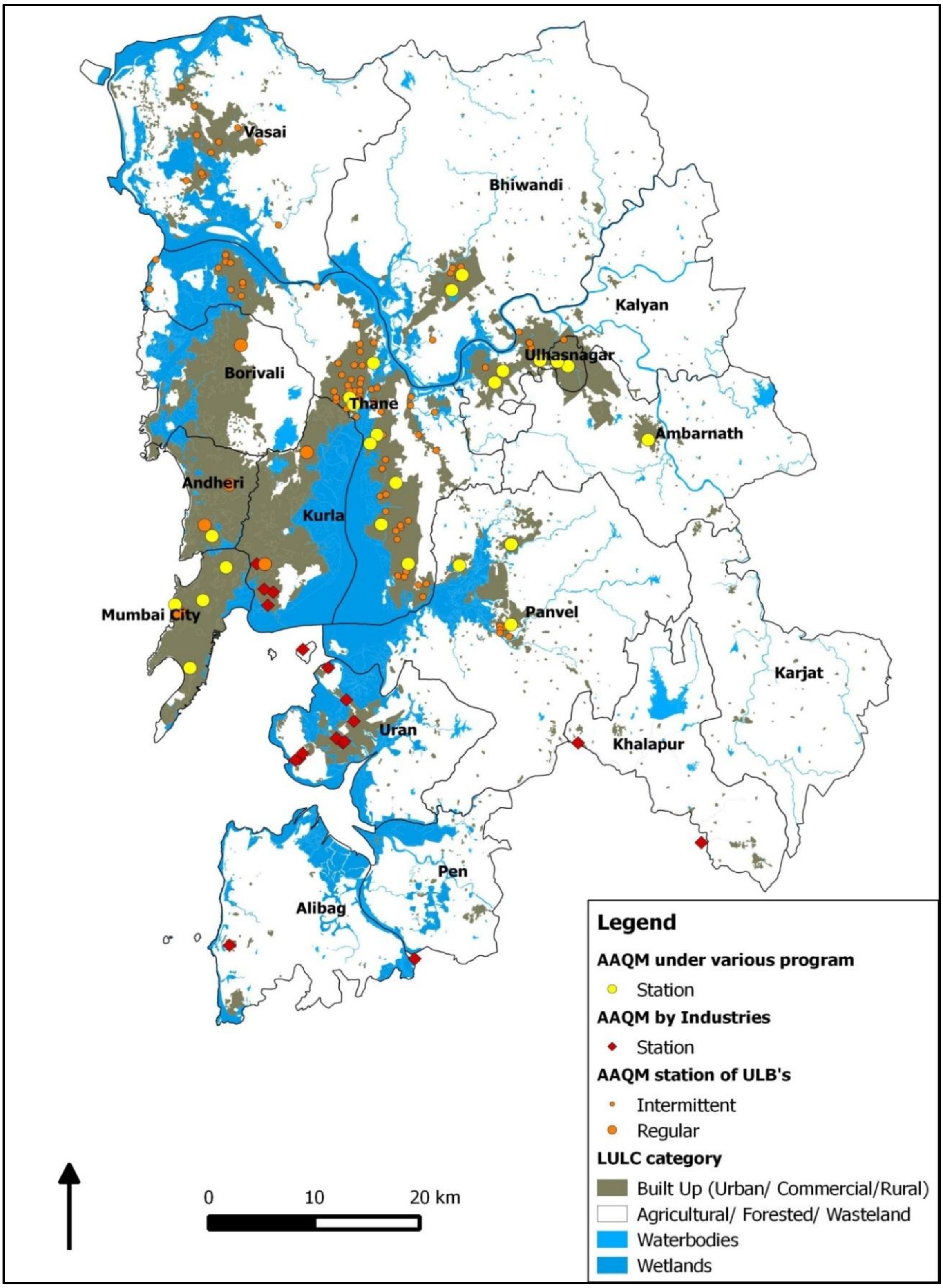


Figure No. 3-2: Existing and Recommended number of ambient air monitoring stations in MMR

Source: Calculations as per IS: 5182 (Part 14), 2000, Methods for Measurement of Air Pollution, Part 14: Guidelines for Planning the Sampling of Atmosphere presented in Annex 12.

**Mumbai city mentioned here is Mumbai city district since there are no talukas in Mumbai city*

The AAQM sites in MMR has been superimposed with the 'Built-up' area, including urban, rural and commercial areas, within MMR and depicted in Map No. 3-2. Visual interpretation of the map exposes the scarcity of AAQM in Mumbai city and suburban district. These are the region of comparatively higher population density. Hence an increased number of AAQM network is needed for residential and commercial as well as industrial zone in this study area. However, since the region is very dynamic in terms of its landscape and anthropogenic activities a more detailed study is required to exactly identify the locations for installing AAQM stations. The study requires reconnaissance survey, meteorological data of the site and detailed analysis of land-use pattern.



Map No. 3-2: Spatial presentation of monitoring sites against built up area in MMR

Source: MPCB, and ESR of ULB's and GIS map from MRSAC

3.3.3.3 Type of regions represented by monitoring sites

The distribution of the monitoring sites based on the type of region which they represent the monitoring station in the MMR is presented in Figure No. 3-3. It indicates that the sites are not distributed ideally. As per CPCB guidelines, Sensitive zones like hospitals, biosphere reserves, archaeological or historical monuments and so on, consists a share of only 2% out of the total monitoring station. Commercial areas like malls and markets also require an intense monitoring as these places are always encumbered with populace. As per the WHO (World Health Organization) if there are 10 stations in a city out of that 6 centres should be installed to cover either industrial or commercial areas, whereas 4 should be installed at residential areas i.e. a ratio of 60:40. The same guidelines have been adopted and cited by CPCB in their guidelines for determining the share for the distribution of region type representation.

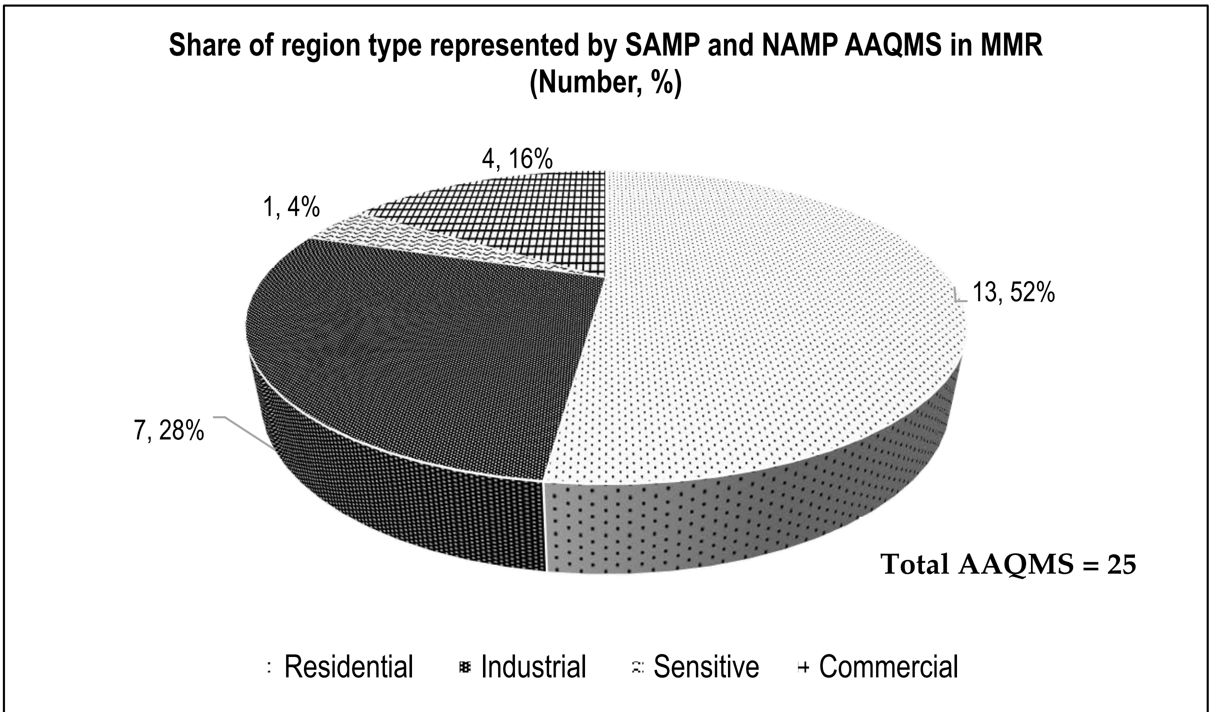


Figure No. 3-3: Share of region type represented by SAMP and NAMP AAQMS in MMR

Source: As per number of AAQMS under NAMP and SAMP in MMR

Specific Recommendation

- It is highly recommended to have real time, state of art infrastructure CAAQMS across MMR. At present there are mere 4 CAAQMS in MMR.
- For appropriate monitoring of all the regions, the existing numbers of monitoring stations are inadequate. A minimum of 160 stations are required to assess and appropriately represent the Air quality of MMR.
- A study to strengthen the monitoring network with a proper road map indicating phase wise implementation action plan and scientific studies to identify appropriate locations for monitoring stations should be undertaken.
- Rapidly developing peri urban areas like Vasai- Virar where the population density is. Increasing new state of the art, real time AAQMS should be set up at the earliest. At the same time, redistribution of existing network may also be necessary to ensure better management.
- Monitoring of the sensitive regions is also very weak. Air monitoring of areas with less anthropogenic activities and representing natural habitat like SGNP (Sanjay Gandhi National Park) should be considered. It shall also help in developing a benchmark for other regions to be compared.

3.4 Status of Air Quality in MMR

Owing to lacunas in the monitoring network and appropriate monitoring, the status of the air quality in MMR has been derived only from the sites monitored by the PCB's (Pollution Control Boards). As on March 2013, a total of 25 stations in MMR are monitored under NAMP and SAMP programs. To develop a comparative analysis the monitoring stations have been segregated into different types of regions represented by different AAQMS viz residential, commercial, industrial and sensitive. The region type has been considered as classified/defined by MPCB, CPCB and NEERI for their respective stations. For determining the status of air quality the data published by MPCB on their website for the year 2012-13 and the data received from NEERI for the three monitoring stations monitored by them under NAMP has been considered.

A parametric analysis has been developed to determine the pollutant concentrations recorded by the AAQMS. It includes station wise pointers indicating the minimum, maximum, annual average and the 98th percentile[8] readings recorded by the respective station. The observations have been compared against the standards set by CPCB as per revised NAAQS (National Ambient Air Quality Standards) released on 18th November 2009.

There are a total of 25 AAQMS in MMR monitored under NAMP and SAMP as on March 2013

Different pollutants have different standard concentrations since the observed health impacts are associated with the various pollutants occur over different exposure time. Given this fact there are different annual and 24 hour standards for each pollutant set by CPCB for Indian conditions. As per NAAQMS, a relaxation of 2% has been given for the number observations exceeding the 24 hours standards. Hence while determining the maximum observed reading at a given station; the point for 98th percentile concentration has also been plotted for further analysis.

A pollutant specific spatial analysis is also been presented in the respective sections to get an over view of the pollution load in different regions of MMR.

[8]A percentile (or a centile) is a measure used in statistics indicating the value below which a given percentage of observations in a group of observations fall.

3.4.1 Status of SO_2 in MMR

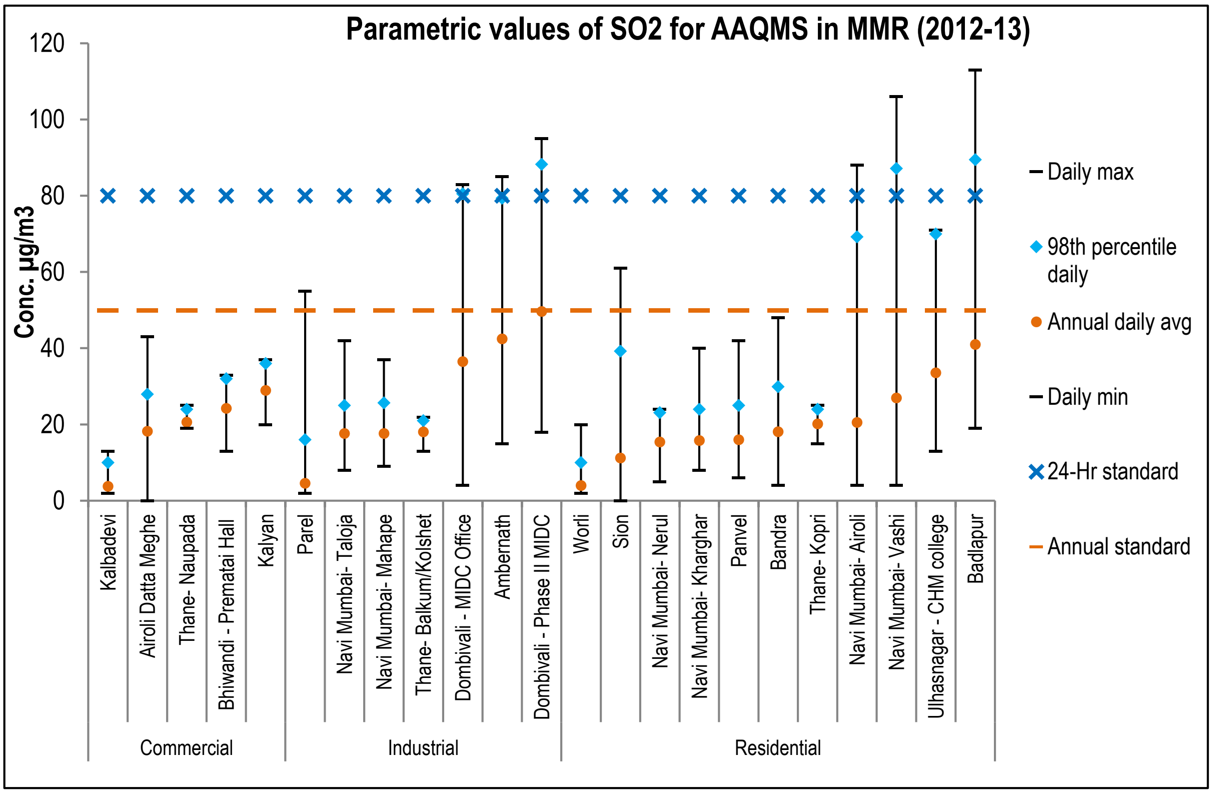


Figure No. 3-4: Parametric values of SO_2 for AAQMS in MMR (2012-13)

Source: As per data retrieved from MPCB's website[9] and data shared by NEERI

Dombivali, Ambernath Badlapur and Ulhasnagar regions are highly prone to SO_2 pollution and acid rain.

As seen in Figure No. 3-4 in terms of Suplhur-di-oxide concentrations, the monitoring station at Dombivali (MIDC Phase-II) recorded the highest annual average concentration (50µg/m^3) of SO_2 levels out of all the monitoring stations in MMR. The SO_2 concentrations observed at another monitoring station at Dombivali (MIDC office) also recorded high levels of SO_2 concentrations.

Ambernath, Badlapur and Ulhasnagar region, which lie in close vicinity of each other and are also highly industrialised areas, were among the top 5 regions which recorded high levels of SO_2. The peak concentration of 113µg/m^3 was recorded at the monitoring station at Badlapur with its 98th percentile reading (89µg/m^3) also exceeding the 24 hour standards of 80µg/m^3.

Monitoring station at Phase-II MIDC Dombivali and at Vashi recorded 98th percentile concentration of 88 µg/m^3 and 87µg/m^3

[9] http://mpcb.gov.in/envtdata/envtair.php

respectively exceeded the 24 hours daily standards. The annual average SO_2 concentrations recorded at Bhiwandi monitoring station (26µg/m³), representing sensitive location monitoring also violated the annual standards set for sensitive areas.

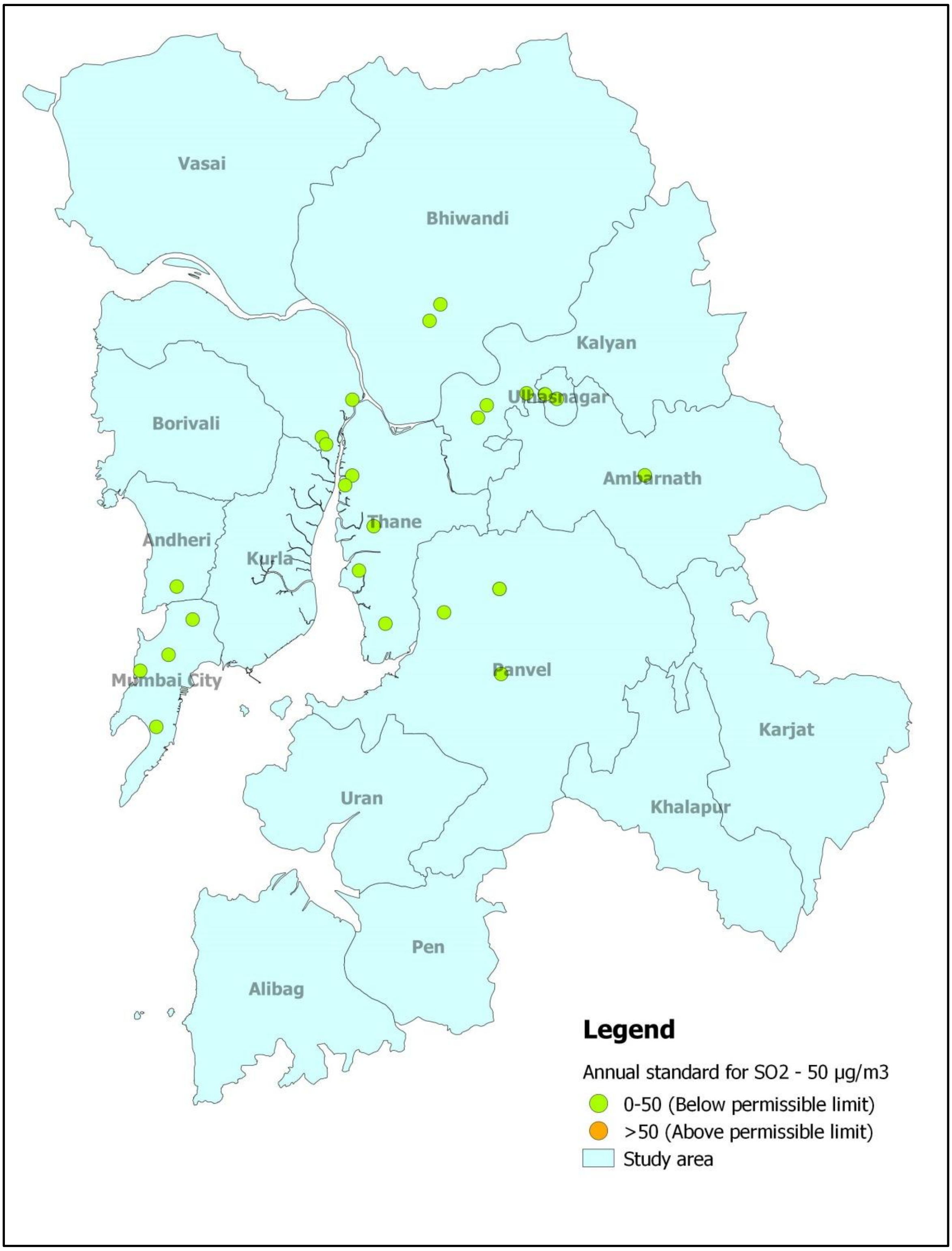
Table No. 3-9: Data sets for parametric values of SO_2 for AAQMS in MMR (2012-13)

Type	Station Name	Daily max	Daily min	Annual avg	98th percentile daily
CPCB Standards		*80*	*80*	*50*	*80*
Commercial	Kalbadevi	13	2	3.8	10
	Airoli Datta Meghe	43	0	18	28
	Thane- Naupada	25	19	21	24
	Bhiwandi - Prematai Hall	33	13	24	32
	Kalyan	37	20	29	36
Industrial	Parel	55	2	5	16
	Navi Mumbai- Taloja	42	8	18	25
	Navi Mumbai- Mahape	37	9	18	26
	Thane- Balkum/Kolshet	22	13	18	21
	Dombivali - MIDC Office	**83**	4	37	**81**
	Ambernath	**85**	15	42	79
	Dombivali - Phase II MIDC	**95**	18	**50**	**88**
Residential	Worli	20	2	4	10
	Sion	61	0	11	39
	Navi Mumbai- Nerul	24	5	15	23
	Navi Mumbai- Kharghar	40	8	16	24
	Panvel	42	6	16	25
	Bandra	48	4	18	30
	Thane- Kopri	25	15	20	24
	Navi Mumbai- Airoli	**88**	4	21	69
	Navi Mumbai- Vashi	**106**	4	27	**87**
	Ulhasnagar - CHM college	71	13	34	70
	Badlapur	**113**	19	41	**89**
	Ulhasnagar - Powai Chowk	**92**	16	43	75
Sensitive	Bhiwandi - I. G. M Hospital	33	12	**26**	32

Source: As per data retrieved from MPCB's website[10] and data shared by NEERI Units: (µg/m³)

Note: Annual average standards for NO_x sensitive area is 20µg/m³

[10] http://mpcb.gov.in/envtdata/envtair.php



Map No. 3-3: Spatial representation of SO_2 pollution in MMR (2012-13)

Source: MPCB, 2013 and MRSAC for the GIS boundaries

3.4.2 Status of NOx in MMR

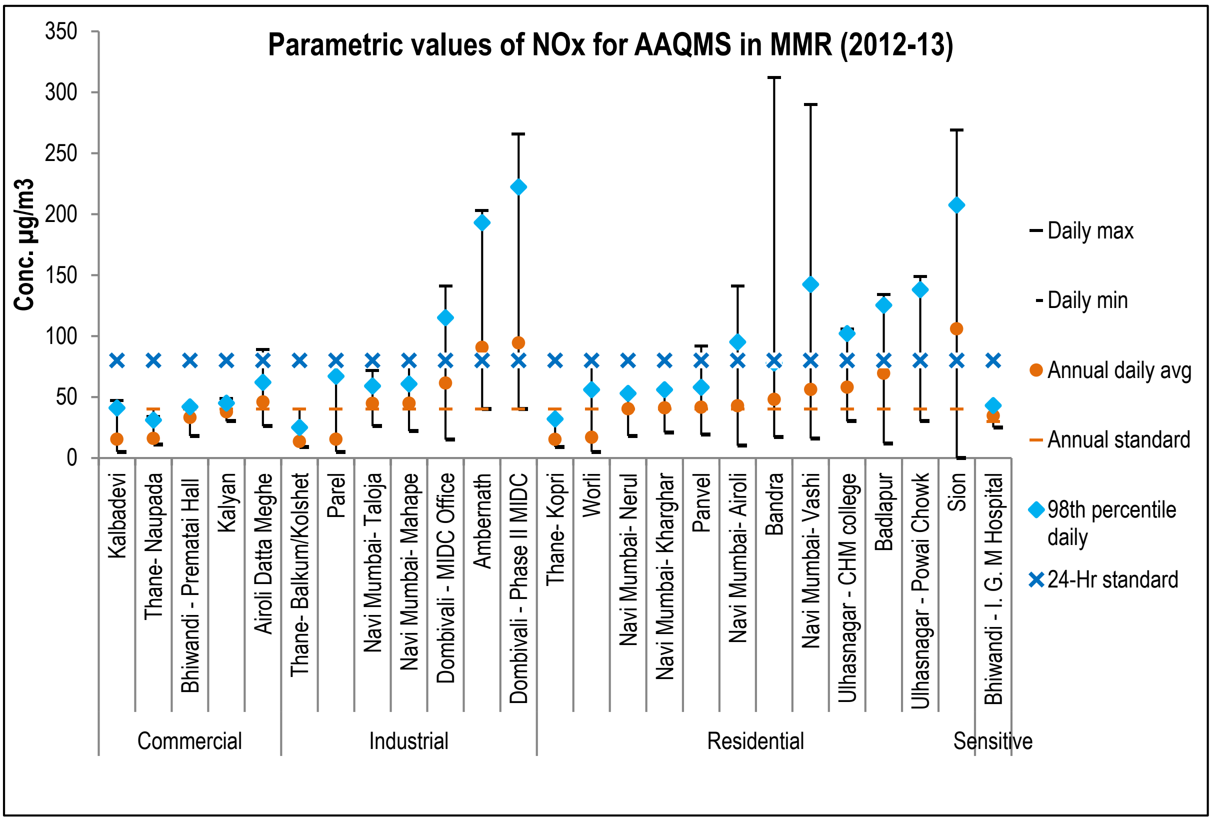


Figure No. 3-5: Parametric values of NO_x for AAQMS in MMR (2012-13)

Source: As per data retrieved from MPCB's website[11] and data shared by NEERI

16 monitoring stations in MMR exceeded the annual average NO_x concentrations in 2012-13

As seen in Figure No. 3-5, AAQMS at Sion recorded the highest annual average NO_x concentration of 106µg/m³ followed by monitoring at Dombivali (Phase-II MIDC), Ambernath and Ulhasnagar (Powai chowk) AAQMS which recorded NO_x concentrations of 94, 91 and 80µg/m³ respectively. All the monitoring stations representing residential areas either violated or were almost equal to the annual average NO_x standards, except for the monitoring at Thane (Kopri) residential area however the monitoring stations at Thane may have location bias.

The maximum daily NO_x concentration of 312 and 290µg/m³ were recorded at the CAAQMS installed at Bandra and Vashi. Upon having a 98th percentile analysis it is interesting to note that the observations at both the stations 78 and 142µg/m³ respectively indicating that the peak reading recorded at Bandra is an outlier. Monitoring stations representing commercial areas in MMR exhibited less annual concentration for NO_x concentration except for the monitoring at Airoli (Datta Meghe) where annual average concentration of 46µg/m³ was recorded.

[11] http://mpcb.gov.in/envtdata/envtair.php

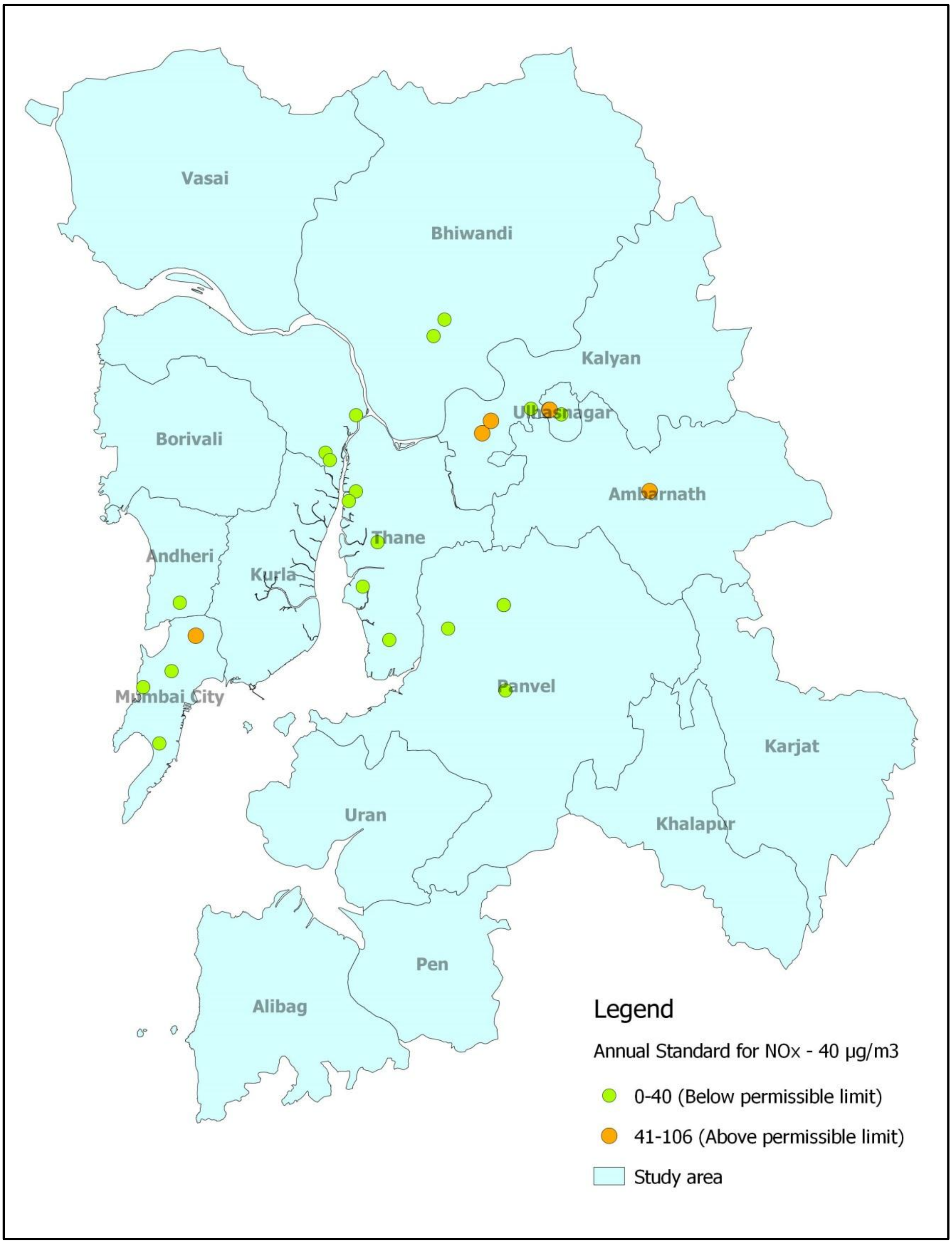
Table No. 3-10: Data sets for parametric values of NO_x for AAQMS in MMR (2012-13)

Type	Station Name	Daily max	Daily min	Annual daily avg	98th percentile daily
CPCB Standard Units: (µg/m³)		*80*	*80*	*40*	*80*
Commercial	Kalbadevi	47	5	15.4	41
	Thane- Naupada	34	11	16	31
	Bhiwandi - Prematai Hall	42	18	33	42
	Kalyan	49	30	38	45
	Airoli Datta Meghe	**89**	26	**46**	62
Industrial	Thane- Balkum/Kolshet	26	9	14	25
	Parel	**83**	5	15	67
	Navi Mumbai- Taloja	72	26	**45**	59
	Navi Mumbai- Mahape	**81**	22	**45**	61
	Dombivali - MIDC Office	**141**	15	**61**	**115**
	Ambernath	**203**	40	**91**	**193**
	Dombivali - Phase II MIDC	**266**	40	**94**	**222**
Residential	Thane- Kopri	33	9	15	32
	Worli	**80**	5	17	56
	Navi Mumbai- Nerul	54	18	**40**	53
	Navi Mumbai- Kharghar	57	21	**41**	56
	Panvel	**92**	19	**42**	58
	Navi Mumbai- Airoli	**141**	10	**43**	**95**
	Bandra	**312**	17	**48**	78
	Navi Mumbai- Vashi	**290**	16	**56**	**142**
	Ulhasnagar - CHM college	**106**	30	**58**	**102**
	Badlapur	**134**	12	**69**	**125**
	Ulhasnagar - Powai Chowk	**149**	30	**81**	**138**
	Sion	**269**	0	**106**	**207**
Sensitive	Bhiwandi - I. G. M Hospital	44	25	35	43

Source: As per data retrieved from MPCB's website[12] and data shared by NEERI

*Note: Annual average standards for NO_x sensitive area is 30µg/m³

[12] http://mpcb.gov.in/envtdata/envtair.php



Map No. 3-4: Spatial representation of NOx pollution in MMR (2012-13)

Source: MPCB, 2013 and MRSAC for the GIS boundaries

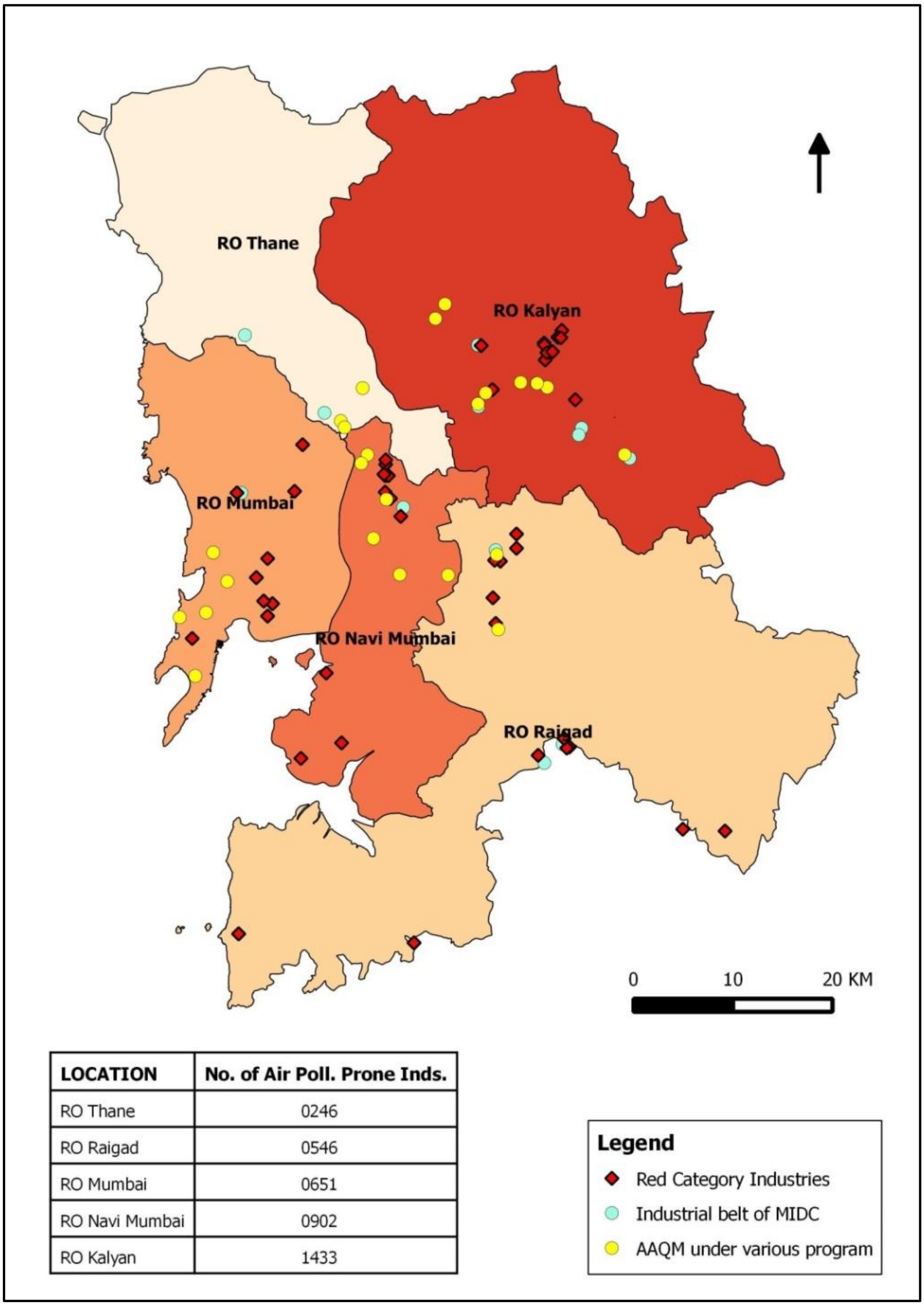
3.4.2.1 Site survey of polluted sites

A recce survey was conducted for the two areas to get more information on the region and to check if there may be any bias in the vicinity of the monitoring station that may be affecting the observations in those AAQMS. The monitoring sites at Ambernath and Dombivali were visited to conduct a recce of the monitoring stations and get a glimpse of the area. The highlight of the visit is presented in Table No. 3-11.

As seen in Figure No. 3-18, Kalyan region has major share of red and orange category industries in the region. Ambernath, Dombivali, Badlapur regions have been developed as MIDC zones by the state. At present these regions account for more than 1400 industries (Map No. 3-5) which induce air pollution. Also these areas have high number of chemical manufacturing industries which handle Benzene, Ammonia, Toulene and so on at MIDC areas of Ambernath (368) and Dombivali (450). However these parameters are not monitored by the local AAQMS.

Table No. 3-11: Site Survey of the Air monitoring stations at Ambernath and Dombivali

	Monitoring Station	
	Ambernath	**Dombivali**
Agency In-charge	MPCB	MPCB
Contact Person	RO–Kalyan, MPCB	RO–Kalyan, MPCB
Area Observations		
Type of Area	Industrial	Industrial
Major type of industry in that area	Chemical and Dye	Chemical and Dye
Approx. vicinity from highway	Close	300 m
Approx. vicinity from arterial road	Close	100 m
Traffic movement	Moderate	Moderate
Approx. number visible stacks	5 to 6	28-30
Observations of station in-charge		
Observations of the monitoring station		
Is the station operational	Yes	Yes
Approx. height at which the sampler/probe is installed	15 ft	10 ft
Open space around the station (at-least 3 sides should be open)	All four sides	All four sides
Is there any source near the station which may cause a bias	Industrial belt	Chemical industries
Frequency of reading	2 days a week	2 days a week



LOCATION	No. of Air Poll. Prone Inds.
RO Thane	0246
RO Raigad	0546
RO Mumbai	0651
RO Navi Mumbai	0902
RO Kalyan	1433

Map No. 3-5: Spatial distribution of red category industries and air pollution prone industries in MMR

Data Source: Statistical Report 2011-12, MPCB

Note: Region as per MPCB RO (Regional office) jurisdictions some regions of the RO's of Thane, Kalyan and Raigad are outside of MMR

Specific Recommendations:

The most polluted sites have been recorded in Kalyan (Ambernath and Dombivali) region of MMR. These are the two most polluted sites in the state. Both the regions have many chemical companies, fabrication units, dye companies, pharmaceuticals companies and so on. Both these regions are booming areas for population migration owing to affordable pricing thus indicating higher exposure in coming years. This region needs immediate attention and the following points should be considered for appropriate action in the region.

- Studies for the source apportionment and emission inventory of the pollution load in Kalyan, Ulhasnagar, Ambernath, Badlapur needs to be conducted.
- CAAQMS should be installed in the MIDC zones of these areas and the real time data be monitored with strict vigilance.
- Parameters like benzene, NH_3, CO need to be monitored with immediate effect.
- Appropriate regulation and strict adherence to the standards be observed in the region.
- The SPA (Special Planning Authority) in the region should consider appropriate development with substantial planning for the region.
- The public transport in the region still runs majorly on petrol and diesel. A policy level intervention to shift the fuel usage to CNG must be considered.

3.4.3 Status of RSPM in MMR

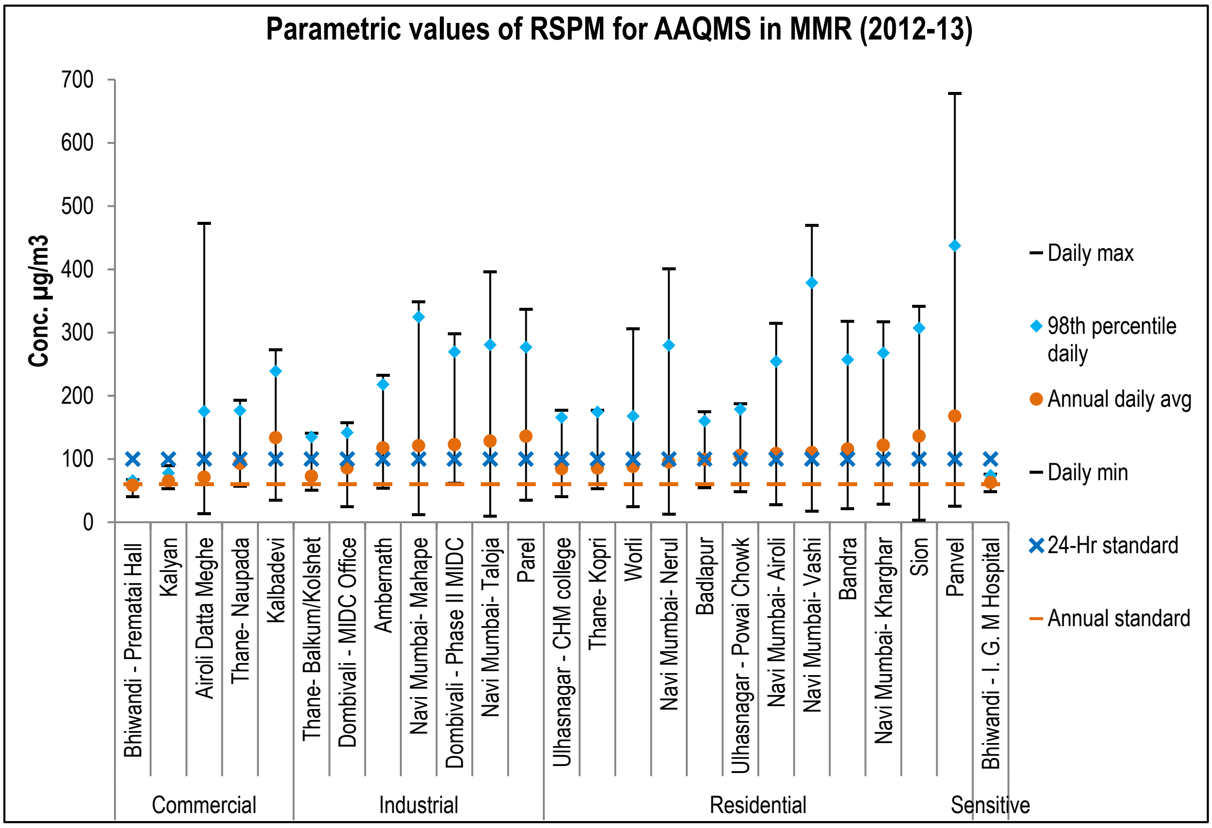


Figure No. 3-6: Parametric values of RSPM for AAQMS in MMR (2012-13)

Source: As per data retrieved from MPCB's website[13] and data shared by NEERI

RSPM is a major concern in MMR and all the monitoring stations violated the annual standards for RSPM

RSPM is one of the major air pollutants in MMR. Vehicular movements, road dust re-suspension, construction activities, quarry activities are some of the major contributors to increasing RSPM levels. As seen in Figure No. 3-6 the AAQMS at Sion, Panvel and 3 monitoring station at Navi Mumbai (Taloja, Mahape and Kharghar) exceeded by more than two times the annual RSPM standards.

Panvel AAQMS recorded the highest (98th percentile) RSPM concentration of 437µg/m^3 followed by Vashi and Mahape which recorded RSPM concentrations 379 and 325µg/m^3 respectively. Industrial areas of Dombivali, Ambernath and Navi Mumbai (Mahape) exceeded the annual standards by more than 25%.

Ambernath, Badlapur and Thane (Naupada, Balkum and Kopri) have a least range between the observed parametric values and the minimum RSPM values are also either exceeding or a borderline with the annual standards indicating immense RSPM pollution in those areas.

[13] http://mpcb.gov.in/envtdata/envtair.php

Table No. 3-12: Parametric values of RSPM for AAQMS in MMR (2012-13)

Type	Station Name	Daily max	Daily min	Annual daily avg	98th percentile daily
CPCB Standards Units: (µg/m³)		*100*	*100*	*60*	*100*
Commercial	Bhiwandi - Prematai Hall	68	41	59	66
	Kalyan	90	53	65	78
	Airoli Datta Meghe	473	14	71	176
	Thane- Naupada	193	57	93	177
	Kalbadevi	273	35	134	239
Industrial	Thane- Balkum/Kolshet	141	51	73	135
	Dombivali - MIDC Office	158	25	86	142
	Ambernath	233	54	118	218
	Navi Mumbai- Mahape	349	12	121	325
	Dombivali - Phase II MIDC	298	62	123	270
	Navi Mumbai- Taloja	396	10	129	281
	Parel	337	35	136	277
Residential	Ulhasnagar - CHM college	177	41	85	166
	Thane- Kopri	177	53	86	175
	Worli	306	25	88	168
	Navi Mumbai- Nerul	401	13	95	280
	Badlapur	175	55	100	160
	Ulhasnagar - Powai Chowk	188	49	106	179
	Navi Mumbai- Airoli	315	28	109	254
	Navi Mumbai- Vashi	470	18	110	379
	Bandra	318	22	116	257
	Navi Mumbai- Kharghar	317	29	122	268
	Sion	342	4	136	307
	Panvel	678	26	168	437
Sensitive	Bhiwandi - I. G. M Hospital	76	49	63	74

Source: MPCB

*Note: Annual average standards for RSPM in sensitive area is 60µg/m³.

Specific Recommendations:

Apart from particulate emissions from vehicles, construction activities, road-dust re-suspension and quarrying activities are a major source of high RSPM levels in the region. Hence a part of the recommendations the following points should be considered for policy level interventions.

Roads

- Appropriate quality and smooth surface roads should be developed.
- Sweeping of the roads should be done regularly. Vacuum suction pumps for sucking of road dust is been regularly implemented by NMMC. Similar initiatives could be undertaken by other ULB's.

Quarrying sites

- Quarrying sites and activities should be regulated with strict vigilance as per the norms laid by CPCB and MPCB.
- Use of water sprinklers should be made compulsory at the quarrying sites.

Construction Sites

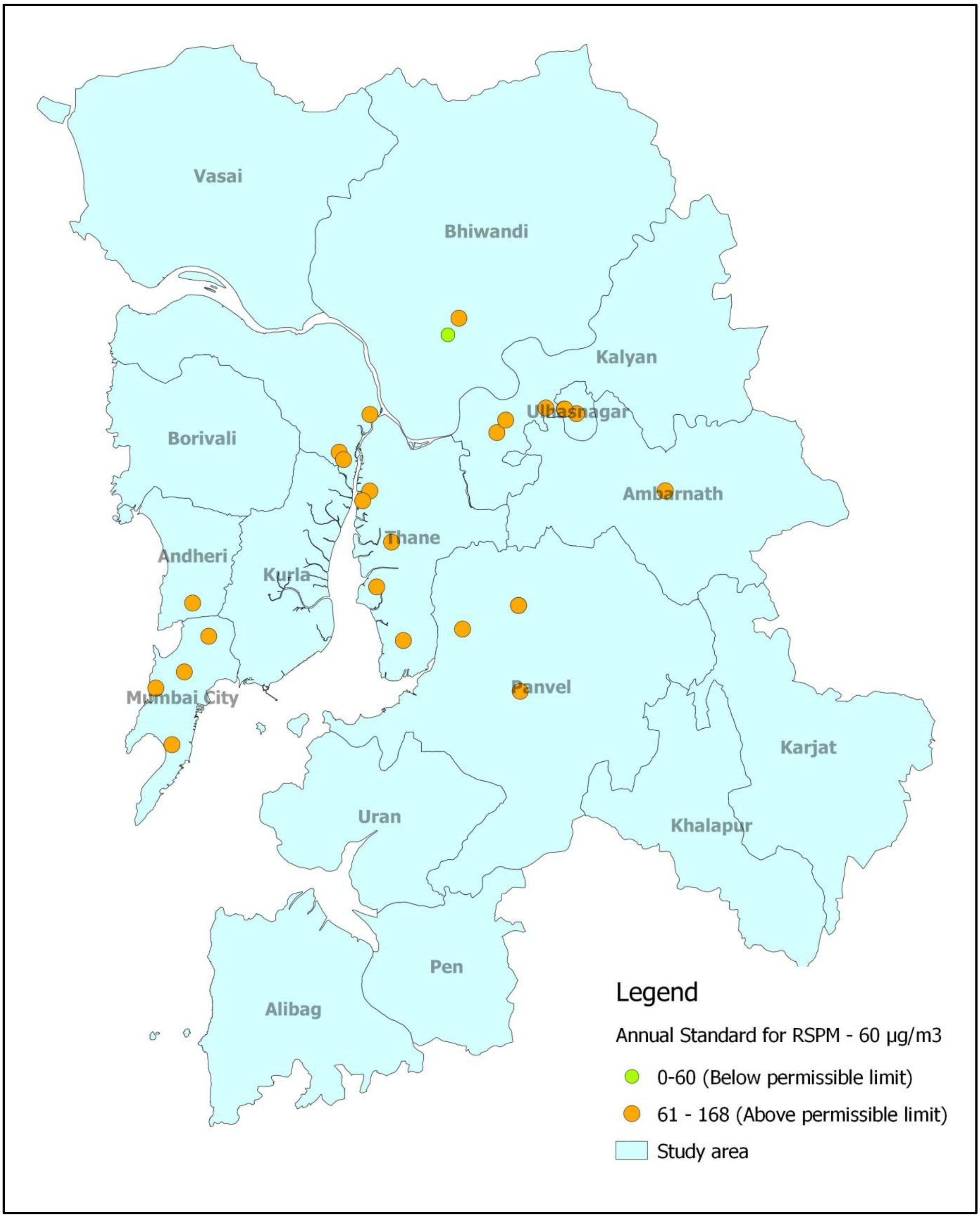
- Appropriate barricading of the under construction site to avoid dispersion of the dust and particulate matter in the ambient air
- Dusty materials such as sand and cement should be kept covered (Picture No. 3-1)
- Constructing a water pit at the entry/exit points of the construction site to avoid dispersion of particulate matter through movement of trucks while entering and exiting the site (Picture No. 3-2)
- Spraying of water on the tyres of the truck and vehicles which move in and out of the construction site.
- Operational measures to be made compulsory and building permissions should be revoked if the norms are not met

Picture No. 3-1: Covering of sand at a construction site

Picture No. 3-2: Water pit at entry and exit points for washing of truck tyres

Picture No. 3-3: Sprinkling of water to reduce dispersion of dust at the construction site

Picture No. 3-4: Road Sweeper use in Navi Mumbai Municipal Corporation



Map No. 3-6: Spatial representation of RSPM pollution in MMR (2012-13)

Data Source: MPCB and MRSAC for the GIS boundaries

3.4.4 Annual average pollution in MMR (2012-13)

Upon having a comparison for the annual average pollution concentrations in MMR it is interesting to note Thane was among the lesser polluted regions in MMR. Whereas, as seen inTable No. 3-13, annual average NOx and RSPM levels have violated the respective standards in nearly all the regions of MMR. Industrial areas of Dombivali and Ambernath recorded high levels of SO_2, NO_x and RSPM and the observed readings either violated or were very close to the NAAQS.

Table No. 3-13: Annual average concentrations of SO_2, NO_x and RSPM in MMR (2012-13)

Region type	Station Name	Annual Average Observations		
		SO2	Nox	RSPM
CPCB Standard		*50*	*40*	*60*
Commercial	Airoli Datta Meghe	18	**46**	**71**
	Bhiwandi - Prematai Hall	24	33	59
	Kalbadevi	3	15	**134**
	Kalyan	29	38	**65**
	Thane- Naupada	21	16	**93**
Industrial	Ambernath	42	**91**	**118**
	Dombivali - MIDC Office	37	**61**	**86**
	Dombivali - Phase II MIDC	**50**	**94**	**123**
	Navi Mumbai- Mahape	18	**45**	**121**
	Navi Mumbai- Taloja	18	**45**	**129**
	Parel	4	15	**136**
	Thane- Balkum/Kolshet	18	14	**73**
Residential	Badlapur	41	**69**	**100**
	Bandra	18	**48**	**116**
	Navi Mumbai- Airoli	21	**43**	**109**
	Navi Mumbai- Kharghar	16	**41**	**122**
	Navi Mumbai- Nerul	15	**40**	**95**
	Navi Mumbai- Vashi	27	**56**	**110**
	Panvel	16	**42**	**168**
	Thane- Kopri	20	15	**86**
	Ulhasnagar - CHM college	34	**58**	**85**
	Ulhasnagar - Powai Chowk	43	**81**	**106**
	Sion	11	**106**	**136**
	Worli	4.0	16.9	88.3
Sensitive*	Bhiwandi - I. G. M Hospital	**26**	**35**	**63**

***Note: Annual average standards for SO_2, NO_x and RSPM in sensitive area is 20, 30 and 60µg/m³ respectively**

3.4.5 Air Quality Index

Quality of air around us has direct implications on our health. The air quality, like weather of a location, can change dynamically within a span of an hour. Hence to convey the information on outdoor air quality in easiest ways possible which could be understood by general public, tools such as AQI (Air Quality Index) have been devised.

Various International environmental agencies such as US-EPA have developed their own set of mathematical algorithms to determine AQI, which are based on human exposure dose of air pollutants. Pollutant specific, parametric indexing has become very instrumental and indicative in drawing conclusion on the status and trend of air quality by measuring pollution.

The AQI is useful for reporting daily air quality and to gauge the pollution load. Most of the AQI developed by various agencies are within a range of 0 to 500. An AQI of 100 or below indicates attainment of National Ambient Air Quality Standards. Higher value of AQI indicates high level of pollution. When AQI values are above 100, air quality is considered to be unhealthy—at first for certain sensitive groups of people, then for everyone (including healthy people) as AQI values get higher. Depending upon 'doses of exposure' they are further divided into five classes of AQI, which present different health concerns. To make it easy to understand, the categories of AQI are assigned color codes (Figure No. 3-7) i.e. color Green to 'Good', Yellow to 'Moderate', Orange to 'Poor', Red to 'Very Poor' and Dark Red to 'Severe'.

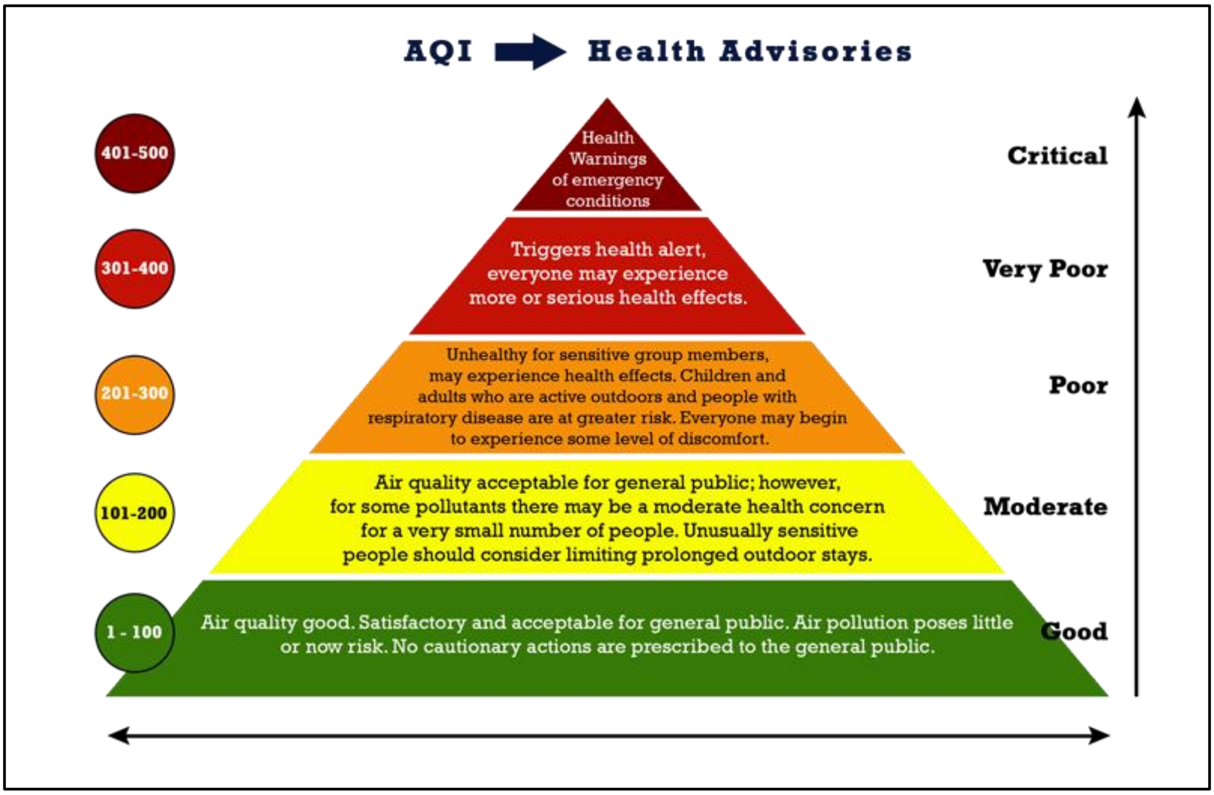


Figure No. 3-7: Health advisories for various range of Air Quality Indices and respective colour codes

Data Source: EPA and System of Air Quality Weather Forecasting and Research, MoES, GoI

3.4.5.1 AQI for Indian Standards

With reference to the formula used for calculating AQI, the breakpoint used for SO_X and NO_2 by EPA are of 1 hour averaging time and not 24-hourly whereas, the AAQMS in Maharashtra report levels of major air pollutants for a period of 24-hour. In addition, an AQI value of 100 or below would correspond to attainment of pollutants concentration in ambient air as per National Ambient Standards. Since it was not possible to derive any value from it, US-EPA's algorithms were not used.

Air quality index is a piecewise linear function of the pollutant concentration and there is a discontinuous jump of AQI unit and the corresponding adjustments are been made to set the low and high range of AQI corresponding to a certain concentration of the pollutant. IIT-Kanpur has defined daily exposure limits of various pollutants and laid sets of formulae to calculate AQI on similar lines with other indexing worldwide Table No. 3-14. These calculations have been endorsed by NEERI (National Environmental Engineering Research Institute), a constituent of CSIR (Council of Scientific & Industrial Research)[14], India.

The algorithm for calculating Air Quality Index is based upon daily averaging time and since dynamic behaviour of concentration of air pollutants causes it to change even within an hour, mentioning of air's quality annually would merge out/average the extremities. The possibility of examining daily air quality gives the scope to study in detail about the subject and hence the daily data recorded by AAQMS against the 24 hour standards has been considered while developing the AQI for the AAQMS in MMR.

Table No. 3-14: Sub-index and breakpoint pollutant concentration for Indian Air Quality Index

Index	Category	SO_2 (24 hr avg) (μgm/m³)	NO_X (24-hr avg) (μgm/m³)	SPM (24-hr avg.) (μgm/m³)	RSPM (24-hr avg.) (μgm/m³)
0-100	Good	0-80	0-80	0-200	0-100
101-200	Moderate	81-367	81-180	201-260	101-150
201-300	Poor	368-786	181-564	261-400	151-350
301-400	Very poor	787-1572	565-1272	401-800	351-420
401-500	Severe	>1572	>1272	>800	>420

$$I = \frac{(I_{High} - I_{low})}{(C_{high} - C_{low})} * (C - C_{low}) + I_{low}$$

where: I = **the (Air Quality) index**
C = **the pollutant concentration**
C_{low}= **the concentration breakpoint that is** $\leq C$
C_{high}= **the concentration breakpoint that is** $\geq C$
I_{low}= **the index breakpoint corresponding to** C_{low}
I_{High}= **the index breakpoint corresponding to** C_{high}

[14]Research Article, Prakash Mamta and Bassin J.K, Analysis of Ambient Air Quality Using Air Quality Index, IJAET/ Vol.I/ Issue II/July-Sept.,2010/106-114; E-ISSN 0976-3945

3.4.5.2 AQI for MMR

The data generated by monitoring of parameters, majorly three of them namely–RSPM, NO_X, and SO_2 at the AAQMS in MMR, have been analysed for above mentioned calculations. The concentration levels were then converted into AQI using the formulae elaborated in Table No. 3-14. Finally, the highest or 'dominant' of the AQI value for the respective individual pollutant becomes the AQI for that day. As against the number of observations the performance of the each AAQMS is presented for the composite air quality in Figure No. 3-8.

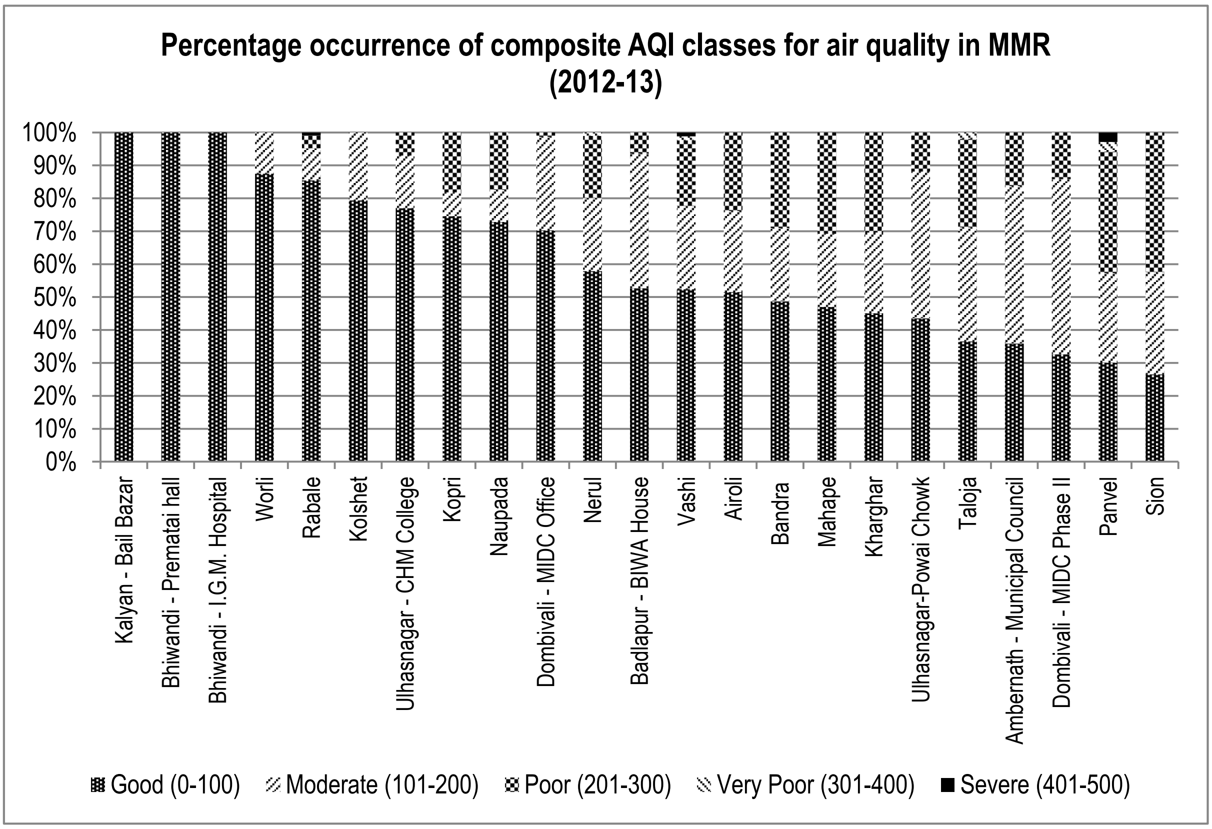
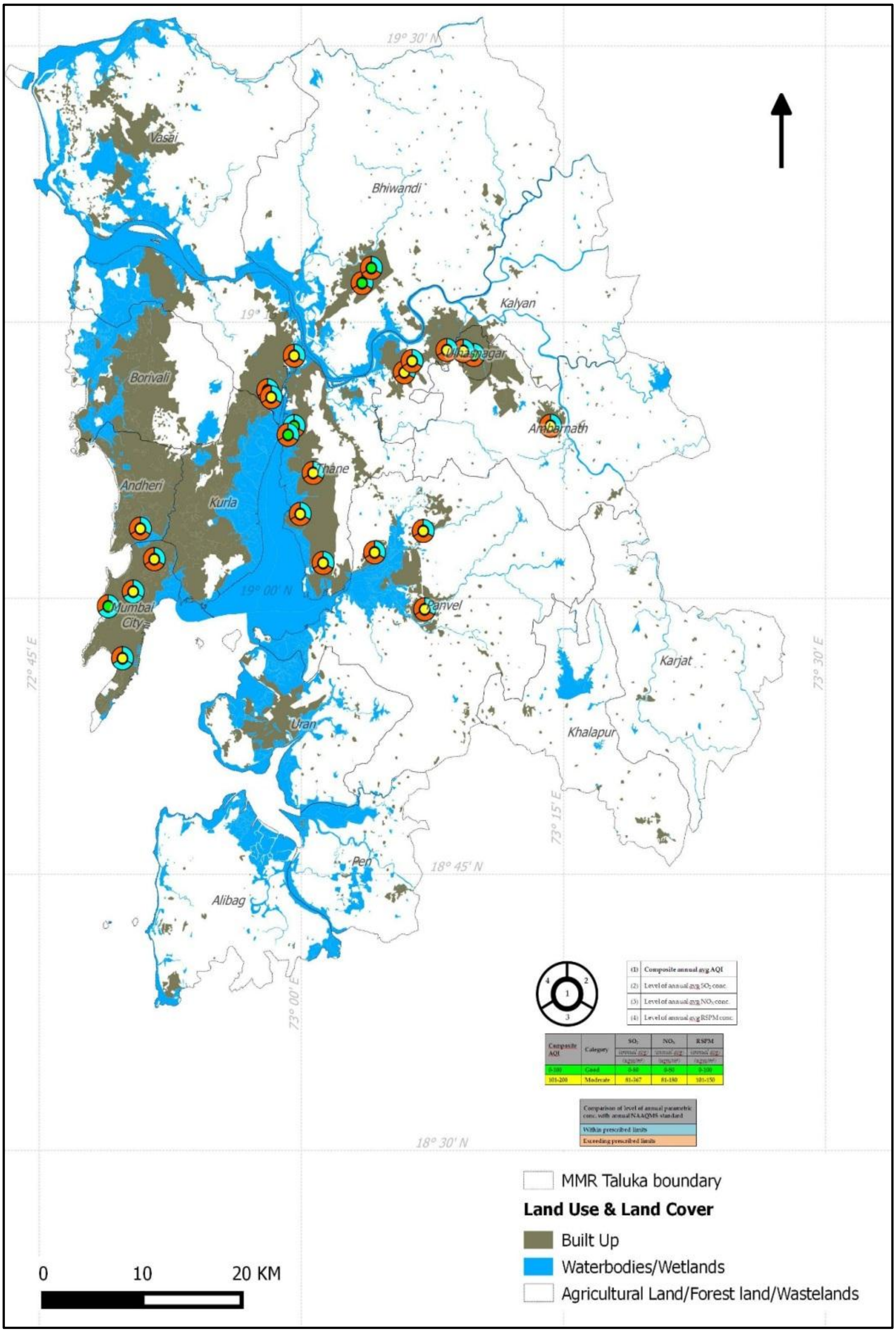


Figure No. 3-8: Percentage occurrence of composite AQI classes for composite AQ in MMR

In terms of only three AAQMS in MMR, viz Kalyan (Bail Bazar), Bhiwandi (Pematai hall and IGM Hospital) recorded 'Good' AQI for almost all the readings/ observations at that AAQMS. While industrial areas like Dombivali, Ambernath, Taloja, Ulhasnagar recorded Moderate and Poor AQI for more than 50% of the observations. The AAQMS at Sion recorded Good Air Quality for mere 26% of the observations while recorded 'Poor' Air Quality for more than 42% of the times. As per the CPCB guidelines and daily standards the air quality for each station needs to be good for almost 98% of the observations. As seen in the spatial representation (Map No. 3-7), high concentrations of RSPM and NOx are of major concern in the MMR region especially in the regions of Mumbai, Navi Mumbai and Thane.



Map No. 3-7: Annual average Air Quality across monitoring locations in Maharashtra 2012-13

Source: Data Sets from MPCB, GIS attributes from MRSAC Map generated by TERI

3.4.6 Emission inventory of Mumbai

Emission inventory study helps is in identifying the sources of a particular pollutant and helps in developing strategies for controlling the emissions significantly. An emission inventory for MMR region is yet to be developed. However, the emission inventory prepared under the source apportionment study conducted for Mumbai city by NEERI is shown in Table No. 3-15. Emission from power plant, industries and vehicles, taken together, account to more than 50% of the pollution load in Mumbai.

Table No. 3-15: Emission of different pollutants from various sources in Mumbai (2007)

Sources/ Pollutant	PM	CO	SO_2	NO_x	HC
	(Tons/ Year)				
Bakeries	1555	11348	25	120	10287
Construction activities	2289	0	0	0	0
Domestic sector	565	19724	1262	9947	368
Industries and stone crushers	1898	880	28510	8435	117
Landfill open burning	2906	9082	108	649	4649
Other area sources	1908	8612	1597	20929	3199
Paved Road dust	3163				
Power plant	5628	3216	24473	28945	1267
Restaurants	593	755	274	499	25
Unpaved Road dust	4761				
Vehicles	1545	18856	230	9169	6838
Total	**26811**	**72473**	**56479**	**78693**	**26750**

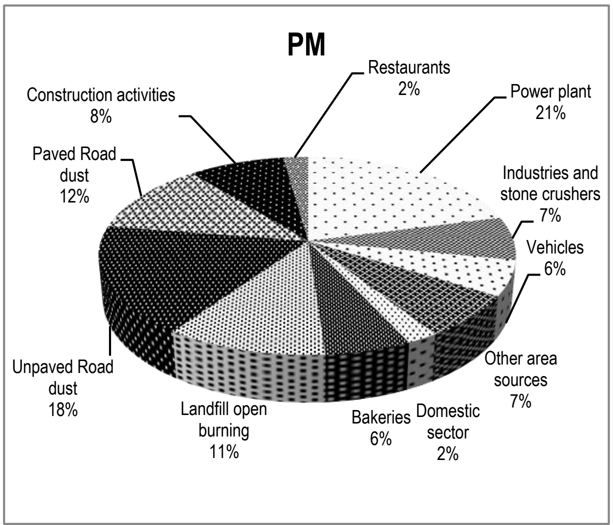
Source: Air Quality Assessment, Emission Inventory & Source Apportionment Study for Mumbai City, CPCB and NEERI 2010[15]

Bakeries in Mumbai city account to more than 38% of the Hydrocarbon emissions, higher than emissions from vehicles

It is interesting to note that domestic sector contributes more carbon monoxide emissions than vehicles in Mumbai while bakeries in the city account to more than 38% of the hydro carbon emissions, which is more than HC emissions from vehicles and open burning at landfill sites. In terms of NO_x emissions from power plants, vehicles and locomotives (especially diesel operated) are the major contributors accounting to more than 70% of the NO_x emissions in the city. Whereas, the PM emission loads from road dust re-suspension, (paved as well as unpaved roads) account to more PM emissions than power plants (Figure No. 3-9). Usage of Furnace Oil (FO), Light Diesel Oil (LDO), Low Sulphur Heavy Stock (LSHS), and Compressed Natural Gas (CNG) by the industries and power plant in the MCGM area contribute to more than 98% of the SO_2 emissions. Transport sector

[15] CPCB and NEERI 2010, *Air Quality Assessment, Emission Inventory & Source Apportionment Study for Mumbai City*, Table E2: Emission Load for Mumbai City from All Sources, Page No E-11

although contributes 6% in the overall inventory, however may impact locally at congested zones/intersections.



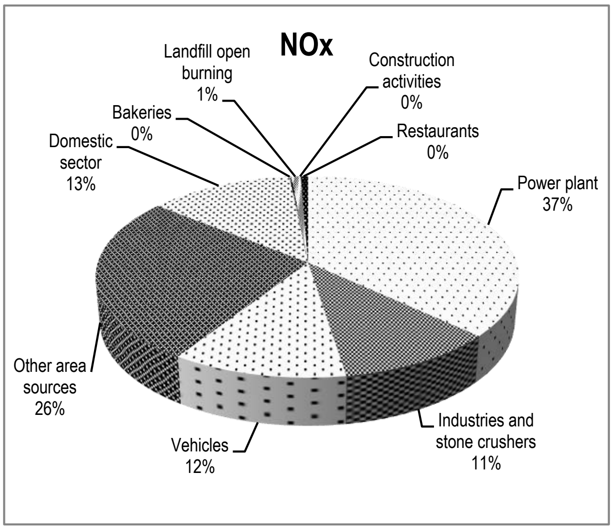


Figure No. 3-9: Contributions of various sources in PM and NOx emission in Mumbai during the year 2007.

Source: Air Quality Assessment, Emission Inventory & Source Apportionment Study for Mumbai City, CPCB and NEERI 2010[16]

Being a very dynamic city, Mumbai has various sources of air pollution. The major source of pollution is the presence of the power plant and the refineries well within the city. Road dust re-suspension and construction activities are also a major cause of RSPM pollution in the city. Given the fact that the peripheral region of Mumbai is expanding and new construction is bound to take place the region needs to be planned with appropriate policies to curb the air pollution. A region wise emission inventory needs to be undertaken to come up with specific strategies.

3.4.7 Noise Pollution

One of the major side effects of urbanization and industrialization is increasing noise levels. The term noise pollution is used to define unwanted sounds that are released into the environment[17]. In a modern megalopolis, the major sources of noise pollution noise pollution arises from many sources such as vehicles, honking horns, movement of aircrafts, hawkers, use of loud speakers, local festivals and programs and so on are the major source of noise pollution.

Various research studies have proven that noise pollution imposes a number of negative impacts on mental and physical health. Depending on the exposure time and frequency to noise pollution it is known to have impacts like annoyance, sleep disturbance, hearing

[16] CPCB and NEERI 2010, *Air Quality Assessment, Emission Inventory & Source Apportionment Study for Mumbai City*, Table E2: Emission Load for Mumbai City from All Sources, Page No E-11
[17] MPCB, 2013, *Reports on Ambient Noise Monitoring In Metropolitan City- 2013*, Introduction, pps 2

impairment, hypertension, ischemic heart disease and so on. Prolonged exposure to high noise levels is known to cause changes in the immune system, and may induce tinnitus, vasoconstriction, and other cardiovascular adverse effect birth defects[18]. Noise pollution affects not only humans but is also known to have impacts on the birds and animals.

Realising the severe health impacts of noise pollution active initiatives have been taken globally. In India the Air (Prevention and Control of Pollution) Act, 1981, considers noise pollution as an air pollutant[19] and the Central Government of India has notified the Noise Pollution (Regulation and Control) Rules, 2000 vide the notification number S.O 1046 (E), dated 14th February 2000[20]. The rules also provide the Ambient Air Quality Standards in respect of Noise for various category of area, also called zones, viz industrial, residential, commercial and silence.

In Maharashtra, MPCB annually monitors noise pollution at 10 locations in MMR all of which are situated in Mumbai and its suburban area. The monitoring stations represent industrial, commercial, residential and silence areas of Mumbai. The monitoring takes place continuously for 24 hours and the readings are taken typically in the month of December every year. The objective of the assessment is to assess the impact of various noise sources on general citizen and compare the noise levels with Ambient Noise Standards for the area[21]. MPCB also conducts monitoring for noise levels during the festival seasons of Diwali and Ganesh Utsav at various locations in Mumbai Thane and Navi Mumbai.

MPCB conducts noise level monitoring at 10 locations in Mumbai in the month of December. Noise levels in Mumbai have been very high in comparison to the limits prescribed by CPCB. As seen in Figure No. 3-10, the noise levels in the residential and silence zone violated consistently violated the limits for past five years during the day as well as night time. In the identified silence zones, the noise varies between 60 dB(A) to 75 dB(A). In the residential areas the noise levels range between 49 dB(A) to 72 dB(A) violating the limits.

[18] Willy Passchier-Vermeer and Wim F. Passchier, *Noise Exposure and Public Health*, Environmental Health Perspectives, Vol. 108, Supplement 1: Reviews in Environmental Health, 2000, pp. 123-131

[19] http://www.moef.nic.in/legis/air/air1.html

[20] http://mpcb.gov.in/images/pdf/Noise_Rule_2010.pdf

[21] http://mpcb.gov.in/envtdata/pdf/MetrolpolitainCities_NoiseReport2013.pdf

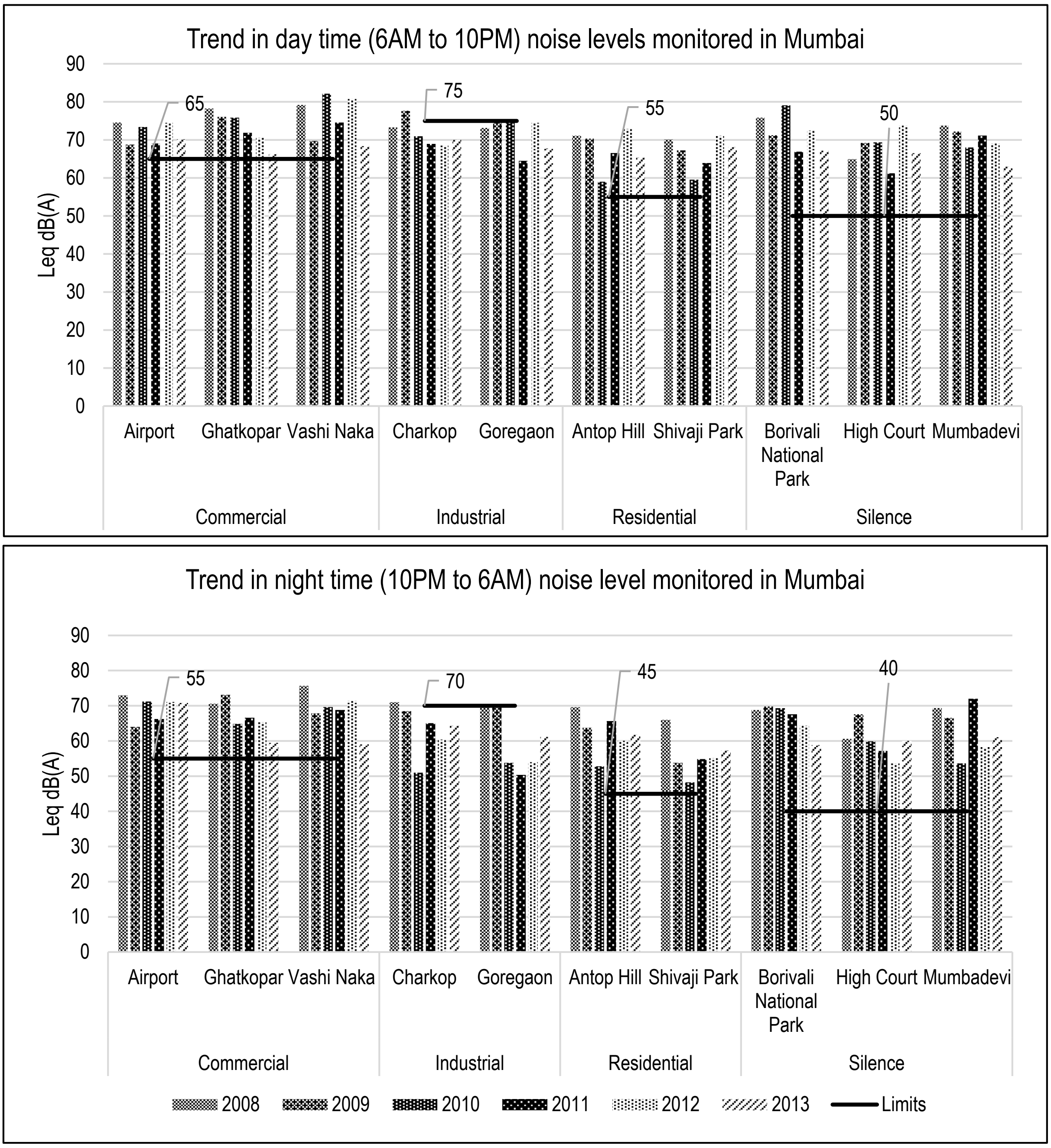


Figure No. 3-10: Trend in noise levels monitored across various locations in MMR

Source: Report on Ambient Noise Monitoring of Metropolitan Cities in Maharashtra – 2008, 2009, 2010, 2011, 2012 and 2013[22]

Note: All the reading mentioned are average of 48 hours comprising of one working and one non- working day.

[22] http://mpcb.gov.in/envtdata/noisepollution.php

The areas representing commercial areas like the Santacruz Airport, Ghatkopar and Vashi naka area, all areas violated the limits set for commercial area for the past five years. However it is interesting to note that the Ghatkopar areas has shown improvement and registered a decline in noise levels during day as well as night time. While the airport areas has consistent noise levels of about 70 dB (A) throughout the day and night, violating the limits set for day as well as night. The industrial areas of Charkop and Goregoan registered noise levels well within the limits.

The noise level monitoring in MMR during Ganesh Utsav -2013 (Figure No. 3-11), recorded very high noise levels. The average noise level at all the locations exceeded the 65dB (A) limits, the stringent among the residential, commercial and silence zones. The highest noise levels were recorded in areas of Bandra and Mulund of about 97.5dB (A). While the areas of Dadar, Chinchpokli, Wadala, and many areas of Thane and Kalyan, recorded peak noise levels of more than 90dB (A). Many of the areas have hospitals in near vicinity, like the monitoring in Thane which was done near Kalwa CSM hospital and Bedekar hospital. The minimum noise levels recorded in these areas, during the festive season, also exceeded the maximum limits let alone the peak noise levels. Similarly during the Diwali festival also MPCB records noise levels across 72 locations in spread across Greater Mumbai, Thane, Mumbai, Kalyan, Ambernath, Dombivali and Ulhasnagar in MMR. The peak readings for all the areas in MMR exceeded more than 75 dB (A), exceeding the limits of 65dB (A), by more than 10dB (A), set as day time limits for residential area.

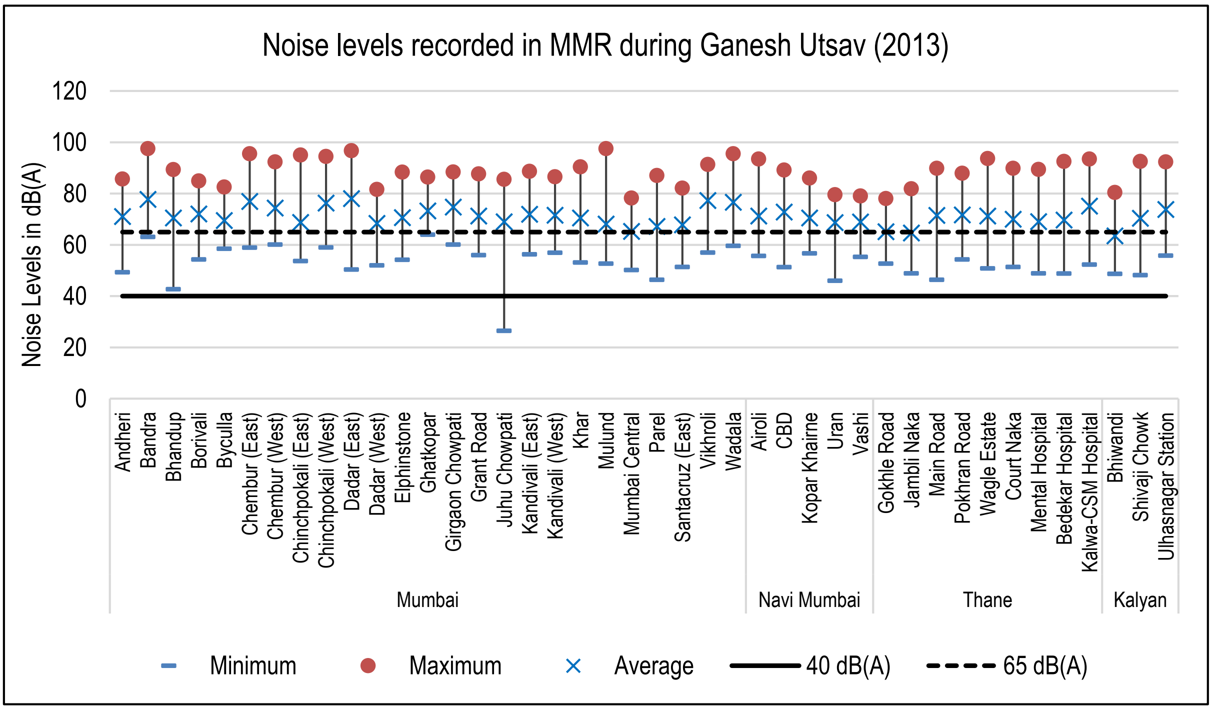


Figure No. 3-11: Noise levels recorded in MMR during Ganesh Utsav - 2013

Source: Report on Ambient Noise Monitoring during Ganesh Utsav 2013[23]

[23] MPCB 2013, *Report on Ambient Noise Monitoring of Metropolitan Cities in Maharashtra 2013*, Table 4.1: Equivalent Continuous (Leq) dBA, Minimum, and Maximum Noise Levels on 9th, 10th, 13th, 15th and 18th Sept., 2013 during Ganesh Festival at different locations in Maharashtra, pps 9 -14

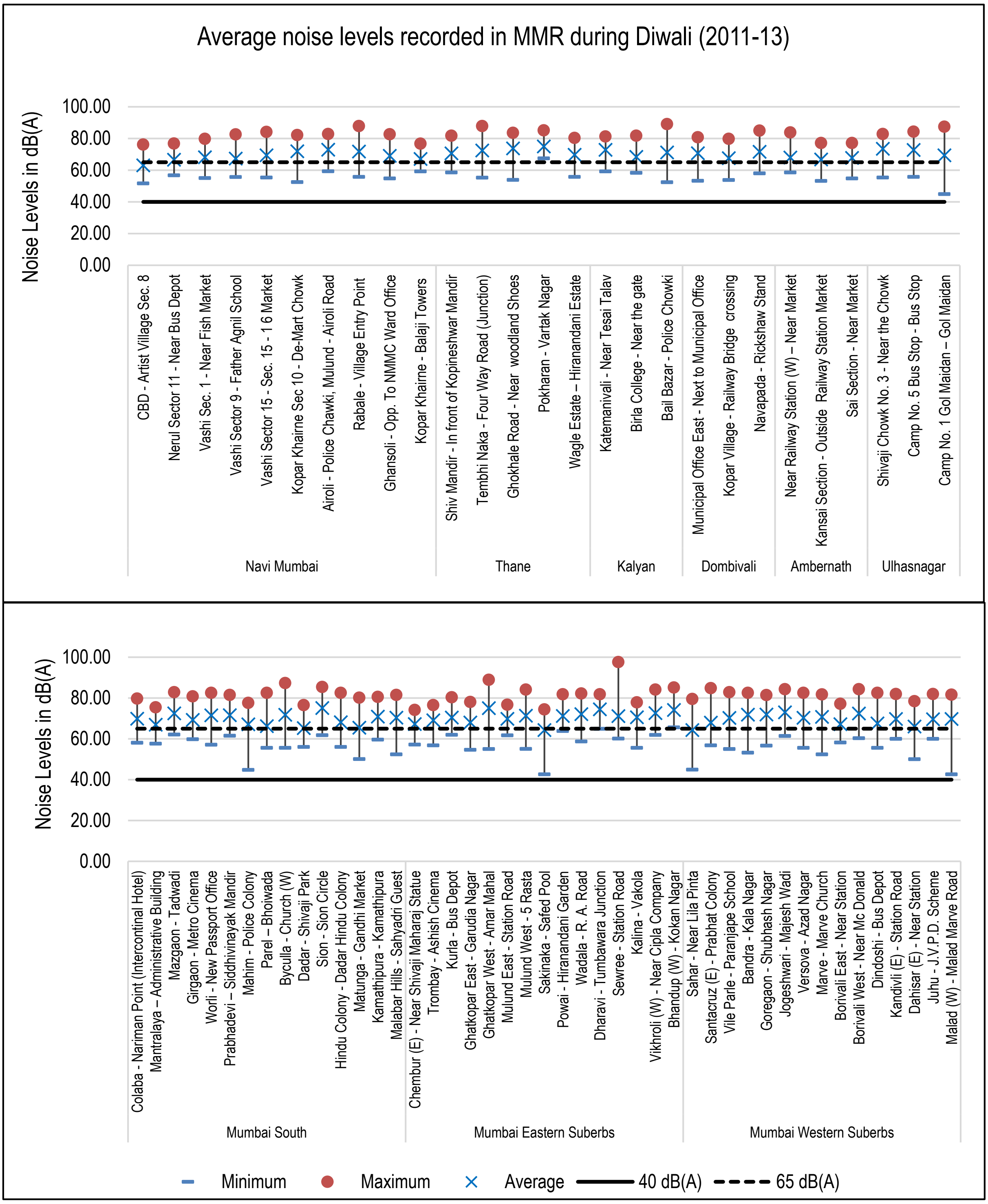


Figure No. 3-12: Average noise levels recorded in MMR during Diwali – 2011-13

Source: MPCB Report Noise Levels during Diwali 2013[24]

[24] http://mpcb.gov.in/envtdata/Comparison%20Data%20of%20Ambient%20Noise%20monitoring%20During%20Diwali%20for%203%20years_2013.pdf

3.5 Pressure on Air Quality in MMR

MMR is presently dealing with problem of air pollution as levels of respirable particulate matter (RSPM) are consistently exceeding the National ambient air quality standard (NAAQS) more than 1.5 times. There are several sources which exert pressure on the air quality of MMR. Other than the residing local population, MMR especially Mumbai megacity also invites enormous floating population due to the economic development, institutional centres and job availability in the city. The ever rising population leads to following causal factors leading to air pollutant emissions.

3.5.1 Vehicular growth

Increased urbanization, economic development and increased population have in turn increased the demand for mobility and subsequently led to the growth of private vehicles. The total registered vehicles have increased from 13 lakhs in 1997 to about 50 lakhs in 2011. About a thousand vehicles add to the fleet every day, and most of them are private vehicles. The trends of increase in different categories of vehicles in the MMR have been shown in Figure No. 3-13.

Importantly, cars have registered higher growth rates (11%) in last five years in comparison to any other modes. This also points to the possibility of further aggravation of congestion on the limited road space available in the region. Despite growth of vehicles in the region, it is still less in comparison to vehicle/1000 people available in other Indian cities.

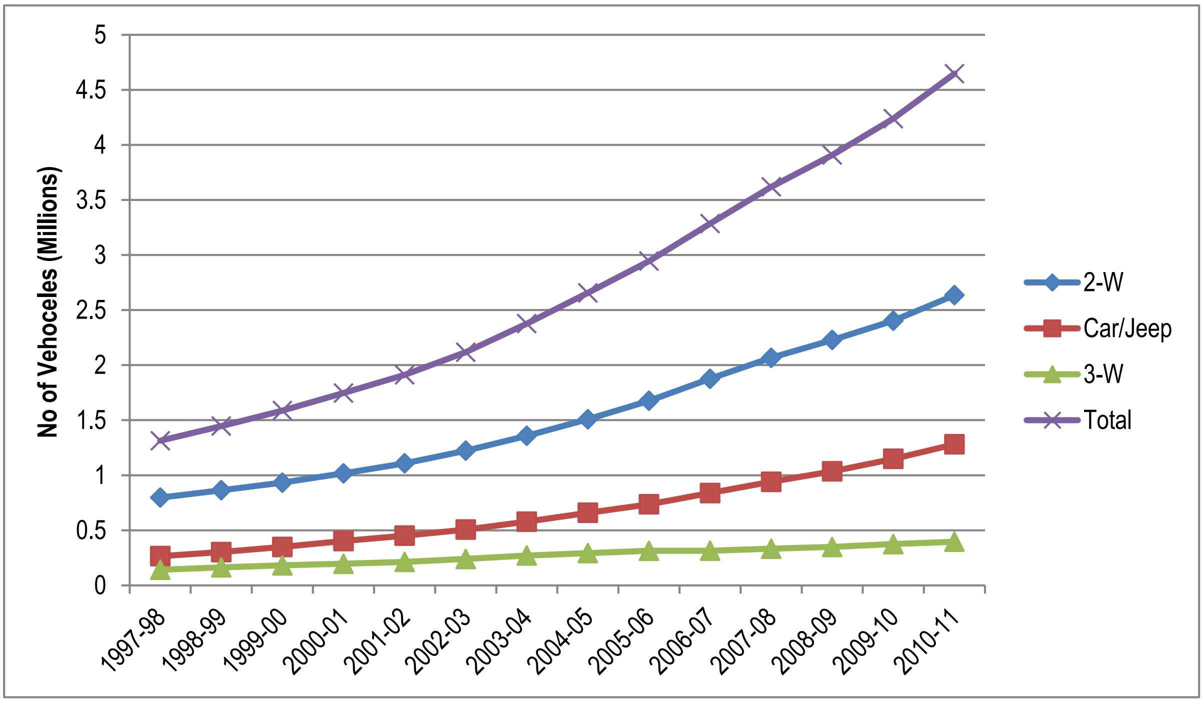


Figure No. 3-13: Trends of vehicular growth in MMR during 1998-2012

Source: MVDM, 2012

The distribution of vehicular fleet registered in MMR is shown in Figure No. 3-14 which shows the dominance of two-wheelers (57%) which is comparatively less than the National average of (72%). The deficit in two-wheelers shares is compensated by higher share of four wheelers (private cars/jeeps about 28%). This is another reason for increased congestion in the region. NEERI, 2013 stated that during peak traffic time in Mumbai, emissions increase by 33% to 75% whereas the travel time increases by 5 min to 30 min for the same route.

More than 1200 vehicles were added every day to the fleet of registered vehicles plying in MMR in 2011-12

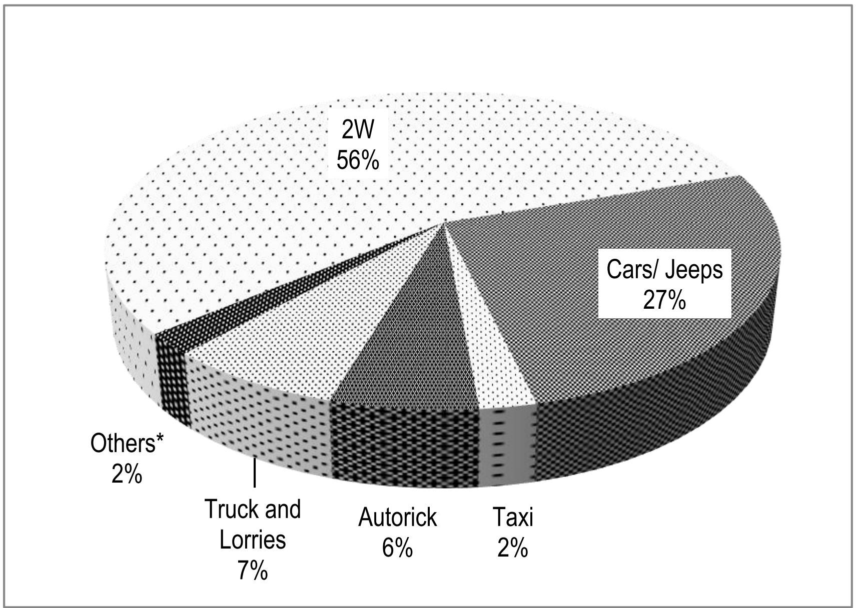


Figure No. 3-14: Share of different category of vehicles in MMR

Data Source: Motor Vehicle Department of Maharashtra 2011

Pollutant and region-wise contributions of different vehicles to the emissions loads are given in Table No. 3-16 & Table No. 3-17. It can be deduced that maximum particulate matter emissions are from Mumbai region followed by Thane and Navi Mumbai. The contribution of Mumbai in the emissions of different pollutants varies between 34-41%, followed by Thane 22-27%.

Table No. 3-16: Emission Load from different category of vehicles (Tons/Year) in MMR region (2009)

Vehicle category	PM	NO_x	HC	SO_2	CO	CO_2
Two-wheeler	279	2152	4861	29	13150	199000
Three-wheeler	636	1025	11112	0	3722	311313
Car-diesel	496	1682	689	378	1820	429266
Car-petrol	25	503	796	57	12605	529763
HDDV	2853	21400	852	1081	13807	1927186
Taxi	4	21	739	0	1232	269403
Total	**4293**	**26783**	**19049**	**1545**	**46336**	**3665931**

Source: NEERI[25]

Table No. 3-17: Region wise distribution of pollutant emissions in (Tons/Year) (2009)

Region	PM	NO_x	HC	SO_2	CO	CO_2
Thane	1149	7308	4458	403	10341	911628
New Mumbai	619	4286	1460	224	4679	463855
Kalyan	176	1034	1274	46	2059	122315
Dombivali	94	542	910	22	1630	67043
Ulhasnagar	170	962	1526	39	2502	117132
Ambarnath	107	587	935	25	1406	72601
Panvel	362	2494	1573	127	4923	292254
Alibag	66	400	362	19	575	47337
Mumbai	1551	9168	6552	640	18222	1571765
Total	**4293**	**26783**	**19049**	**1545**	**46336**	**3665931**

Source: NEERI[26]

[25] http://www.theicct.org/sites/default/files/RKumar_0.pdf
[26] http://www.theicct.org/sites/default/files/RKumar_0.pdf

Share of different vehicles in the total vehicular emission loads is presented in Figure No. 3-15. HDDVs being operated on diesel have the maximum share in NOx and PM emissions and gasoline driven cars and two-wheelers have significant contribution ion CO and HC emissions. Three-wheeler auto-rickshaws have the highest share in HC emissions.

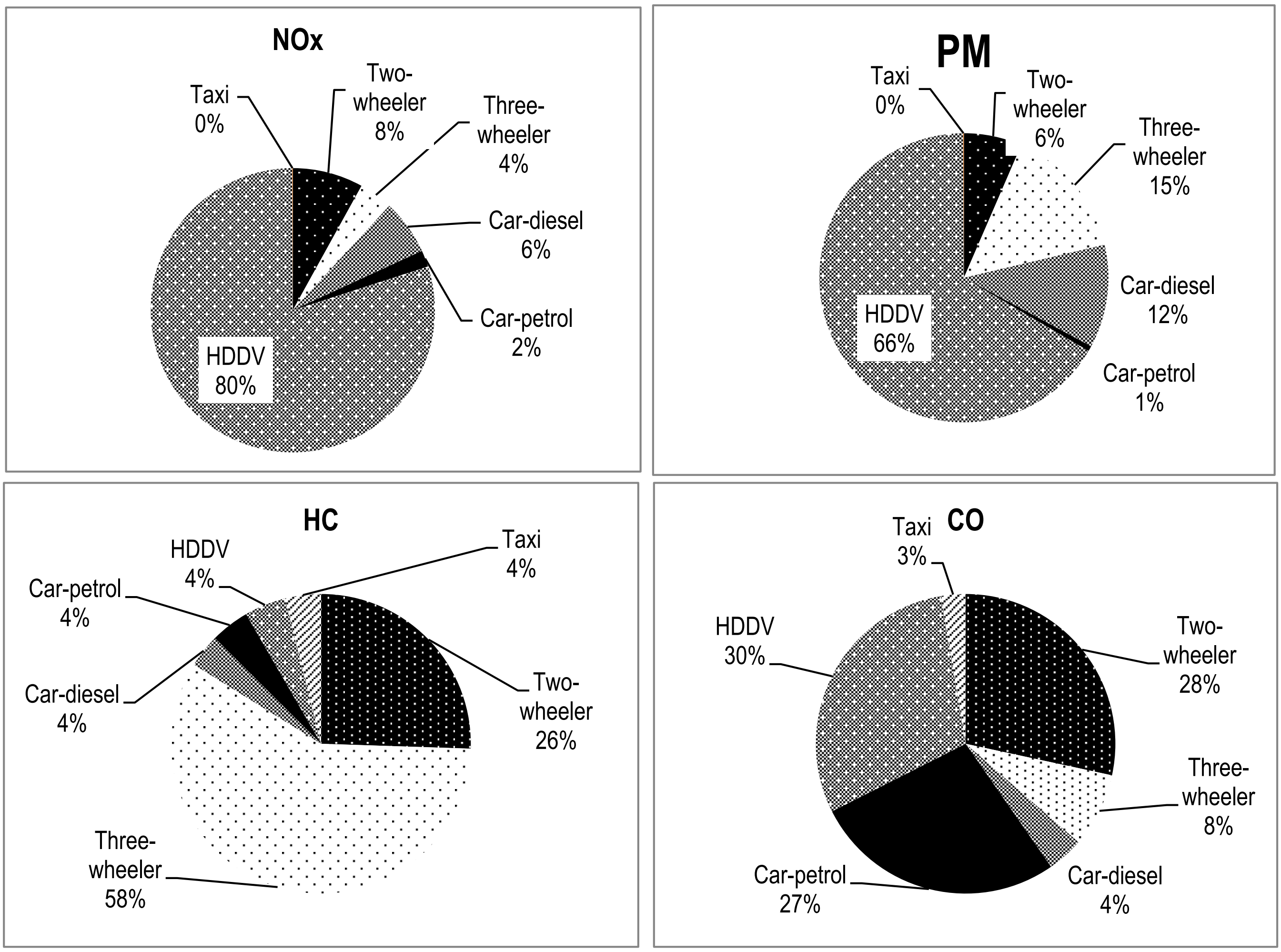


Figure No. 3-15: Share of different vehicles in the total vehicular emission loads

Data Source: NEERI, 2013[27]

[27] http://www.theicct.org/sites/default/files/RKumar_0.pdf

3.5.1.1 Old vehicles

Older vehicles, due to primitive technology and less maintenance emit many times higher pollutants than a new or well-maintained vehicles. Figure No. 3-16 shows the distribution of vehicles in MMR based on their vintages. It can be stated that 35% vehicles in MMR are of pre-2000 era and do not comply with advanced Bharat stage norms introduced later.

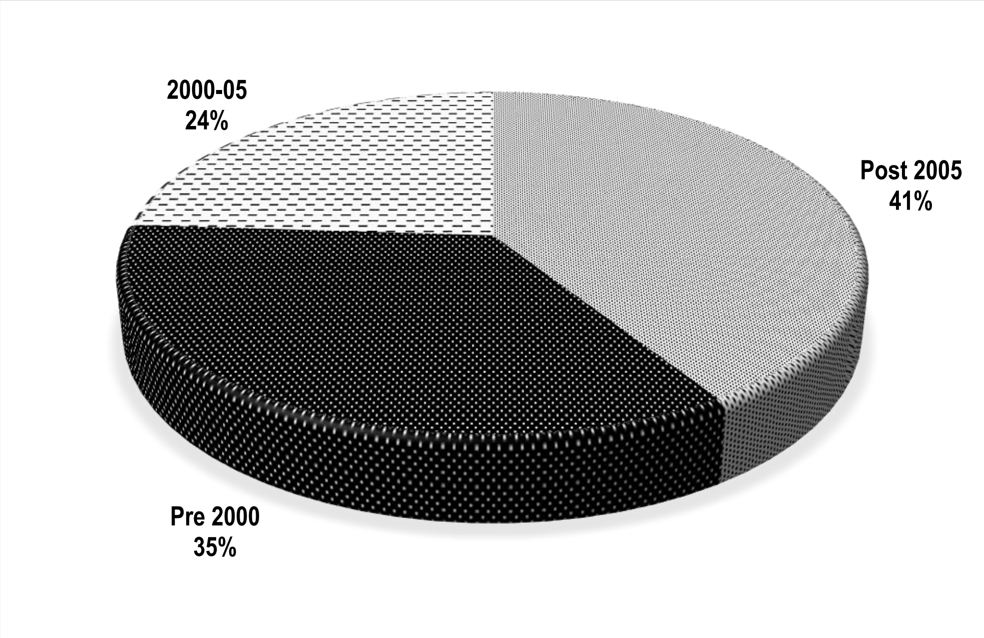


Figure No. 3-16: Distribution of vehicles in 2011 based on their vintages in MMR

Data source: MVDM, 2011

3.5.2 Road dust re-suspension

When vehicles moves on a surface loaded with silt, the dust gets suspended in the air and contributes to deteriorate the air quality. This is an emerging source of air pollution especially where ensuring the quality of construction, maintenance and cleaning of roads is a concern. Re-suspended dust is directly proportional to the number of vehicle, its weight and speed as well as the amount of dust on roads.

CPCB, 2010 also shows a major contribution from paved and unpaved roads in Mumbai. Re-suspension of dust emissions from Paved Road Dust is estimated to be 8666 Kg/day (CPCB, 2010). Vehicular tail pipe emission has been reduced by the introduction of Bharat Stage norms but not much has been done to tackle this emerging issue. CPCB, 2011 also highlights the presence of emissions from unpaved roads in Mumbai (13045 Kg/day).

3.5.3 Industrial growth

MMR has become a major industrial centre in the state. Region has many engineering industries such as motor vehicle manufacturing plants (buses, cars and motorcycles) and these are located in an area near Mazagaon. Other industries like metals, pharmaceutical, chemicals and leather industries are located away from Mumbai city and extend up to Kalyan. The industrial spread has been more towards the Trans Thane Creek area also known as Thane- Belapur industrial belt, Kalyan and Raigad. Moreover, in the recent times, the region has also attracted Education, Tourism, Transportation, Information Technology and Healthcare industries, which although does not pollute directly but have implications over the energy demands. Figure No. 3-17 shows that the major industrial growth of industrial units in MMR has been in Kalyan and Raigad regions of MMR.

Industrial growth has been rapid in Kalyan and Raigad regions

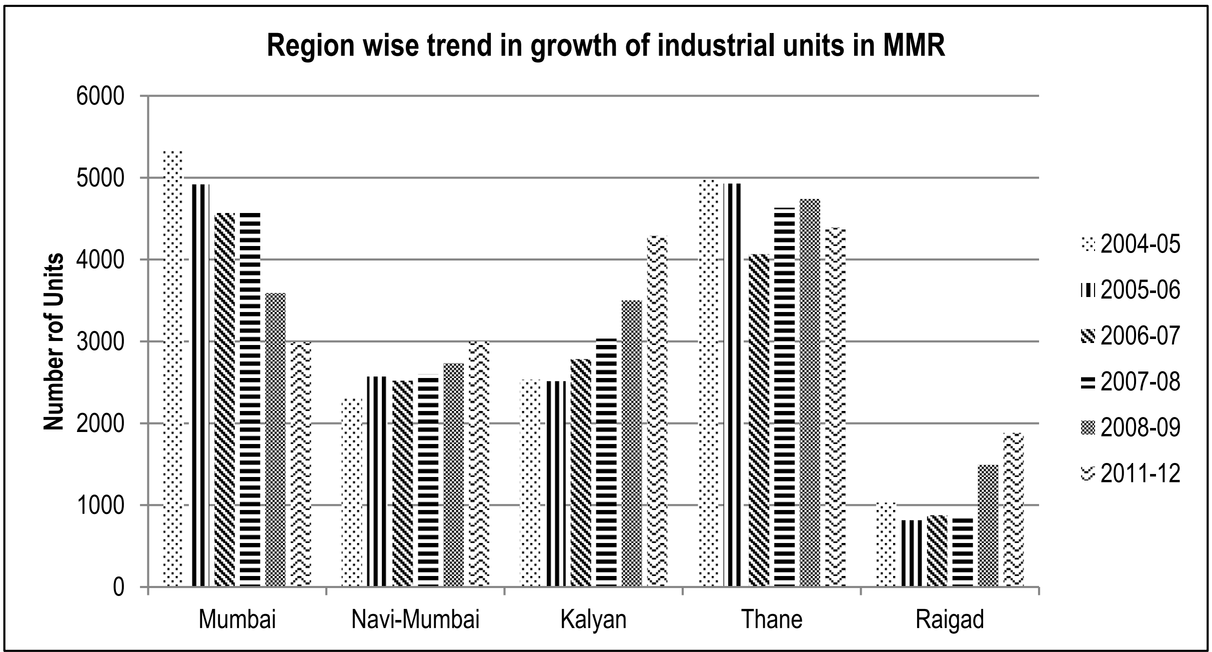


Figure No. 3-17: Region wise trend in growth of industrial units in MMR

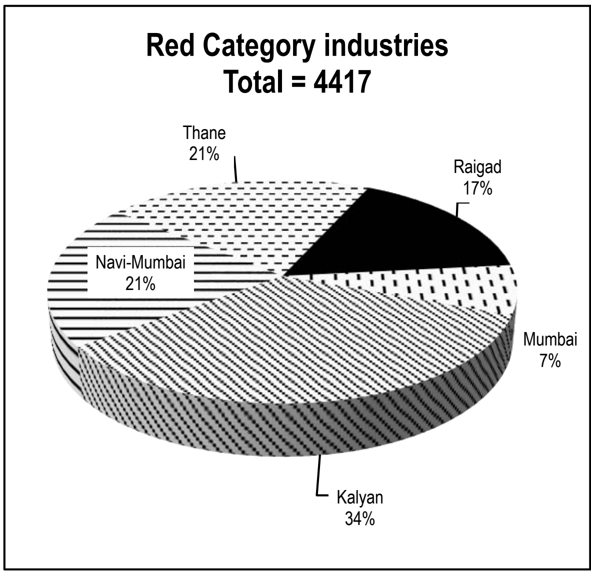
Source: MPCB, 2013

Note: Region as per MPCB RO (Regional office) jurisdictions Some regions of the RO's of Thane, Kalyan and Raigad are outside of MMR

CPCB, 2010, estimated the industrial sector contribute 503.7 T/yr of PM emissions in Mumbai. Apart from these industries, stone crushing industry is an important sector contributing to dust emission in the region. CPCB, 2010, reported Total Suspended Particulate emissions of 1394.3 T/yr from the sector in Mumbai.

3.5.3.1 Category wise share of Industries in MMR

Many of the industries within the MMR limits of study are air polluting and come under red category specified by CPCB. Figure No. 3-18 shows the region wise distribution of red category of industries in MMR for the year 2011-12. Kalyan region accounts for the maximum number of red category as well as orange category industries in MMR. The region wise category and number of industries is presented in Table No. 3-18.



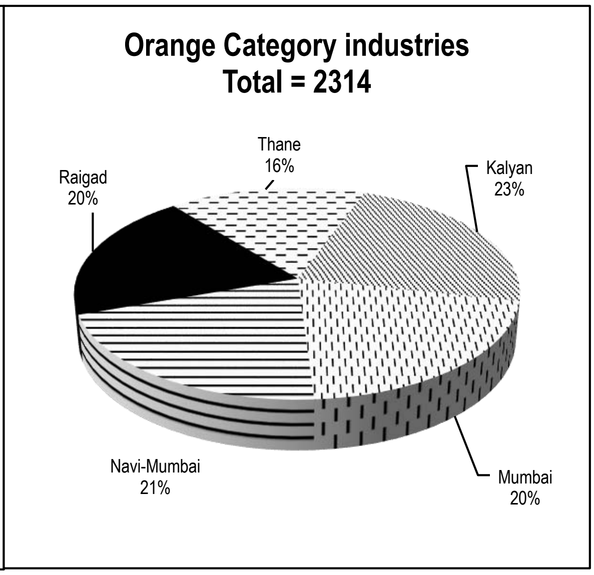


Figure No. 3-18: Region wise share of red and orange category of industries in MMR

Data Source: Statistical Report MPCB, 2011-12

Table No. 3-18: Region and category wise number of industries in MMR

	Category of Industries								
	Green			Orange			Red		
	LSI	MSI	SSI	LSI	MSI	SSI	LSI	MSI	SSI
Kalyan	8	14	2225	13	17	498	52	57	1407
Mumbai	4	7	2188	61	44	372	84	38	194
Navi-Mumbai	7	8	1578	22	25	430	92	51	786
Raigad	6	13	678	26	34	395	134	82	515
Thane	12	26	3053	7	12	358	103	43	779
Total	**37**	**68**	**9722**	**129**	**132**	**2053**	**465**	**271**	**3681**

Data Source: Statistical Report MPCB, 2011-12

Note: LSI: Large Scale Industry; MSI: Medium Scale Industry; SSI: Small Scale Industry; Region as per MPCB Regional office jurisdictions Some regions of the RO's of Thane, Kalyan and Raigad are outside of MMR

3.5.4 Domestic & Commercial activities

MMR is highly urbanised with 94% of urban population and only 6% of rural population. According to Provisional Report Census 2011, 18 million people live in urban area while only 1.1 million live in rural area. While the urban areas of the region are dependent on cleaner fuels such as LPG/PNG for cooking, but people living in rural areas continue to use polluting fuels like fuel wood, biomass etc. Figure No. 3-19 shows the percentage of household using different types of fuels in urban and rural areas of the region.

Average population density of MMR region is 4822 person/Km². Mumbai and Mumbai suburban districts are highly populated as compare to other areas of the region. More than one-third population of urban MMR live in slums. According to census 2001, 6.7 million people live in slums and out of this, 5.8 million live in slums of greater Mumbai district. LPG is used as a major cooking fuel in the organised areas of the district while kerosene is used as a fuel for domestic use by slums. According to survey conducted by NEERI Mumbai in the year 2005, 88% of slum population in greater Mumbai consumes kerosene as major cooking fuel (CPCB, 2010). Table No. 3-19 shows the total emissions load of particulate matter (PM) in Kg/day from slums and rest of the Mumbai city.

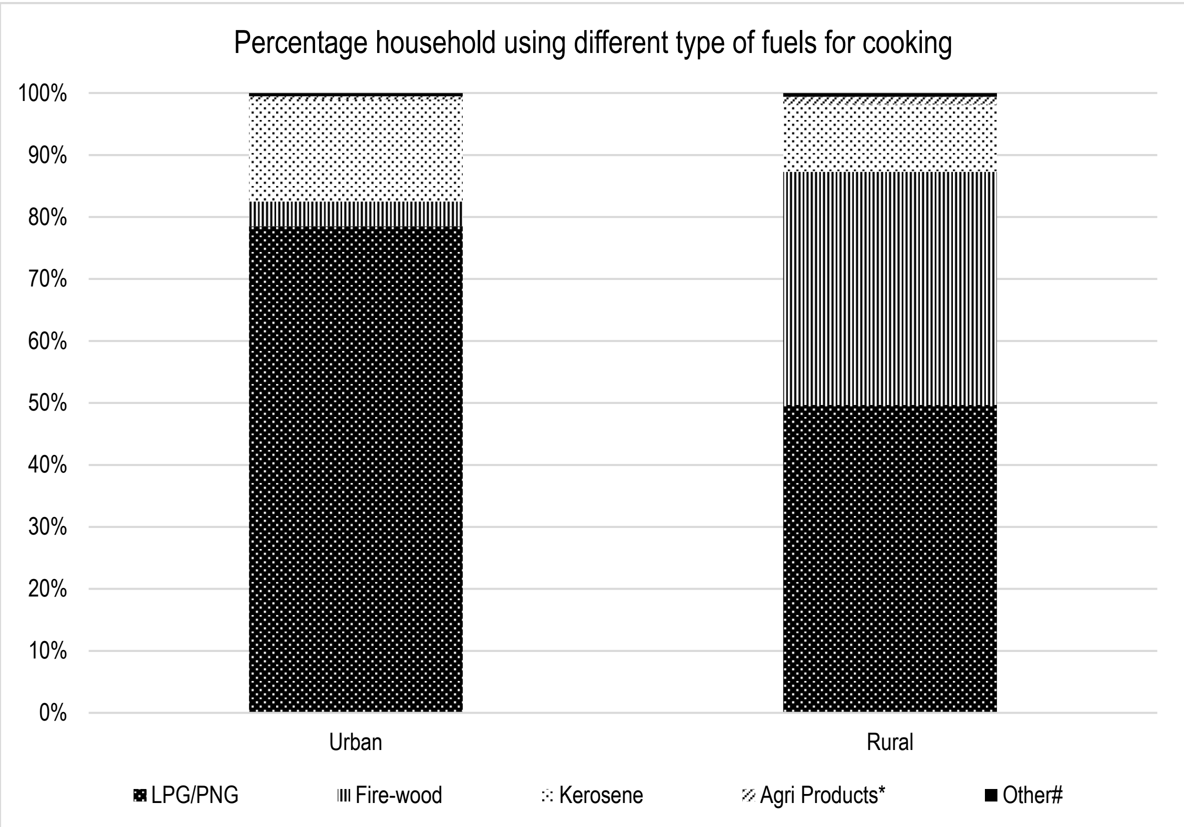


Figure No. 3-19: Percentage household using different type of fuels for cooking

Source: Census, 2011 Provisional Report

Table No. 3-19: Total Emission load in Kg/day from Kerosene and LPG in Mumbai city

Area and Fuel	PM (Kg/day)
Slum Kerosene	441.2
Other Kerosene	55.87
Total LPG	1050.63
Grand Total	**1547.5**

Source: Air Quality Assessment, Emission Inventory & Source Apportionment Study for Mumbai City, CPCB and NEERI 2010[28]

3.5.4.1 Power Plant

MMR has two thermal power plants and one hydro power plant. Tata Thermal power plant having an installed capacity of 1580 MW is located in Mahul area of Mumbai and it is a coal based plant while Uran, which is a gas based thermal power plant is located in Navi Mumbai and is having installed capacity of 672 MW. Coal and Natural gas combustion in power plants contribute to the air quality problem of the region. CPCB, 2010 quantified that 21% of PM emissions in Mumbai are from power plant.

3.5.4.2 Commercial activities

There are many commercial activities which are known to contribute to the pool of air pollutants in the atmosphere. Wood burning in bakeries is an important activity leading to emissions. CPCB, 2010 quantified that 6% PM emissions in Mumbai are contributed by this source.

3.5.4.3 Construction activities

Construction activities contribute to dust emissions. Big construction projects if not handled properly may lead to significant dust in the atmosphere. The region is filled up with many construction activities including that of Metro/Mono rail project. Big housing projects, flyovers, commercial buildings, and industrial construction activities contribute significantly to dust. CPCB, 2010 quantified that 8% PM emissions in Mumbai are from construction activities.

[28] CPCB and NEERI 2010, *Air Quality Assessment, Emission Inventory & Source Apportionment Study for Mumbai City*,

3.6 Response to Mitigate Air Pollution

There are measures taken by the government in controlling the air pollution and improving the air quality of the region. Sector-wise measures are:-

3.6.1 Transport Sector

To combat with the problem of deteriorating air quality in Indian cities, continuous efforts are made by government to improve the vehicular technology and fuel quality in the country. Vehicular emission norms are notified under the Motor Vehicle Act, 1988 while fuel quality standards are notified under the Environment (Protection) Act, 1986. Timeframe of introduction of these norms in Mumbai is as follows:

Introduction of vehicular emission norms

- 1st Norm implemented from 1990/91
- Norms for cat converter vehicles implemented from 1995
- 2nd emission norms introduced in 1996.
- Euro-II equivalent norms implemented from 2000.
- Bharat Stage-III implemented from 2005.
- Bharat Stage-IV implemented in 2010

Improved fuel quality

- Low leaded petrol (0.15 g/l) in 1994
- Leaded Petrol phased out in 1995.
- Petrol with 5% Benzene introduced in 1996 & 1% from 2000.
- Diesel Sulphur 0.5% from 1996, 0.25% from 1998 and 0.05% in 2001.

Figure No. 3-20 shows that Sulphur dioxide concentrations in Mumbai have decreased due to reduction in sulphur content of fuel.

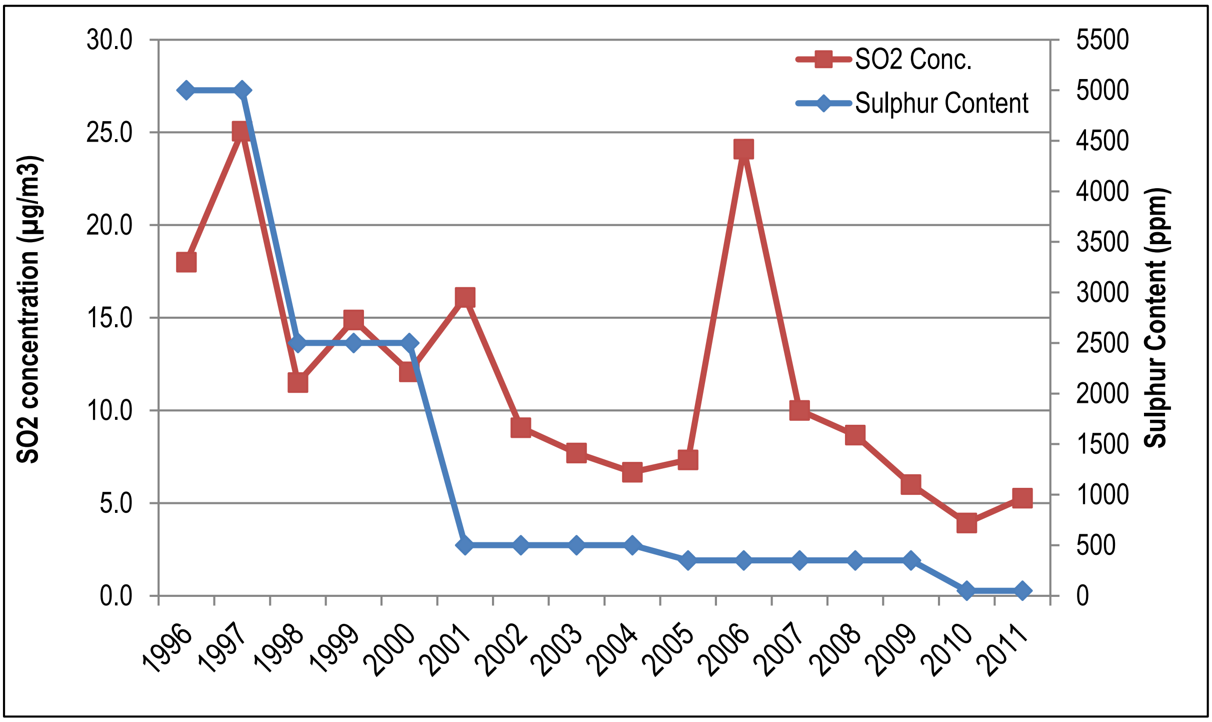


Figure No. 3-20: SO_2 concentration and improvement in Sulphur content of diesel in Mumbai from 1996-2011.

Source: National Ambient Air Quality- Status & Statistics 1999 to 2012[29]

3.6.1.1 Use of CNG & LPG for vehicles

Since 1992, CNG is being supplied as a fuel to transport sector to Mumbai on experimental basis by GAIL. Later, Mahanagar Gas Limited has given the responsibility to manage CNG supply to the area. In October, 2001, in light of recommendation of committee of Honourable Bombay high court, it has become mandatory for commercial vehicles to use either CNG or (Liquefied Petroleum Gas) LPG as a fuel (Source: TDMS, 2013).

At present, CNG has been supplied as a cleaner fuel in Mumbai, Thane and Navi Mumbai to reduce air pollution. In all there are 192269, 22386, 1680 and 302 vehicles running on CNG, including cars, auto-rickshaws, LMVs, and buses Greater Mumbai, Thane, Kalyan and Raigad region respectively (Source: MVDM, 2011). The total consumption of CNG by the fleet and rickshaws is 984 T/d in 2010 (Source: MoPNG, 2012).

At present there are total 25118 taxis, cars and auto-rickshaws which work on LPG, (Source: MVDM, 2011).

[29] http://www.cpcb.nic.in/upload/NewItems/NewItem_192_NAAQSTI.pdf (other reports were referred from TERI library)

3.6.1.2 Enhancement of Public Transport system

Mumbai's public transport system constitutes suburban railway lines, Brihanmumbai Electric supply & Transport (BEST), public cabs/taxis and auto rickshaws.

Suburban railways of Mumbai is the oldest in Asia, it started operating in 1857. With a route length of 303 km, more than 2600 suburban passenger trains, it carries 7.4 million passengers on daily basis. According to the Trans Form study conducted for MMR, rail travel accounts for 51% of all trips by motorised transport.[30] To further enhance the capacity of suburban railways, MRVC is implementing MUTP projects in the region. Phase one of the projects is completed in 2011-12 and work of phase two is in progress.

MMR region has efficient bus transport system known as BEST. Its services are available in entire Mumbai, Navi Mumbai, Thane and Mira-Bhayandar. It has total fleet of 4,652 buses which carry 4.2 million passengers on daily basis. Augmentation in the capacity of fleet has been done under JNNURM[31].

Mass Rapid Transportation System

MMRDA has been working to create Mass Rapid Transportation System (MRTS) in Mumbai. They have proposed a metro rail project in Mumbai. The system is designed to reduce congestion in the city and will be built in three phases over a 15 -year period with an overall completion in 2021. Metro will cover a total of 63 Km stretch in the core of the city. Trial run for 3km stretch has already been started in May 2013. Stretch between Versova-Airport roads will be open to public by September 2013.

Mono rail project has also been proposed for the city of Mumbai. The project is to begin on a pilot basis in 19.5 km between Sant Gadge Majaraj Chowk to Wadala Depot and then on to Chembur. Trial run is already been conducted in February, 2013 and system is expected to open for public by August, 2013.

Implementation of these projects will not only impact the mobility but will reduce dependence on private vehicles and will reduce the emissions.

3.6.1.3 Transport infrastructural development

There are a number of initiatives taken to develop infrastructure for providing safe and smooth mobility to the residents of MMRDA. Some of the initiatives taken by MMRDA are as follows:

Eastern Freeway

To provide easy access to commuters travelling from south Mumbai towards Thane-Nashik and Panvel-Pune, 16.9 Km long Eastern freeway is constructed by MMRDA. This freeway is built up in three parts, part-I is Eastern Freeway and it is constructed to cater the mobility demand from Mumbai port trust. It is 9.29 Km long and 17.2 m wide. Part-II is constructed on Anik-Panjarpol Link road. This begins from Anik in Wadala and ends at Panjarpol Junction on the Sion-Panvel Link Road. This is a 4.3 Km long stretch with 4+4 lane road. And part-III is constructed on Panjarpol-Ghatkopar Link Road. This stretch is 3 Km long and

[30] Source: MRVCL, 2013
[31] Source: PIB, 2013

17.2 meter wide. This project was completed in June, 2013 and completion of the project has also helped in decongesting the major roads along the proposed route.[32]

Skywalks

Apart from conventional mode of public transport, skywalks are constructed in MMR to efficiently disperse the commuters from congested area to strategic location such as bus station, taxi stands etc. The first skywalk was inaugurated in June, 2008. There are 36 skywalks in the MMR. The survey conducted by authorities' shows that more than 15 lakh commuters make use of these skywalks.

[33]Milan rail over bridge: This 700 meter long bridge is constructed at Milan Subway, Santacruz to provide east-west connectivity and to solve the traffic problems arise during every monsoon due to flooding. This bridge was opened to the traffic in May, 2013.

Mumbai Urban Infrastructure project: To improve the mobility in the Mumbai city, Mumbai Urban infrastructure project was undertaken in November, 2002. The main aim of the project is to improve the east-west and north-south connectivity in the city. The major objectives of the project are:

- Prepare a traffic dispersal model for efficient mobility and connectivity
- Develop North-South road links in the suburbs including a Mass Rapid Transit connectivity
- Strengthen/augment East-West connectivity in the suburbs
- Provide efficient / fast public transport corridors
- Facilitate safe and convenient movement for pedestrians (Subways/FOBs/Footpaths including Skywalks)
- Provide high capacity uninterrupted road connection to both the Airports
- Remove level crossing in Mumbai
- Provide bus terminal / bus depots and to create facilities for passengers

3.6.1.4 I&M (Inspection and Maintenance) of old vehicles

Efforts have been made to implement the PUC norms 2004 in MMR. In MMR, there are 219 nos. of PUC centres for Petrol, 56 nos. for diesel & 244 nos. for petrol & diesel. Overall, 8% of vehicles come for inspection and failure rate is 1%.Penalties are laid on vehicles if found exceeding the emission limits.

3.6.1.5 Traffic management

Restriction have been put on goods vehicle and passenger buses entering the city by PMC and Police Commissionerate. Other traffic management measures include :- Pay and Park Schemes on major roads, one way traffic movement on few roads, construction of multi storied parking complexes, installation of countdown timers at signal junctions, and Area Traffic Control System using signal synchronizations on major corridors in the centre of city.

[32] Source: MMRDA, 2013

[33] Source: MMRDA, 2013

3.6.2 Industrial Sector

Industrial location policy was first formulated by government of Maharashtra in 1993 and was subsequently formulated in Trade and commerce policy in 1995 by state government, with the purpose of decongesting the city and ensuring pollution free environment. According to the policy, MMR is divided into three zones. According to the policy, only non-polluting, high tech and high values added industries were allowed in Greater Mumbai and areas of Thane and Mira Bhayander Municipal corporations. This policy was made available to all industries except cotton textile industries, godowns, service industries and service industrial estates (Source: MIDC, 2013)

3.6.3 Noise Pollution Control

- Area not less than 100m around the Hospitals, educational institutions, courts, are declared as Silence zones
- Restrictions on usage of Loudspeakers during night time
- Usage of loudspeakers (with limited noise) only after mandatory written permissions form the concerned department

3.7 General Recommendations

Our study has clearly identified the gaps and shortcomings of the existing air quality monitoring programs and infrastructure. The region is fast growing and densely populated, besides this, the city of Mumbai is India's financial capital and major power centre for businesses and industries. MMRDA is aiming at providing world class infrastructure and amenities to the region and maintaining good air-quality is part of it. While certain regions like Kalyan, Ambernath and Ulhasnagar are highly prone to pollution and need immediate attention of authorities, other region also need strategic and executable plans to control and reduce pollution on short and long term basis.

3.7.1Required Studies

Following studies are recommended to further understand and improve of air quality issues and impacts in the region.

3.7.1.1 Network enhancement study

A study to strengthen the monitoring network with a proper road map indicating_phase wise implementation action plan and scientific studies to identify appropriate locations for monitoring stations should be undertaken. This would help in bringing in reliability, consistency and appropriateness for the air quality monitoring program.

3.7.1.2 Source apportionment and emission inventory studies

Source apportionment and emission inventory studies for the region should be carried out. This shall help in devising region specific strategies with appropriate information of the source and quantum of emission from that source.

3.7.1.3 Health Impact assessment study

Currently available health data is not sufficient to identify impact of pollution on health; we suggest a detailed study would be useful for this. It needs to be coordinated at higher levels to access data from private and government hospitals. Specific study for RSPM pollution from quarrying and construction activities can also be carried out. These studies can help in devising new strategies for reducing such pollution.

3.7.2 Air quality monitoring- Network and data management

3.7.2.1 Strengthening of networks

There is dearth of AAQM stations in MMR. A minimum of 160 stations are required to assess and appropriately represent the Air quality of MMR as per the norms /standards. At present there are mere 42 locations installed under CPCB/MPCB programs, industrial units, sites regularly monitored by MCGM which monitor air quality regularly in MMR[34]. A region wise break up of required stations is presented in Figure reproduced below and detailed calculations are presented in Annex 12.

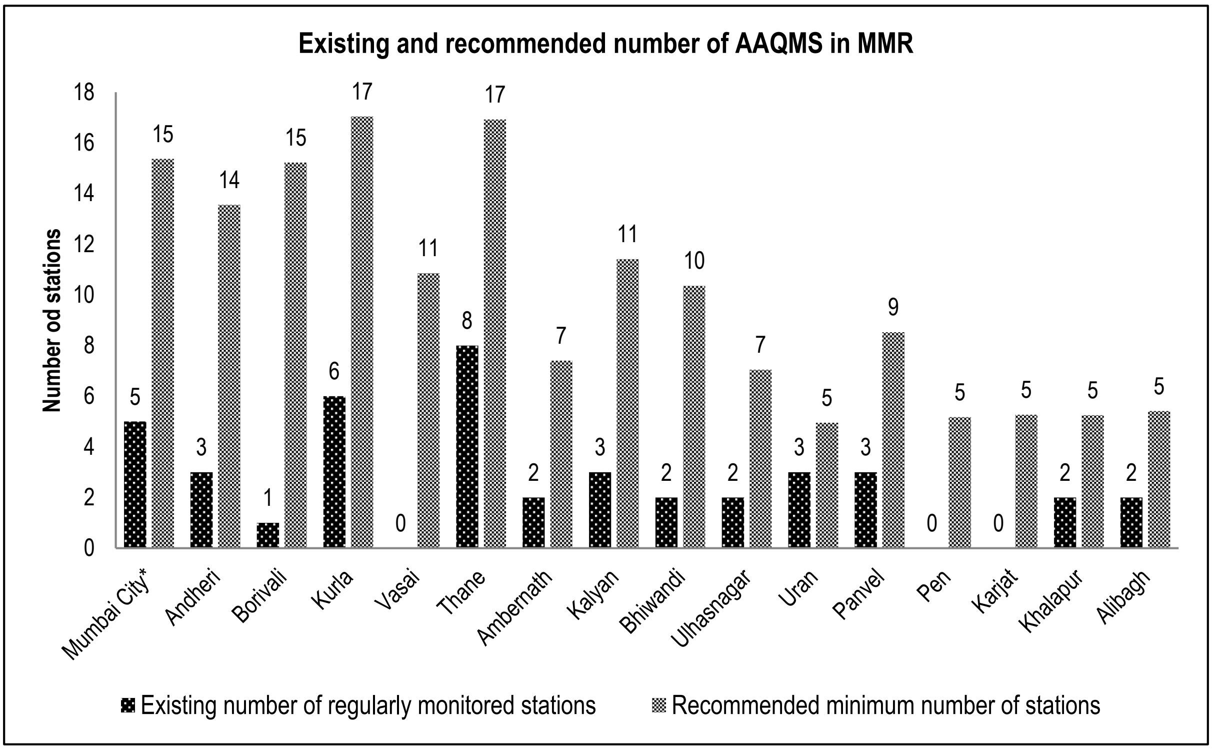


Figure No. 3-21: Existing and recommended number of AAQMS in MMR

Some important areas which need to be covered under the NAMP/SAMP on priority are Mumbai city district, Talukas of Andheri, Kurla and Borivali, and municipal corporations of Vasai, Virar and Mira Bhayandar. Additionally, monitoring sites under ULBs can also be brought under SAMP.

[34] This excludes stations established by ULBs and others.

3.7.2.2 Industrial area air quality monitoring

Large industries

Ambernath and Dombivali regions of Kalyan taluka are highly industrialised with large number of chemical industries which handle chemicals like benzene, ammonia and so on. As per the Air (Pollution and Prevention) Act, these industries are expected to monitor and maintain air quality and report to MPCB. However, our study found that this needs to be strengthened and we suggest stringent monitoring action through independent monitoring mechanism. CAAQMS, for continuous monitoring of chemical gases needs to be installed at both these locations for continuous surveillance of pollutants and hazardous gases in these areas.

Medium and small scale industries

The region has number of medium and small scale industries, more than (3950 small and medium red category industry) establishments like bakeries, foundries which together, prima facie, are responsible for a reasonable share of emissions. This, however, needs to be studied in detail. The source apportionment study recommended above can take care on this. Once identified, these industries then can be covered under protocol for controlling the emission and / or can be suitably shifted to safer location. A suitable funding/ financial support mechanism would also be required to implement air quality improvement measure in these industries.

3.7.3 Network of ULB monitoring stations

ULB's which monitor the air quality, like TMC, NMMC, and KDMC should be linked with the SAMP to regularise the monitoring at a given location and to enable appropriate representation and analysis for the region. They already have infrastructure to carry of the monitoring but the same should be used more efficiently and effectively. During our interaction, MPCB officials raised doubts over the reliability and quality of the data coming from ULB stations. During site visits we also observed that some of the ULBs do not have adequate trained and skilled manpower to collect and analyse the data.

At the policy level, the amendments should be considered in the BPMC (Bombay Provincial Municipal Corporations Act) for having a dedicated environmental cell, dedicated Environment Officer and trained staff for dealing with environmental monitoring and environmental issues.

3.7.3.1 Monitoring by Urban Local Bodies

ULBs do have AAQM equipment including mobile sampling and monitoring equipment. The study identified following issues

- Many ULBs have mobile monitoring facilities. However, as mentioned in the report they generally don't follow standard monitoring protocol. The sites for sample collection are, in most of the cases, not fixed and the sampling frequency is also not maintained as per the protocol. This results in data being collected but not useful for analysis. This needs to be addressed. Either the MPCB or the Centre proposed above can address this issue.

- The parameters monitored should be uniform across the ULBs and as per the NAMP guidelines. Sites monitoring SPM, should be replaced/ notified with RSPM monitoring equipment. Since as per new guidelines SPM is not monitored and the standards for SPM.
- Up gradation of old equipment and appropriate maintenance of the equipment should carried out.
- Capacity building of the staff.

3.7.4 Sensitive area monitoring

CPCB guidelines have defined protocols and stringent norms for sensitive sites like regions which have more number of hospitals, eco sensitive zones. And so on. Areas like Parel which has 5-6 hospitals in close vicinity, SGNP, Matheran, Karnala sanctuary and other rural areas do fall under sensitive area category. AAQM of these areas need to be strengthened.

3.7.5 Data Management

As seen earlier, the region has number of air quality monitoring stations reporting to various agencies, but they operate in discrete manner. TERI recommends establishment of special authority/ centre for air quality under MMRDA.

3.7.5.1 Establishing a special authority/Centre for air quality

TERI recommends setting up of a MMRDA specific authority having representation from. MMRDA, MPCB, CPCB, MIDC, Health department, Transport department. The authority can centralise the data collection and analysis of AAQ data and operation and maintenance of AAQM stations. It can act as a focal point for the region for this purpose. The authority can also carry out the studies recommended above. A separate budget may also be provided for the authority for its activities. Software should be developed to capture the real time data from the NAMP, SAMP sites, the data from ULB's and the data from CAAQMS of the industries to procure information on weekly basis.

3.7.6Strategies for containment of air pollution

3.7.6.1 Transport Sector

Vehicular pollution is one of the major pollution sources in urban environment. The study has identified important issues in the preceding sections. To summarise, traffic congestion due to poor traffic planning and management, bad road conditions, inadequate road network to cater the increasing number of vehicles, and old vehicles are some of the major issues in MMRDA. In light of these, we recommend following measures;

- Intelligent traffic management systems to be employed for smooth traffic flow and reduced congestion and corresponding idling emissions.
- Enhancement of public transport and feeder services
- Improvement in road quality shall significantly help in reducing vehicular emissions as well as road dust re-suspension

- Control of emissions from older vehicles through effective inspection and maintenance program, plying restrictions and subsidies for retro-fitments.
- Scrapping of older vehicles through policy intervention
- Grants to ULBS to purchase clean public transport vehicles. A scheme similar to JNNURM for purchasing, cleaner vehicles.
- Promotion of electric and hybrid vehicles

3.7.6.2 Construction Sector

- Construction sector is booming in the region resulting in air-pollution due to dust and emissions from construction machinery. We propose suitable stringent measures should be introduced to control this.

3.7.6.3 Industrial Sector

- Population centres around industrial estates are growing fast and this population is exposed to industrial pollution. MMRDA and MIDC can constitute a review committee to study these issues especially for Ambernath, Badlapur, Ulhasnagar and Dombivali areas. Appropriate relocation policy can be designed for these industrial areas.
- Stricter enforcement of stack emissions standards especially for medium and small scale industries.

Environmental Status Report of Mumbai Metropolitan Region

Section
4 Climate Variability

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4.1 Introduction

4.1.1 Global Climate change and Variability

Variations in the earth's climate have always been a natural phenomenon, but recently there have been studies which indicate a definite change in this natural phenomenon. The causes were initially attributed to natural changes, but recent experiences clearly indicate that these variations are not only an influence of the natural variations but also largely due to anthropogenic factors. As per the United Nations Framework Convention on Climate Change (UNFCCC), Article 1, climate change can be defined as a change of climate which is attributed directly or indirectly to human activity (Box No. 1), that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time period.

Box No. 1: Is Climate Change and Climate Variability the same?

Climate change could be defined as a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.
Whereas, Climate variability refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events. It can be primarily observed as a local phenomenon.

- *Source: UNFCCC, Article 1*

Source: http://unfccc.int/essential_background/convention/background/items/2536.php and

http://www.ipcc.ch/ipccreports/tar/wg1/518.html

Despite the fact that climate change is a global phenomenon with observed global impacts like global warming, global cooling, sea level rise, and so on, local impacts are also conspicuously experienced and hence cannot be neglected. One of the predominant impacts of climate change locally, is the variation in local weather conditions and microclimate, often termed as '**Climate Variability**'. According to the Third Assessment Report of the IPCC (2001), Climate Variability refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events.[1]. Increased temperatures and uncertainty in terms of arrival of monsoon, irregularities in the amount and distribution of rainfall, and many other such changes, indicate the disturbed state of the atmospheric balance occurring in different parts of the world today.

4.1.2 Urbanisation: A challenge and opportunity

Urbanisation has never seen a faster pace than the present, till date. The rate at which the urban agglomerations are expanding today, they pose various challenges and opportunities to the human development as well as the environment. Air and water pollution, solid waste generation, greenhouse gas emissions are some of the by-products of rapid growth. Recent

[1] IPCC Third Assessment Report, 2001, working group 2, Impacts, Adaptation and Vulnerability

observations from the World meteorological Organisation's Global Atmosphere Watch Network stated that the observed concentrations of CO2 levels in the atmosphere have exceeded the symbolic 400 parts per million[2] , giving a wakeup call to all of us about the catastrophic events which the world would face, in the absence of appropriate preparedness mechanisms in place. In addition to the developmental issues, other issues like increasing levels of Air Pollution and so on are adding to the chaos.

Undoubtedly, globalisation, resulting in the mushrooming of economic opportunities, is bringing the world closer and concentrated in the form of compact urban cities. Living in these cities, demand energy intensive lifestyle. While these cities offer challenges, they also provide opportunities to integrate sustainable approaches in the early planning stages. Efficient planning can considerably reduce the footprint, while keeping the pace of development. Thus an assessment of such approaches is crucial for its integration with the regional planning processes. Furthermore, other factors like well-defined institutional hierarchies in the form of Urban Local Bodies (ULBs), faster dissemination of information technologies and so on, make cities a better place to introduce his change.

Box No. 2: Holding ponds and their significance in climate adaptation.

Holding ponds allow the city to breathe during crisis situations. Given that some areas of Navi Mumbai are below the sea level, holding ponds based on the Dutch technology were created during the formative years of this satellite city in 1980s.

Holding ponds act as a buffer between the storm water drain and the creek, i.e. holding the storm water during rains and release it after the high tide recedes, preventing flooding of the area. In spite of their significance, these spaces are currently neglected and misused as dumping grounds. In MMR, they are most commonly found in Navi Mumbai.

4.1.3 MMR: Regional dynamics and Vulnerabilities.

MMR is a dynamic region, with multiple entities co-existing together. From high population densities, being the paramount concern, other aspects like co-existence of natural ecosystems like Wetlands, Mangroves, manmade ecosystems like Holding ponds[3] (Box No. 2), influx of migration, scarcity of land and so on are adding to the overall dynamism of the urban fabric. In addition to these pressures other pressures like sewage disposal, solid waste management, food storage and distribution are inviting additional challenges to the development of the city. With the climatic scenarios changing or projected to change in the coming centuries, cities like MMR would require more attention, by the virtue of being multidimensional.

The region shows significantly high population density of 5403 persons per sq.km spread over the built up area of 619.2 sq. km. This clearly indicates the immense vertical growth of MMR.

In addition to these unswerving pressures, the region is also surrounded by the Arabian Sea on three sides. Further, with the population of MMR crossing 23 million accounting for more than 50% of the urban population of the state of Maharashtra, there is practically no room left for any further

[2] http://www.unep.org/newscentre/default.aspx?DocumentID=2716&ArticleID=9503
[3] http://www.sdmarchitects.com/holding-ponds-in-navi-mumbai.html

expansion at present. The population is also seen to be increasing from 77.78 Lakhs in 1971 to 188.93 in 2001, which indicates an alarming situation for the future and calls for urgent reforms in the present policy and infrastructure frameworks. Thus any spatial/physical, sectoral, environmental, organizational, economic planning in the region will be more effective only if it is strategic and driven by locally identified needs and values[4].

4.1.4 Need for integrating climate change in planning process

13 per cent of the world's urban population lives in low elevation coastal zones, which are highly vulnerable to climate change.

Situated at the foothills of Sahyadris and alongside the coast, the climate of the region is very distinguished. Both these entities dominate as well define the climate of the region. While the region falls in warm and humid climatic zone, the climatic extremes are seldom observed in the region. The average annual rainfall is usually around 2000mm whereas the average minimum and maximum temperatures are around 22°C- 23°C and 30°C and 31°C respectively. Owing to such conducive climate, many parts of the region undertake agricultural activities in and around the region, which supports the food supply and demand/ requirements of the region. As other coastal cities, in MMR too there co-exist many factors, which make it more prone to the impacts of climatic variations. Like what is documented in various studies, the impacts of climate change will be particularly severe in low-elevation coastal zones, where many of the world's largest cities are located. Although they account for only 2 per cent of the world's total land area, approximately 13 percent of the world's urban population lives in these zones with Asia having a higher concentration[5]. MMR also being situated close to Arabian Sea will require preparedness strategies to be drafted in order to minimise the impacts of future climatic variations if any.

Some of the common factors, which make coastal cities more vulnerable, are as follows;

Many of the informal settlements in the coastal cities are in the low lying areas, making them more prone to flooding and displacements due to extreme weather events.

1. Infrastructure development and reclamation activities take place rapidly in these cities as a response to the influx of the population from the nearby/peri urban areas.
2. The combination of various factors together like high tides combined with the heavy rainfall events add to the overall worrisome scenarios in such cities.

Further, with forest and grasslands in the region sharing about 40% of the land cover, such large green pockets help in balancing the climate of the region. With the city expanding at a faster pace and likely to observe more population, climatic variations in the region are expected to compound the issues already present. As seen in the following sections, the climate of the region is seen to be experiencing variations and is expected to have underlying impact on various facets of the city. Thus, integrating climatic variations with planning is crucial.

Essentially, MMR naturally houses some natural adaptation measures, which if preserved can make the region resilient. Features like holding ponds, mangroves, wetlands, salt pans and so on which are very much a part of the region, act as mitigation as well as adaptation entities, especially during the floods. They not just act as buffers, but are also a habitat to

[4]Planning for climate change, 2011, UN-Habitat.
[5] Global Report on Human Settlements: Cities and Climate Change, 2011, UN Habitat.

rich biodiversity, which requires preservation and conservation. Thus, as the UN report states[6], that if the urbanisation is required to be ushered in the city, then the transformation requires a sustainable and grounded approach to the use of an urban space. Further, for the cities, like Mumbai and the Metropolitan region, where there is a wide scope for development, a planned development or rather a 'prepared approach' can help safeguard the interests of the developers and planners, while aligning itself with the ideologies of sustainable development.

Table No. 4-1: Types of land uses and their share in MMR

Sr. No.	Type of Land Use	Total area (in sq. km)	Share in total area of MMR (in %)
1.	Total Area of MMR	4427	
2.	Total built-up area	619.2	14.5
3.	• Urban built-up area	580.8	13.1
4.	• Rural built-up area	61.7	1.3
5.	Agricultural land	1561.6	35.2
6.	Forest	908.8	20.5
7.	Wastelands	655.3	14.8
8.	Wetlands (manmade coastal wetlands such as holding ponds, natural such as mangroves, saltpans, creeks, mudflats, salt marsh, inter-tidal zones)	547.7	12.3
9.	Water bodies	106.4	2.4

Source: MRSAC, 2006

4.1.4.1 Role of ULB's in the planning process and functioning of the city

Urban Local Bodies contribute towards the overall functioning of the city. While the role of the state governments in mainstreaming climate resilient actions in planning processes is significant, the contribution of Urban Local Bodies in the formulation of context specific resilient measures also cannot be neglected. An integrated urban management approach is thus required to be formulated in consultation with these bodies and hence it becomes crucial to involve them in all the stages of any future planning exercise. In order to gauge the potential of the urban local bodies towards their preparedness to climate change, it is imperative to understand the current capabilities. Mapping of these institutions, in terms of the manpower, awareness, capacities, limitations and opportunities needs to be profoundly assessed to identify and further address these gaps.

Thus, urban local bodies can play a crucial role in mainstreaming the impacts of such sudden climatic catastrophes into planning and remain prepared for the same.

[6]State of the World's Cities, 2012/2013, UN Habitat.

4.1.4.2 Urban Heat Island (UHI) and MMR

Today the cities are practically losing out on green and open spaces. While the encroachment on the agricultural land is quite common in the peri urban areas of the urban agglomerations, there is an increasing threat to the overall green infrastructure in the cities today. In metropolitan areas like Mumbai Metropolitan Region, due to higher built-up density at the core of an urban area and absolute lack of open space and native vegetation, it results in higher temperature than the surrounding suburban/ rural area forming an island of heat and this phenomenon is known as Urban Heat Island Effect (UHIE).

While addressing the development in the cities, it becomes imperative to understand the indirect, adverse and intangible impacts laid by heat island effects (Figure No. 4-1).

In fast mushrooming areas like MMR, buildings essentially, are constructed with concrete which absorbs heat and emits the same back into atmosphere causing rise in the local temperatures. Whereas natural surfaces like vegetation and open ground soil absorb solar radiation and release water vapour through evapotranspiration process keeping the surroundings cooler than the developed hard surfaces. In such areas, where UHIE is predominant, the temperatures in the night soar few degrees more than normal and is usually higher than that of the areas surrounding the dense urban areas.

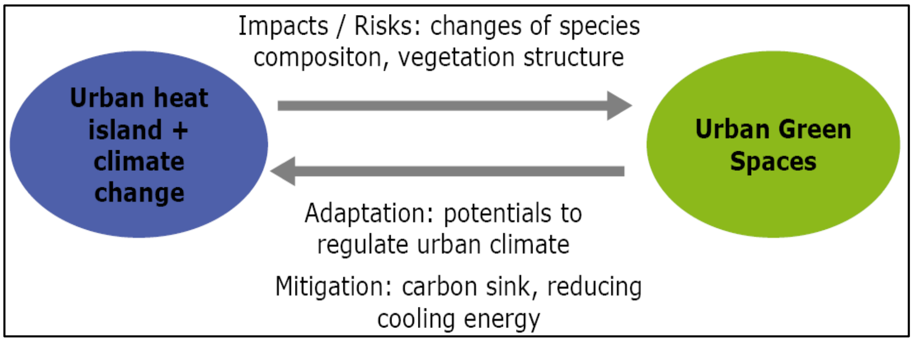

Figure No. 4-1: Linkages between UHIE, Climate Change and Open Spaces

Source: C. Dora, Research and services for healthy megacities in the 21st Century, World Health Organization[7]

Not just the density, but urban design and urban forms also influence the generation of UHI in cities. A study conducted by R. Giridharan et, al 2007[8] in Hong Kong using 4 weeks of field experiments deduced that, variables like surface albedo, altitude, vegetation above 1m in height, average height to floor area ratio, location quotient and proximity to sea are critical variables in mitigating as well as regulating both daytime and nocturnal UHI. Appropriate solutions may help mitigate the UHI impact if these variables are addressed at the concept design stage itself. Another research study by S.Ishii et; al. 2010[9], undertaken to analyse the capacity for implementation and impacts on energy savings and subsequent greenhouse gas (GHG) reduction potential of mitigation technologies such as photovoltaic cells (PV) and combined heat and power (CHP) technologies with respect to three potential urban forms (high density centralised, medium density averaged and low density de-

[7] http://www.wmo.int/pages/prog/arep/cas/documents/Presentation_Dora.pdf

[8] R.Giridharan, S.S.Y.Lau, S,Ganesan, B. Givoni, 2007, Urban design factors influencing heat island intensity in high-rise high-density environments of Hong Kong, Buildings and environment, Elsevier, vol 42, p 3669–3684

[9] Shoichi Tabushi, Toshiya Aramaki, Keisuke Hanaki. 2010, Impact of future urban form on the potential to reduce greenhouse gas emissions from residential, commercial and public buildings in Utsunomiya, Japan, Energy Policy, Volume 38, Issue 9, Pages 4888–489.

centralized) for Utsunomiya City, Japan, also revealed interesting findings on the UHI. It stated that given current building use patterns, scenarios for 2030 and 2050, medium density averaged form, which benefits from both PV and CHP technologies, appeared to outperform the other forms, resulting in an energy savings and GHG reduction potential of 27.6% in 2030 and 67.6% in 2050. Thus, urban planning with decentralised density zones manifests a clear solution to UHI problem.

Several other studies conducted for the Indian cities like Delhi revealed that the central parts of Delhi are found to be warmer by a maximum of 4–7 °C or even more, than the surrounding rural areas, thus confirming the formation of nocturnal urban heat island over Delhi[10]. Research also clearly indicates that the heat island effect could be significantly reduced with appropriate planning and designing of buildings in urban areas. One of the studies, conducted by R. Memon et; al 2007[11], concluded that the heat re-radiated by the urban structures plays the most important role which should be investigated in details to study urban heating especially the UHI. It was also concluded that the future research should be focused on design and planning parameters for reducing the effects of urban heat island and ultimately living in a better environment. Thus UHI is not just a problem created by hard paved surfaces and higher reflective surfaces but it's also a function of appropriate urban and regional planning. Integration of green design principles and solar passive planning principles in the concept design stage itself, can contribute significantly in mitigating the UHI in large and multidimensional metropolitan areas like MMR.

Box No. 3: Pollution and Climate Change in cities

While there is this dubious distinction between Air Pollution and Climate Change, it is also often believed that Air Pollution is one of the major contributors to climate change. To some extent, this may hold true, as though climate change is a global issue, amalgamation of these multiple local issues, ultimately contribute to the overall effect. In fact, air pollution and climate change influence each other through complex interactions in the atmosphere. When energy from the sun reaches the Earth, the planet absorbs some of this energy and radiates the rest back to space as heat. The Earth's surface and atmospheric temperature ranges depend on this balance between incoming and outgoing energy. Atmospheric greenhouse gases (GHGs) like carbon dioxide (CO2) and methane (CH4) can trap this energy and prevent the heat from escaping. This helps in maintaining optimum temperatures within the atmosphere.

On one hand, where increase in the levels of GHGs alter the energy balance between the atmosphere and the Earth's surface , other components such as sulfate and ozone, can also influence this energy balance. In addition to being the damage agent to the environment, it also takes a toll on human health. In the context of urban areas, many of our activities, especially transport and energy generation, contribute significantly to both local air pollution and global climate change. Furthermore, processes such as fossil fuel burning in industry, construction activities emit pollutants that cause local and regional pollution. These pollutants include particulate matter (PM) and ground-level ozone (O3), the key ingredients of smog nitrogen oxides (NOx), sulphur oxides (SOx), volatile organic compounds (VOCs) and carbon monoxide (CO). The same processes also release greenhouse gases, mainly carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O), which are linked to global climate change and hence it's imperative to consider how theses global to local linkages work . Fortunately since the sources of air pollution are common most of the time, the mitigation measures could be devised such that they can cater to these two issues simultaneously.

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[10] Puneeta Pandey, Dinesh Kumar, Amit Prakash, Jamson Masih 1, Manoj Singh, Surendra Kumar,Vinod Kumar Jain, Krishan Kumar, 2012, Science of the Total Environment, Elsevier,Vol 414 Pp, 494–507.

[11] Rizwan Ahmed Memon, DENNIS Y.C. Leung⁎, LIU Chunho, 2007, A review on the generation, determination and mitigation of Urban Heat Island, Journal of Environmental Sciences, Science direct, Vol 20 Pp120–128

4.1.5 Review of the existing Environmental Status reports

As a part of the study, Environmental Status Reports (ESRs) for the years2006-2012 for all the Municipal Corporations were reviewed. The ESRs have documented various issues where the emphasis has been laid more or disasters like landslides, floods, fire outbreaks and so on along with the mechanisms adopted by the corporations to manage them. However specific impacts pertaining to climatic parameters like rainfall, temperature, wind and humidity as well as correlation between these parameters is yet to be established. The context specific impact assessment and mitigation measures also require to be formulated.

Box No. 4: Climate Resilient Cities

MMR may consider developing a comprehensive plan towards becoming the Climate Resilient Region. In the context of Climate Change, rising vulnerabilities and risks, many cities have undertaken similar initiatives at various levels. For instance, Asian Cities Climate Change Resilience Network (ACCCRN), a nine-year initiative (2008-2017) supported by the Rockefeller Foundation ACCCRN has worked in ten cities in four Asian countries (India, Indonesia, Thailand and Vietnam) on developing and demonstrating effective processes and practices for addressing urban climate vulnerabilities, and the cities under consideration include Surat, Indore, Gorakhpur, Shimla, Bhubaneswar, Mysore, and Guwahati.

4.2 TERI's Climate Change project with Government of Maharashtra

In 2008, India's Prime Minister Dr. Manmohan Singh released the country's National Action Plan on Climate Change (NAPCC). Subsequently, the Government of Maharashtra appointed TERI (The Energy and Resources Institute) to carry out a comprehensive study **on "**Assessing Climate Change Vulnerability and Adaptation Strategies for Maharashtra" in March 2010.The study outputs would be subsequently used to formulate the Maharashtra State Adaptation Action Plan on Climate Change (MSAAPCC) as part of NAPCC. Climate projections were developed for three time slices viz; 2030, 2050 and 2070s and the study was conducted to gauge the changes in the climate with respect to the baseline.

Four priority areas were considered for further assessments which included the following, a) Hydrology & fresh water resources, (b) Agriculture & food systems, (c) Coastal areas marine ecosystem and biodiversity and (d) Livelihood (including migration and conflict). Additionally, there were some cross-cutting areas that were identified including issues related to human health, ecosystem and biodiversity, markets, and risk management. Based on the sector and cross-sectoral impact and vulnerability assessments and taking account of the regional diversity within the state, the study developed key recommendations for the selected sectors along with implementable adaptation measures. Following detailed consultative process with the key stakeholders and with the insights from the cross sectoral impact assessment, district level action plans have been drafted for 6 districts in the state. The inputs from these case studies shall be now used to draft the final State Action Plan on Climate Change. Other project details could be procured from TERI's official project website as given below;

http://www.ccmaharashtra.org/

4.3 Approach and Methodology

4.3.1 Objectives

- To study the changing trends of the climatic parameters like rainfall, temperature, humidity and wind speeds by undertaking the climatic trend analysis for the period of 42 years.
- To gauge the preparedness of the city towards the changing climate through consultations and literature review
- To undertake flood modelling and simulation exercise to assess the vulnerability of MMR to flooding, with reference to the 26th July 2005 flood event.
- To gauge the perceptions of agriculture and fishing communities within MMR, about the climatic variability and current capabilities.
- Undertake extensive consultations with the Urban Local Bodies within MMR to understand their preparedness.

4.3.2 Approach

Since, the Environmental Status reports formulated by the municipal corporations and councils do not comprise of any particular section focussing on climate change and its impacts, an integrated approach with a very specific and focused methodology was formulated to understand and represent the climatic status of the region. Hence, the methodology to assess these particular issues was developed in such a way that it would not just capture the past climatic trends over the region and simulate extreme events, but it would also take into consideration the preparedness of the Urban Local Bodies (ULB's) towards such an issue through detailed consultations (Figure No. 4-2).

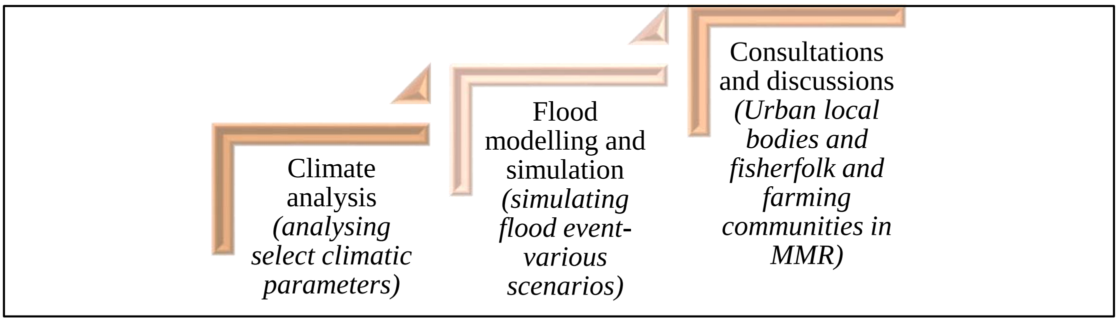


Figure No. 4-2: Approach used for the study.

The study further attempts to link the consultations with the climatic analysis while drawing conclusions about the status of the climate and preparedness of the region towards future climate anomalies if any. Thus the following research questions were used to capture the status.

Table No. 4-2: Methods and Research questions considered for the study

Research questions	Methods adopted
What linkages between climate change and urbanization does the global literature establish?	Literature review and personal interactions (research papers, reports, websites of government institutions, international protocols and so on.)
What has been the climatic trend over MMR in the past 42 years? Is there any significant change observed? How vulnerable is the region to heavy rainfall events like 26th July 2005 and what are the possible pockets, which can flood in such events?	Statistical methods (regression, anomaly plotting, trend analysis) Flood modelling (simulation of 26th July 2005 event)
What is the level of preparedness of the urban local bodies towards the change in trends if any?	Consultations and discussions (Urban local bodies, other government officials and communities)
What could be some of the most relevant and region specific recommendations for the region?	Data analysis (primary and secondary analysis)

4.3.3 Climatic parameters and trend analysis

Four climatic parameters were used for the assessment viz; Rainfall, Temperature, Humidity and Wind (Box No. 5).The trend analysis in the study analyses the "normal" climate of the region. A Normal is defined as the arithmetic average of a climate element (e.g. temperature) over a 30-year period. A 42year period/data was used for the analysis, as this period is considered long enough to smooth out year to year variations and is able to show longer climatic trends[12].MMR being a large region, it was necessary to select weather stations representing the region which can capture the variations uniformly and in a distributed manner. Thus, in consultation with the senior officials from India Meteorological Department (IMD), Mumbai and Pune office, and National Data Centre (NDC) Pune, following stations were selected for data procurement and analysis; Colaba, Santacruz, Alibaugh, Thane Belapur Industrial Belt, Bhira, Dahanu.

Box No. 5: Why these climatic parameters?

The climate system of any given region is complex. It is usually described in terms of the mean and variability of temperature, precipitation and wind over a period of time, ranging from months to millions of years. To get climatic overview from research perspective, records for above mentioned parameters for a set of 30 years is regarded adequate to arrive at logical conclusion (IPCC AR4, 2007). Hence for the present analysis, parameters like temperature (Maximum and Minimum), Rainfall (Average annual), Wind (speed) were considered. Since MMR forms a part of the coastal belt of the state, another component which governs the climate of the region is Humidity. Hence in addition to the above mentioned weather parameters, humidity was also included for assessments.

4.3.3.1 Cleaning of the data and data gaps

Cleaning of the data coupled with discussions with the IMD officials revealed that, the monitoring station at TBIB was defunct and hence has large data gaps. Further, data gaps

12 http://www.wmo.int/pages/themes/climate/climate_data_and_products.php

were also observed in Bhira station data. Some observations had severe discrepancies and some were not recorded. Hence it was decided to omit the data from Bhira as well as TBIB stations to avoid gaps in the result. The data from the remaining four stations was considered. The methodology used to analyse trend for each parameter, is detailed in the following sections.

4.3.3.2 Consultations

For the detailed consultation exercise, all the Municipal Corporations and 3 Municipal Councils in MMR were approached. Since there is no specific department that deals with the climate change impacts, the most relevant departments for the study were identified. Deputy Municipal Commissioners (DMCs), the Disaster Management Cells of respective Municipal corporations were approached for interactions and detailed personal consultations. The DMCs of the cell were also requested to involve other concerned officials from other departments. The details of the consultations including the minutes and photographs are discussed in the Annex 13, 14 and 15.

Apart from the consultation with the government officials, 2 community consultations with the Agriculture communities in Thane whereas, fishing communities in Uran were also undertaken to involve the local level perspectives in the analysis to understand the climatic variations and the consequent impacts experienced by the communities.

4.3.3.3 Flood modelling and Simulations

The model attempts to identify areas in MMR which are prone to flooding when exposed to heavy rainfall events. The model used for the simulation exercise is Mike 21.It **simulates unsteady two dimensional flows** in one layer (vertically homogeneous) fluids and has been applied in a large number of studies[13]. The model is based on the very **basic mass balance equation and conservation of momentum equation**. These two equations together, describe the flow and water level variations. Following stages were adopted to undertake these simulations,

- **Step 1**. Creation of DEM (digital elevation model) Land use map in ArcGIS by using satellite imagery (Source: Earthexplorer.usgs.gov)
- **Step 2.** Creation of Bathymetry and bed roughness map according to the land use in MIKE modelling software
- **Step 3.**Creation of Time series and profile series data for Rainfall and Tidal Variation respectively as an input for boundary conditions
- **Step 4.**Calibration of the model with all other hydrological and hydrodynamic parameters (i.e. viscosity, evaporation rate, wind condition etc.)
- **Step 5.**Creation of Flood risk map with flood level as a model result for different rainfall Intensities, durations and volume to see which areas in MMR are prone for flood in exposure to such kind of rainfall
- **Step 6.**Validation of the modelled flood map by accuracy analysis from the observed flood points in MMR according to Disaster management report.

[13] http://www.mikebydhi.com/products/mike-11/hydrology

4.4 Analysis and interpretations

Impacts of climate change are differential in nature. Various entities, natural as well as manmade resources, are predicted to be affected from the impacts of climate change. While these impacts are too deviant to be quantified at this stage, a quick assessment of these impacts on various sectors/resources could be gauged. Following table below gives an overview and intensity of such impacts especially in the context of coastal region likes MMR.

Table No. 4-3: Climate change impacts (overall)

Climatic parameters	Water			Biodiversity	Coastal areas	Forest	Agriculture		Health
	Surface water	Ground water	Rivers &lakes				Urban	Peri Urban	
Rainfall (variations)	High	Low	High	Medium	High	High	Low	Medium	Medium
Temperature (variations)	High	Medium	High	Medium	Low	Low	Low	Low	Medium
Humidity (variations)	Low	Low	Low	Medium	Medium	Low	Medium	Medium	Medium
Sea level rise (Increase)	Medium	Medium	Medium	Medium	High	Medium	Low	Medium	Low

Climatic parameters	Infrastructure	Transport	Settlements		Solid waste	Communities		Energy consumption
			Formal	Informal		Agrarian	Fishers	
Rainfall (variations)	High	High	Low	High	Low	High	Medium	Low
Temperature (variations)	Medium	Low	Medium	High	Low	Medium	Low	High
Humidity (variations)	Medium	Low	Low	Low	Low	Medium	Low	Medium
Sea level rise (Increase)	Medium	Medium	High	High	Low	High	High	Low

High	Medium	Low

4.4.1 Rainfall

4.4.1.1 Drivers and Pressures

Global atmospheric changes have recently been the most debated phenomenon. Changes in local rainfall patterns are one of the many such impacts. While there have been evidences of these variations, concrete quantifications in terms of precise changes are still areas of research. Changes in the average rainfall documented in the literature may not be enough to sound conclusive, and would require a further research looking at the distribution of the rainfall patterns to understand it better.

Changes in the local rainfall patterns could be attributed to the global changes like several central El Niño events in the Pacific Ocean (warmer-than-normal sea surface temperatures, commencing during summer), increase in the earth's atmospheric temperatures and so on. Local factors which contribute to the local climatic variations, could be Land use and land cover changes leading to deforestation, increase in the number of pockets of heat islands affecting the spatial distribution of the rainfall over the region and so on. Thus it's crucial to assess the possible reasons which drive such changes locally, by drawing cues from the global climatic studies. Also for effective planning, these global changes required to be downscaled to local context while drafting context specific strategies.

4.4.1.2 Status

In order to assess the status of the rainfall patterns over the region, a comparative assessment was carried out to analyse the changes in the different categories of rainy days across the decades in MMR for the period 1971- 2012.

Table No. 4-4: Changes observed in various categories of Rainfall

Decade	1971-80	1981-90	1991-2000	2001-10	Increase or decrease in the number of rainy days between 1971-80 and 2001-10 (in %)
Total no. of rainy days (more than 0 mm per day)	1008	1048	1002	1022	1.3
Very Light Rainy Days (0.1 – 2.4 mm per day)	307	323	289	285	-7.7
Light Rainy Days (2.5 – 7.5 mm per day)	228	226	236	214	-6.5
Moderate Rainy Days (7.6 – 35.5 mm per day)	313	315	307	328	4.5
Rather Heavy Rainy Days (35.6 – 64.4 mm per day)	83	89	82	96	13.5
Heavy Rainy Days (64.5 – 124.4 mm per day)	55	67	63	72	23.6
Very Heavy Rainy Days (124.5 – 244.4 mm per day)	19	24	23	26	26.9

Extremely Heavy Rainy Days (> 244.5 mm per day)	**3**	**3**	**3**	**3**	**0**

Source: IMD, Terminologies and Glossary[14]

As seen in (Table No. 4-4), it has been observed that, in the last decade, total number of rainy days has increased minimally by 1.3 %.However, number of very heavy rainy days increased from 19 in number in the decade of 1971- 80 to 26 in the decade of 2001-10. This indicates an increase of 27% in the occurrence of very heavy rainy days. Similarly, there is an increase observed in the moderate, rather heavy, heavy, very heavy categories of rainy days; while a decrease is observed in the very light and light rainy days as compared to the earlier decades. The number of extremely heavy rainy days has remained unchanged over the four decades.

Once it was evident that number of rainy days has not increased significantly over the past four decades, analysis was carried out to investigate any shift in the onset of monsoon. For MMR, the onset of monsoon, 10 June, has been considered as per IMD standards specified for the region (Figure No. 4-3) [15]and there has not been any significant change in the onset of monsoon in the region for past 42 years.

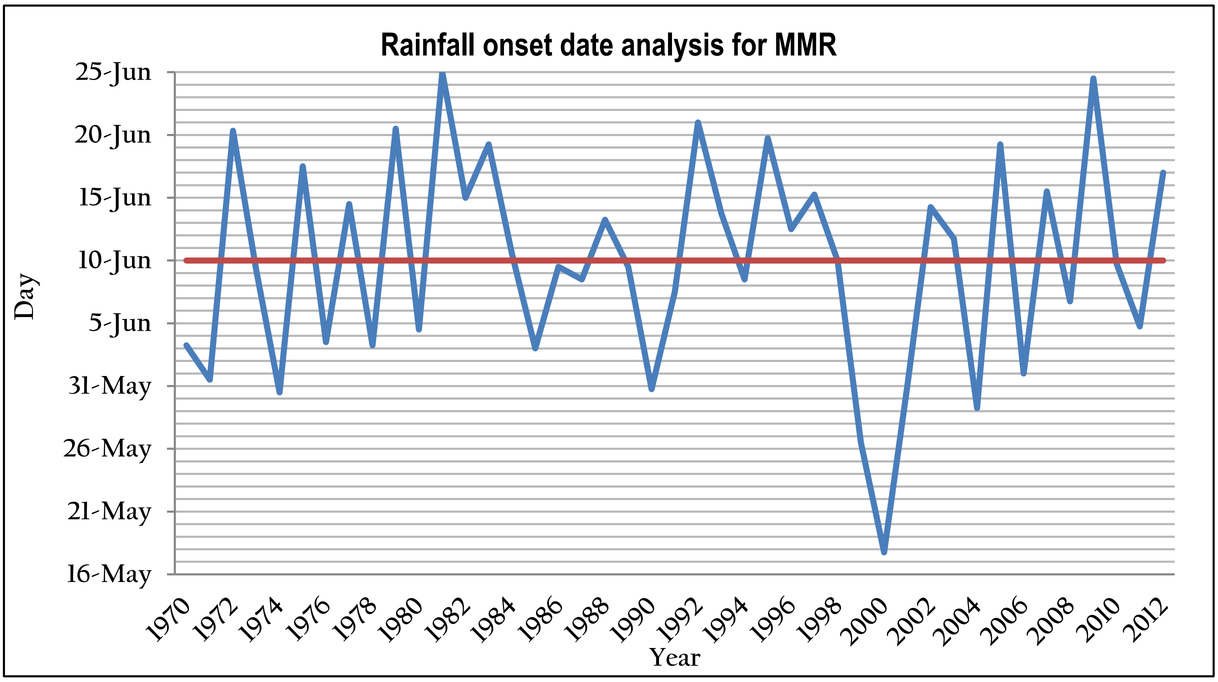


Figure No. 4-3: Rainfall onset date analysis for MMR

In order to assess the rainfall trends over the region for the period 1970-2012, the annual and seasonal rainfall data sets were compared with the respective long term averages, defined for the region[16].The station wise data sets and the long term averages were averaged to arrive at a value for the entire region, against which the anomaly was plotted. The positive and the negative deviants were analysed to capture the variations in the rainfall patterns.

[14] Based on terminologies and glossary provided by IMD. The document can be accessed from http://www.imd.gov.in/doc/termglossary.pdf. Last accessed on 26 November 2013

[15] http://www.imdmumbai.gov.in/scripts/detail.asp?releaseId=E0000SW1

[16] The long term averages are defined for 30 years by IMD. These values are extracted from Climatological Normals (1960-1991) published by IMD and are station wise.

Rainfall against the corresponding years has been plotted in the following graphs, where the annual averages have been compared with the long term averages of that particular station. (Figure No. 4-5) below, shows the annual rainfall anomaly over the region (monsoon season) for the past 42 years. Similar methodology was used to understand the rainfall variations in monsoon.

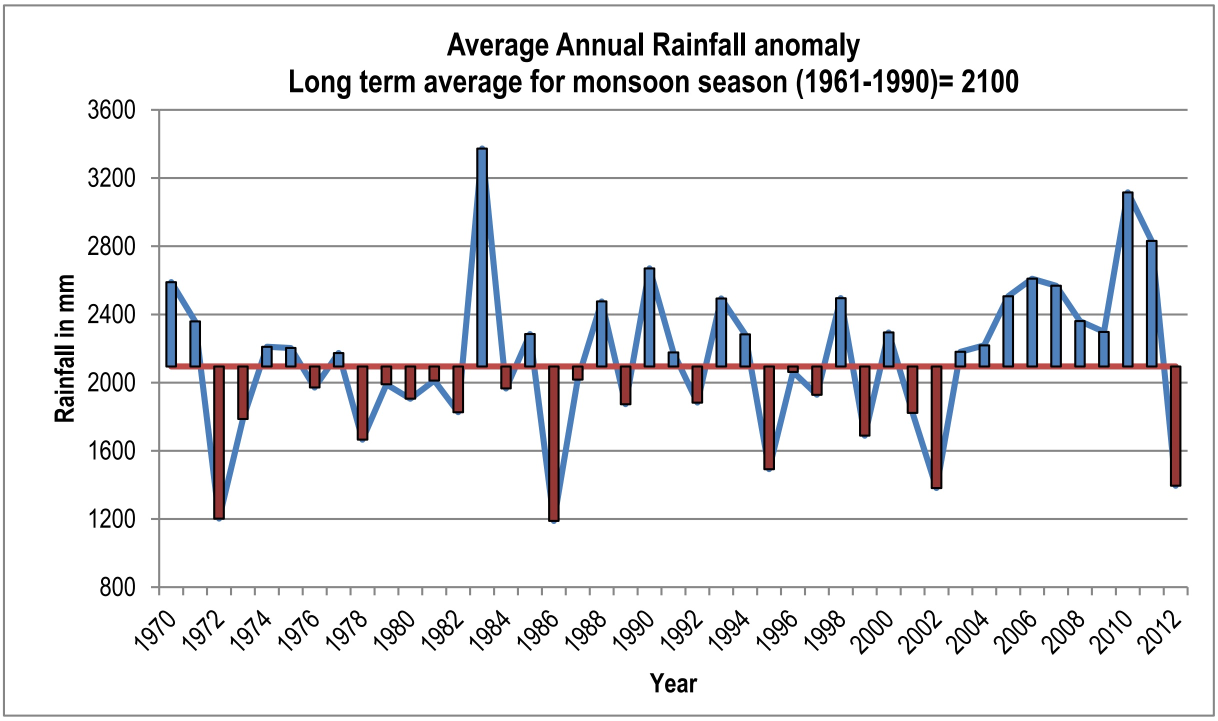


Figure No. 4-4: Average Annual Rainfall anomaly

Annual mean anomaly over the rainfall region is represented in the (Figure No. 4-3). It is observed that the rainfall over the region has been varying between +/-150-400mm from the long term average (Figure No. 4-4). However, the rainfall from 2003 has been consistently above the long term average except for the year 2012, which was also declared as a 'drought year' by the state government. Another observation that needs to be highlighted is, though the year 2005 experienced an extreme event, on 26 July with 944 mm rainfall in one day, the total rainfall does not show large deviation from long term average. Thus mere analysis of long term average of rainfall does not capture any abnormal or extreme rainfall.

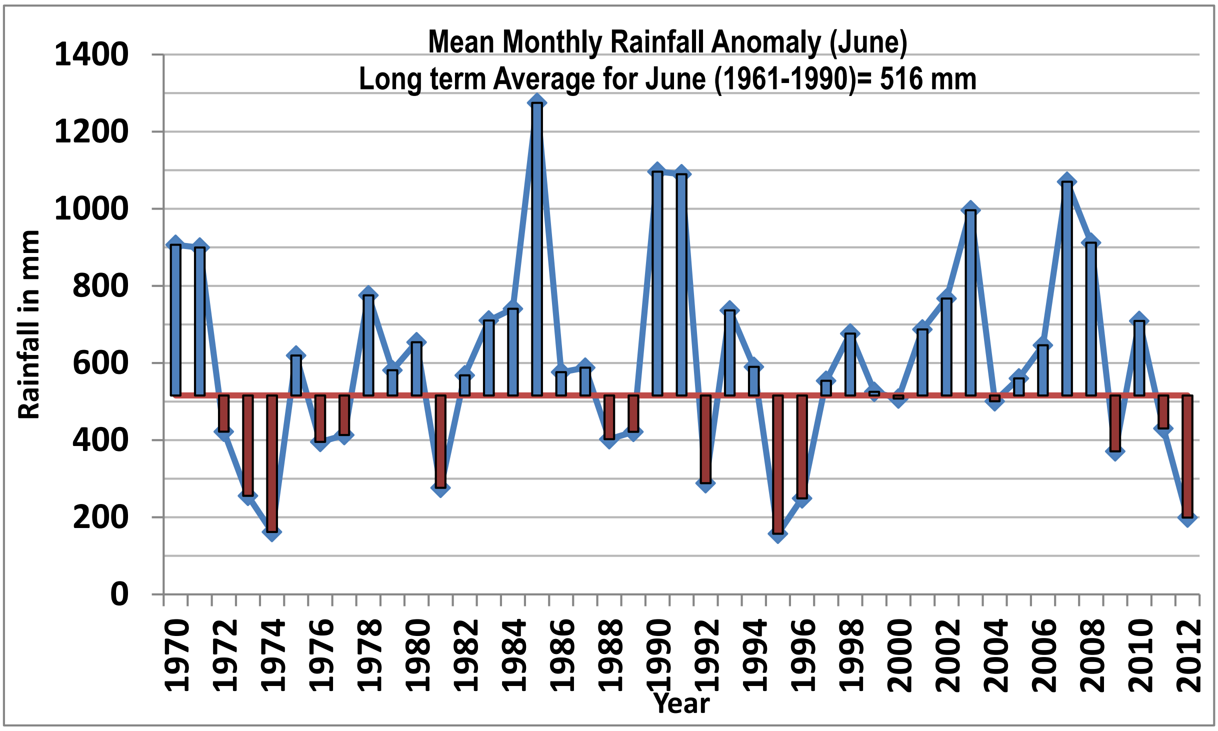


Figure No. 4-5: Mean Monthly Rainfall Anomaly (June)

The region receives less rainfall in the month of June than in the month of July. There has been large deviation of the monthly mean from the long term average (Figure No. 4-5).In the period 1997-2008, the June rainfall is seen to be above the long term average for a longer duration of time. Thus the June rainfall fluctuates within the range of **+/- 200-300 mm.**

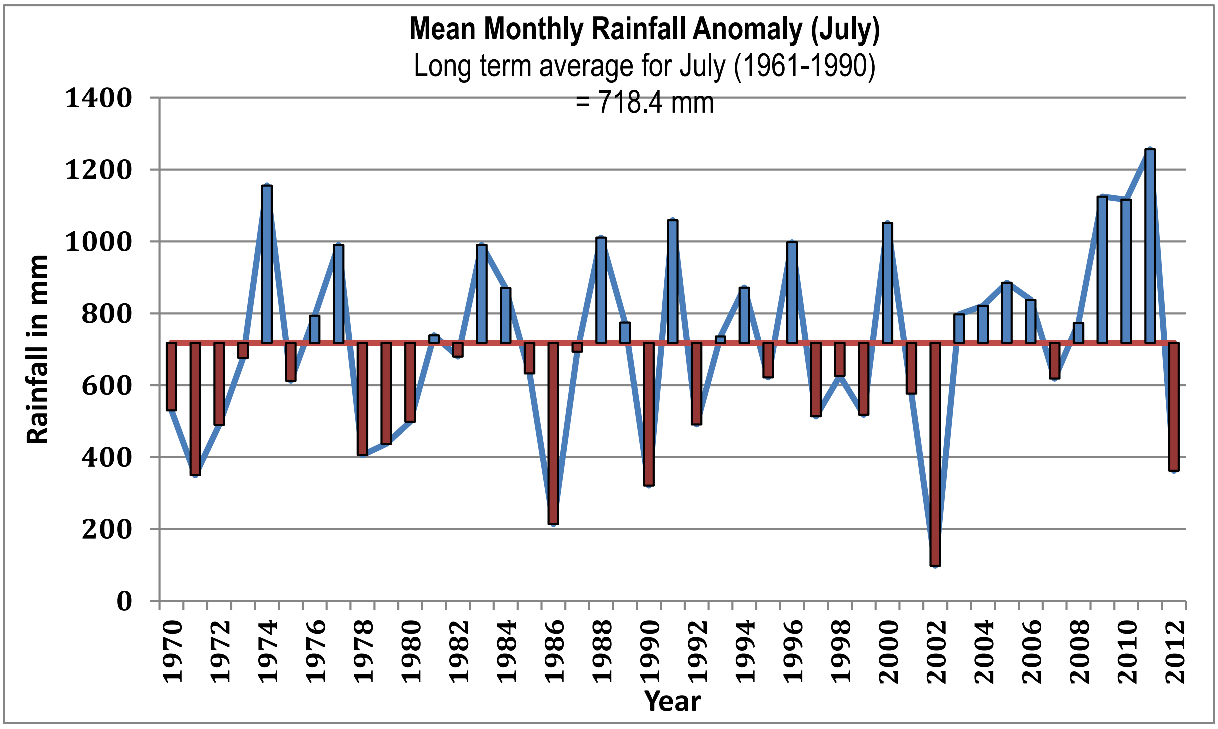


Figure No. 4-6: Mean Monthly Rainfall Anomaly (July)

Similarly for the month of July, the rainfall is seen to be consistently above the long term average in two periods viz; 1988-1998 and 2003-2012. Aligning the results with the global literature on climatic variations and changing rainfall patterns, it could be well received that recently there have been variations in the rainfall patterns, though no significant trend could be established. The variations are observed to be within the range on +/- 200-400 mm (Figure No. 4-6). It needs to be highlighted that the year 2005 is not the highest rainfall year. Rather, in the year 1991, the region received highest rainfall of 1734 mm.

The rainfall in the month of August is also seen to be exceeding the long term average on most of the occasions, however, the period from 2000-2008 has consistently experienced rainfall above the long term average (Figure No. 4-7) Out of the 42 years, only in 13 years, the rainfall is below the long term average. Though there have been some years of peak rainfall, most of the events are seen to be fluctuation within the range of +/- 200-400 mm.

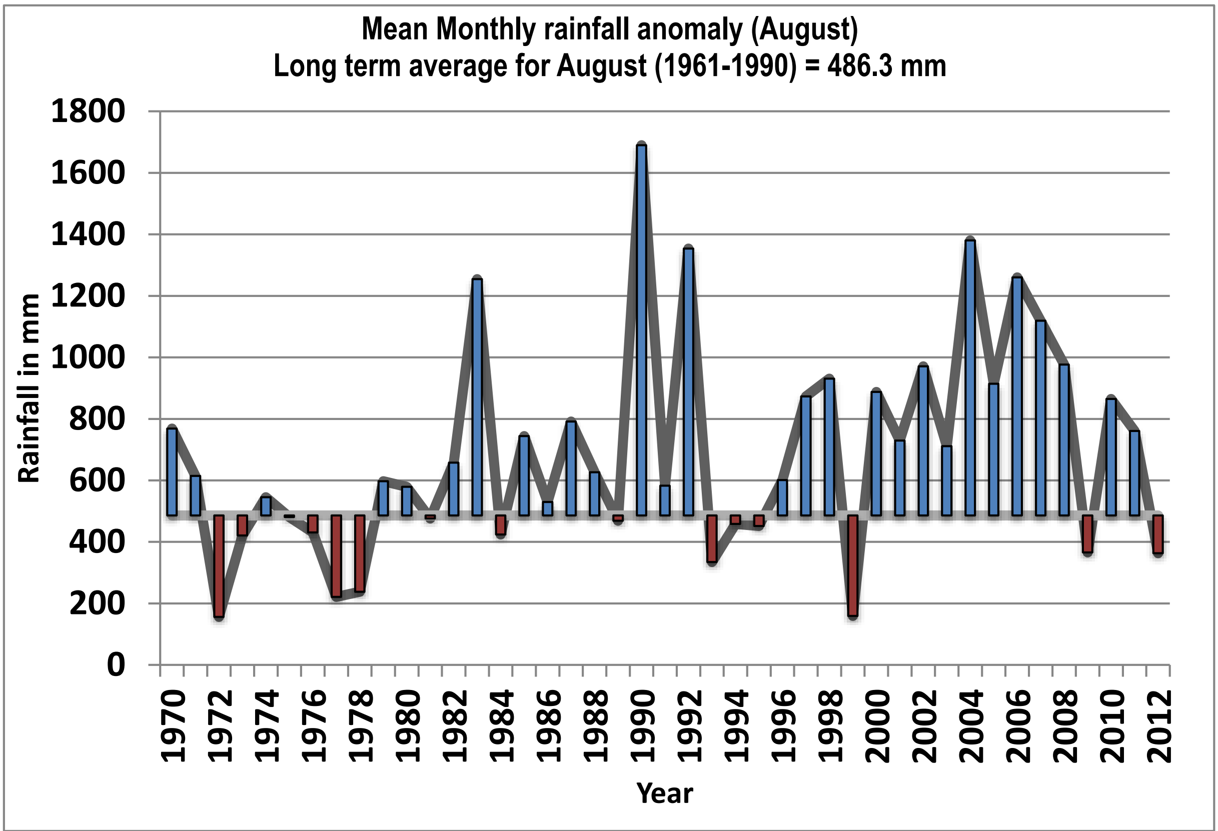


Figure No. 4-7: Mean Monthly rainfall anomaly (August)

The average rainfall in September is the lowest in the monsoon season. However, in this period from 1972- 2012, it is seen to be fluctuating between **+/- 200- 300 mm**, which is well within the normal variations generally experienced by the region (Figure No. 4-8).

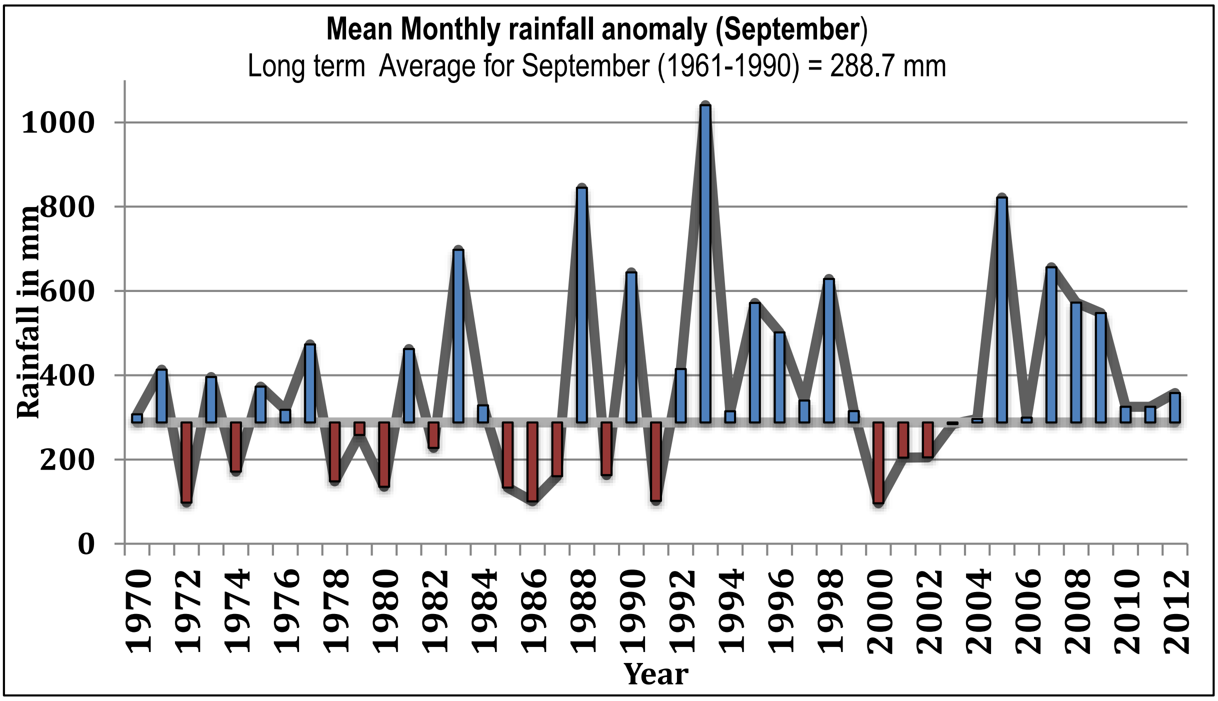


Figure No. 4-8: Mean Monthly rainfall anomaly (September)

The month of October is characterised by the retreating monsoon with 51.2 mm of long term average rainfall (1961-1990). But overall, there are large deviations above the long term average rainfall in the last 42 years, as seen in (Figure No.4-9) though there are incidences of negative anomalies, the positive anomalies exceed the frequency as well as the quantity vis-a-vis the negative anomaly incidences. A further research comparing the annual total rainfall versus its distribution in the respective months might help understand the changing rainfall patterns over the region.

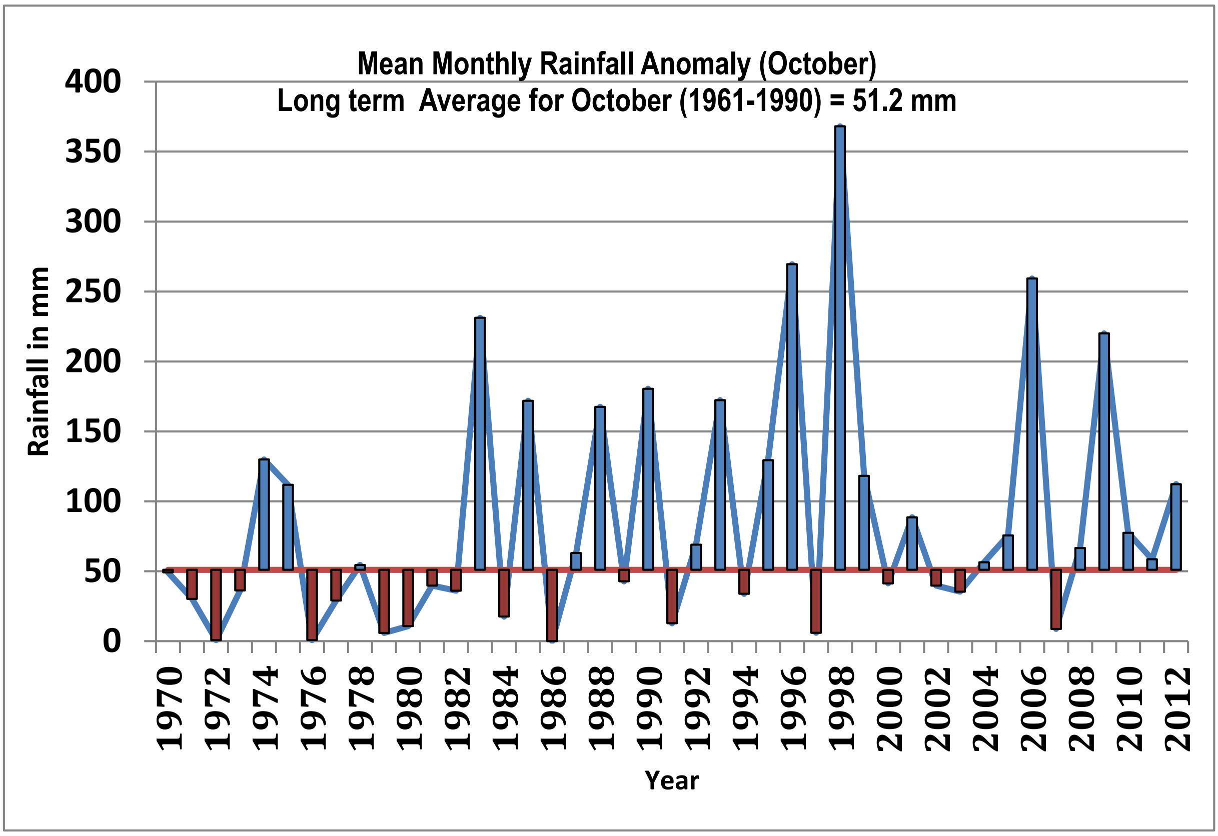


Figure No.4-9: Mean Monthly Rainfall Anomaly (October)

Hence it can be inferred that there is no significant change in the total amount of rainfall over the last four decades. As pointed out earlier in the description for the average annual rainfall and July rainfall, that high intensity rainfall events do not necessarily contribute towards the total rainfall to be the highest in a particular period. And similarly, highest rainfall years do not necessarily include high intensity rainfall events.

4.4.2 Water logging assessment

The hydro geological assessment of the region indicates that the entire district is underlain by Deccan trap basaltic lava of upper Cretaceous to lower Eocene age. The shallow Alluvium formation of recent age also occurs as narrow stretch along the major river flowing in the area[17]. There is a very less tendency for the water to get stagnated in the ground due to highly permeable nature of aquifers. The current water logging is mainly due to concretization of the surface owing to urbanization. Furthermore, as the 7 islands are joined by reclaiming the low lying areas, flood prone zones need to be addressed with due attention.

4.4.2.1 Drivers and pressures

Traditionally, rainfall has always been very high in the region. As it may be discussed in Volume 1 also, Mumbai is an amalgamation of 7 islands. The areas where these islands have been merged together are low in elevation and often face water logging, despite storm water drainage coverage. It may be noted that 'water logging' being an urban phenomena, it needs to be clearly distinguished from 'Flood'. A flood is generally defined as an excess of water (or mud) on land that's normally dry and is a situation wherein the inundation is caused by high flow, or overflow of water in an established watercourse, such as river, stream, or drainage ditch; or ponding of water at or near the point where the rain fell[18]. This is a duration type event. A flood can strike anywhere without warning and occurs when a large volume of rain falls within a short time. However, flooding can occur due to many factors such as, Climatological, Geomorphological, Failure of Dams and various other anthropogenic impacts.

4.4.2.2 Status

In order to assess what is the impact on the city when the rainfall is coupled with the high tide level, a quick assessment was undertaken as part of the study, where the highest annual rainfall event was considered along with the high tide level on that day. To understand the impact, the published newspaper articles from Times of India[19] for the respective dates were analysed to gauge the level of impact recorded following such event (Table No. 4-5). It was thus observed that the city experienced disruption especially when the rainfall was coupled with high tide time and that too during the peak traffic hours. Also, incidences, where water was not drained out within the next tide time, the low lying areas continued to remain water logged for a longer duration of time. Delays in the local train timings, public transport throwing city out of gear, water logging in subways and so on were some of the highlights reported.

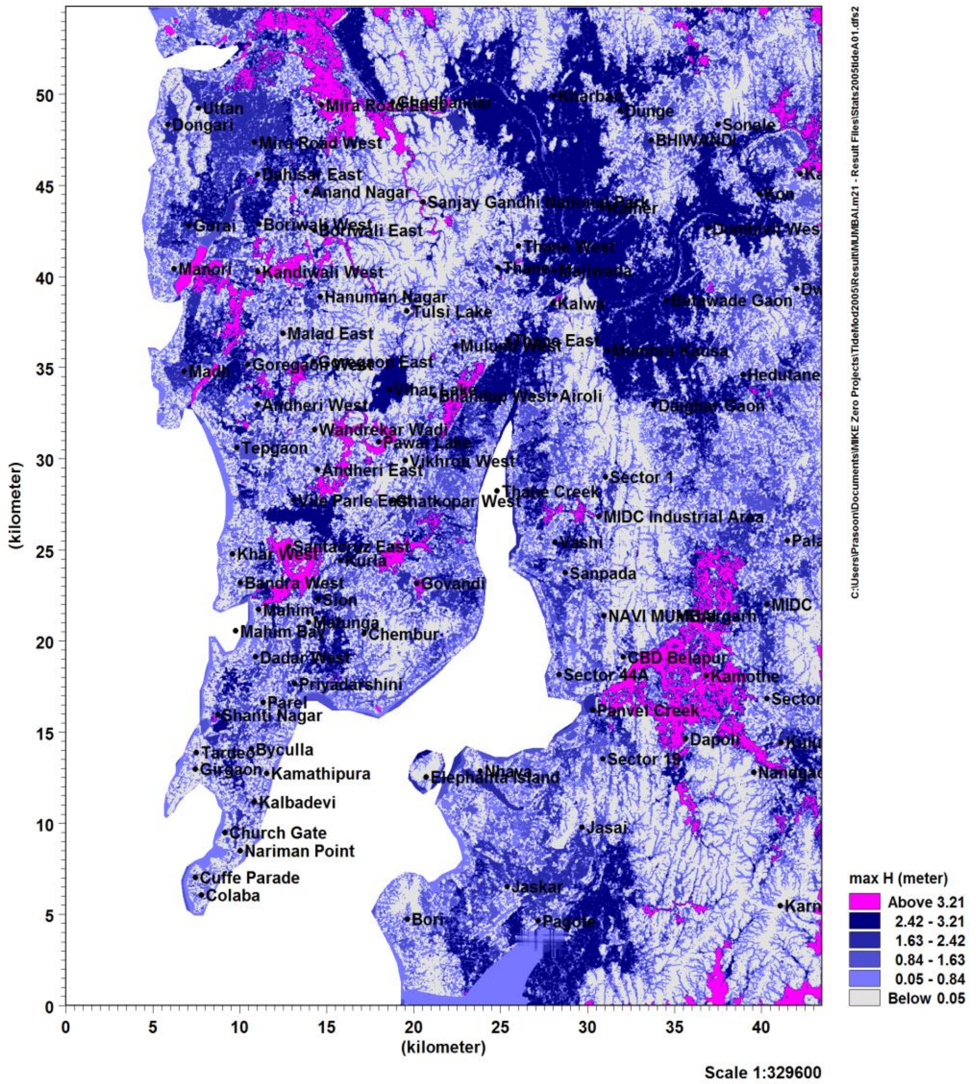
[17] http://cgwb.gov.in/District_Profile/Maharashtra/Greater%20Mumbai.pdf
[18] http://nidm.gov.in/idmc/Proceedings/Flood/B2%20-%2036.pdf
[19] http://timesofindia.indiatimes.com/city/mumbai

Table No. 4-5: Impacts of heavy rainfall and high tide levels

Year	Highest rainfall in mm	Date of highest rainfall	Station	High tide level (m)	Time of high tide	Post Event Headlines in Media
2005	944.2	7/27/2005	Santacruz, Mumbai	3.7	4:13 AM	Rains wreak havoc in Mumbai; 150 killed in Konkan.
				4.1	4:16 PM	
2006	231	7/5/2006	Santacruz, Mumbai	3.1	7:05 AM	Heavy rains lash Mumbai, schools remain close Rain causes havoc in Mumbai, 24 killed
				3.4	6:15 PM	
2008	249.7	7/28/2008	Colaba, Mumbai	3.7	8:17 AM	Wet weekend spells good news for lake levels Waterlogging, during the high tide in the afternoon, was reported.
				3.4	7:24 PM	
2009	439.1	7/16/2009	Dahanu, Thane	3.4	5:51 AM	Heavy rains lashed the city
				3.6	5:20 PM	
2010	236	6/24/2010	Dahanu, Thane	4.2	10:56 AM	The city also witnessed waterlogging and wall collapses in several areas following the downpour
				3.5	10:22 PM	
2011	232.6	8/29/2011 (New Moon)	Santacruz, Mumbai	4.7	11:58 AM	Mumbai weather: Incessant rainfall leaves city in deep water

In addition to this assessment, a flood modelling exercise was undertaken to assess the flood prone areas in the MMR region and their vulnerability towards heavy rainfall event. The 26th July 2005 event was considered for simulation (Map No. 4-1). Thus, the model helped understand the vulnerability of various areas in the region towards heavy rainfall incidences. The model has been used in various studies (S. Patro et al. 2009[20], I.R.Warren et al. 1992[21], H. Madsen et al, 2010[22].) and was also validated by accuracy analysis from the observed flood points in MMR according to Disaster Management Report. Recently, the region experienced considerably heavy rainfall in the year 2013. Thus, 15 minute interval rainfall data for the month of June- 2013 was also procured and is used in the model to understand the vulnerability of the region towards similar flooding event (Map No. 4-2).

[20] http://link.springer.com/article/10.1007/s12524-009-0002-1
[21] http://www.sciencedirect.com/science/article/pii/026698389290006P
[22] http://onlinelibrary.wiley.com/doi/10.1029/96WR03848/abstract;jsessionid=5C476C40E51803E4E767B35B32C2AB24.f02t02



Map No. 4-1: Water Depth Map 2005 with tide variation and drainage

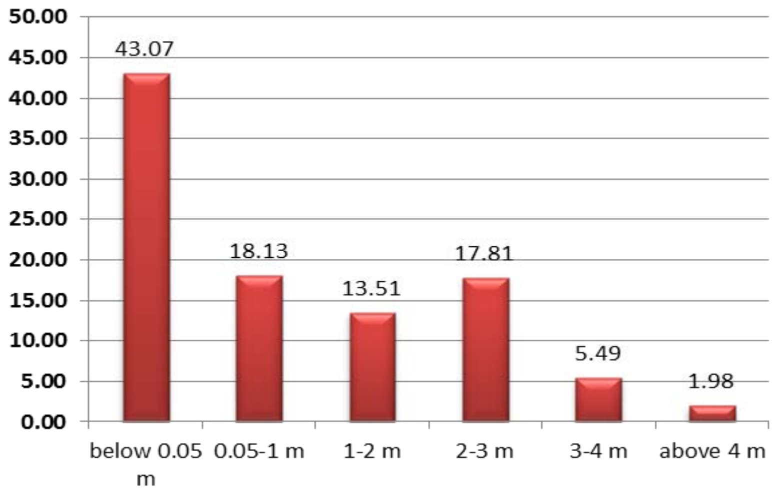
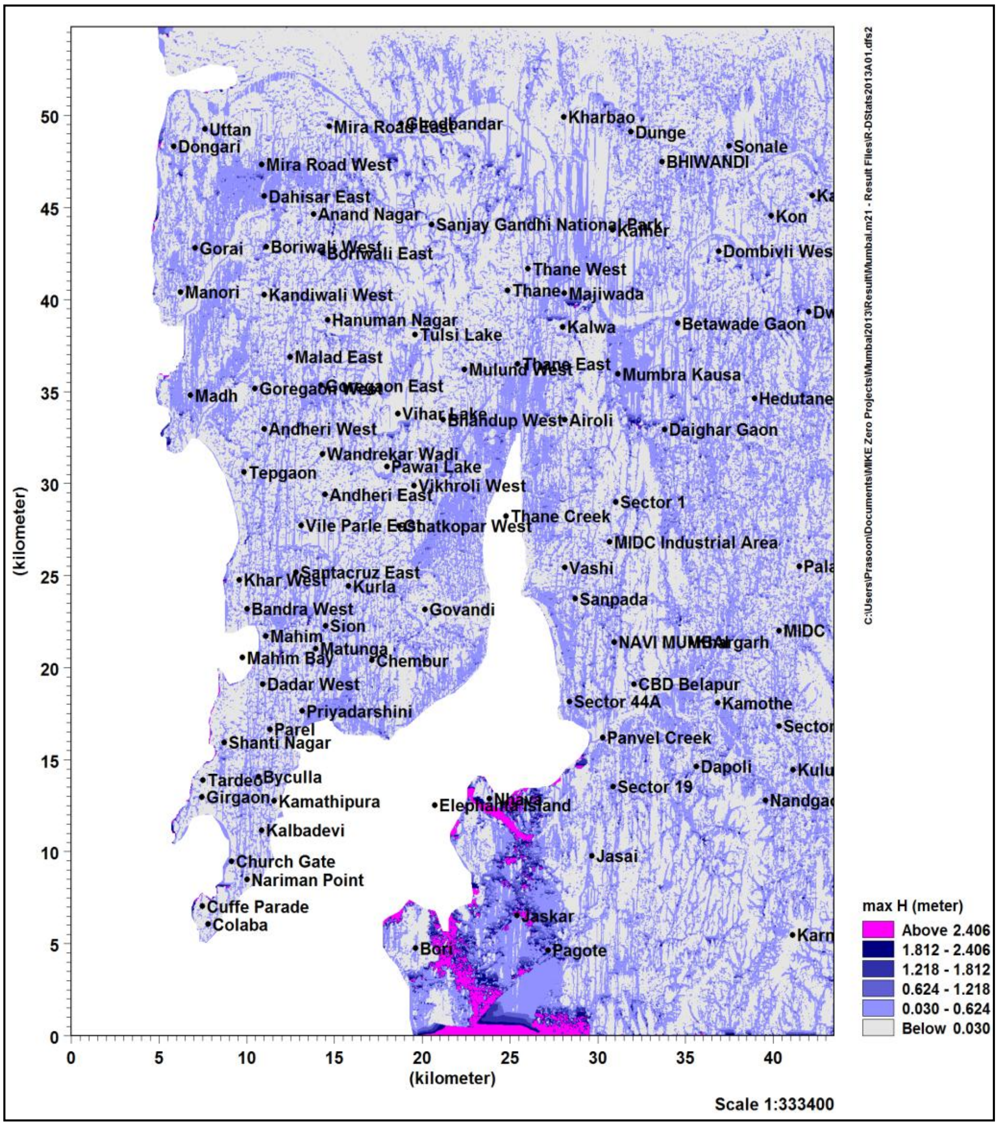


Figure No. 4-10: Percentage of area under floods

Source: TERI



Map No. 4-2: Water Depth Map 2013 with tide variation and drainage

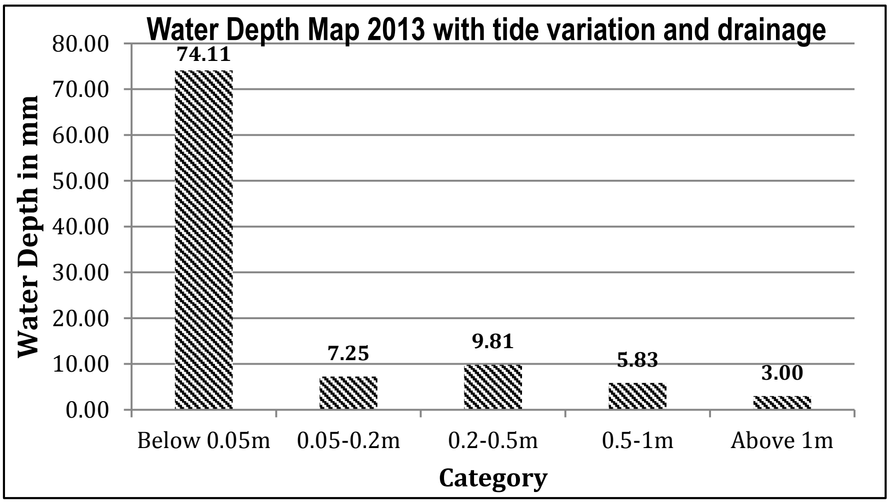


Figure No. 4-11: Water Depth Map 2013 with tide variation and drainage

The capacity of the storm water drainage network was as per the Brihan Mumbai Storm Water Drainage (BRIMSTOWAD) report, prepared in 1993, which was designed for 25mm per hour.

However the downpour which occurred on 26th July had an intensity of 125mm/hr, for 6-8 hours which was substantially beyond the capacities of the then existing drainage networks. This means that flooding was inevitable. Following this, the capacities of the drainage systems have been upgraded to 50mm/hr under the same program.

Presently, the rehabilitation of almost 20% storm water drain has been accomplished

From the assessment, it was observed that the region experienced major flooding on the 26th July heavy rainfall event, where almost 20% of the region was under 0.05-1m water depth, whereas around 5.49% of area was inundated with a water depth between 3-4 m, which also comprised of the area proposed for the new Airport for the city. Though, the areas under low water depth account to almost 50% of the region, it may not be appropriate to conclude that most of the city is safe from water logging or flooding, as some of the major areas of the city are seen to be falling under major flooding category (3-4m) though the percentage coverage of these areas is less (Map No. 4-2).

26th July event was a rare extreme event, for which the city infrastructure systems may not be prepared. Following the event, Government of Maharashtra appointed a Fact Finding Committee on 19th August 2005 to assess, improvise and further implement the upgrading of the existing systems to make the city more resilient towards such events.

Further, apart from the extreme event, the study also attempts to analyse how the city behaves in a normal rainfall event. The recent June 2013 rainfall data (66 mm for June 2013 with 15 minute time series rainfall data) procured from IMD was used to simulate the results. It was observed that most of the region experienced inundation due to water logging up to 0.05 m depth which was normal. Whereas almost 10% of the region experienced water logging up to 0.05-0.2m water depth. As also seen in (Figure No. 4-11), southern areas of the region faced major water logging. Thus, it could be well deduced that most of the city is rain ready for this quantity of rainfall, whereas in the areas of major flooding, further assessments and improvements in the existing infrastructure could contribute towards reducing the vulnerability of these areas.

4.4.2.3 Impacts

As discussed before, climate of the earth system or any given region always experienced variations. But with the global atmospheric changes driving the earth's climate towards warming, there are predicted changes over and above these already existing variations, defining a new graph of variation for the region. Such variations, can lay differential impact of various urban and peri urban sectors. (Table No. 4-5) describes various impacts of such changes on the system and why it becomes essential to integrate such studies into regional planning processes.

Table No. 4-6: Possible impacts of rainfall variations on different sectors

Areas of impact due to Rainfall variations	Impacts
Infrastructure & transport	Variations may lead to water logging in low lying areas of the region. Building infrastructure may face issues like increased leakages; develop cracks owing to more splash of rain on the building façade. Storm water drainage networks, would require more capacities, so as to with stand the variations (especially during positive variations/increase in rainfall). Key transport infrastructure including roads and rails may get affected owing to uneven distribution of rainfall. Irregularity in the distribution of the rainfall may result in excess downpour on certain days, causing damages to the road infrastructure which would further disrupt the transport services in the city.
Agriculture	MMR consists of 35% of Agriculture areas, where mainly rice, vegetables such as leafy vegetables, brinjal , cabbage; fruits such as mango, papaya and flowers such as marigold, roses and so on are grown. At present approximately 104.8 thousand tonnes of area is just under paddy cultivation. Variations in rainfall patterns may directly affect the paddy cultivation. Changes in the time and distribution of rains can disturb the agriculture calendars resulting in crop damages and losses. Further, excess flooding in fields may damage sensitive fruit crops. Untimely rainfall patterns may compel the farmers to sell their land and shift more towards alternative and profit making professions. This may result in migration and pressure in urban pockets in the region
Health	Vector borne diseases are most sensitive to the changes in the climatic fluctuations[23]. Changes in the distribution of rainfall across the monsoon months may result in the increasing the vulnerabilities od the region towards such diseases. As against increase, decrease in rainfall may also lay impacts on the water availability is expected to have a cascading effect on the food production and consequently on the food security and nutritional status of the region.

4.4.2.4 Responses

In the background of the water logging in the region, both the state level as well as the urban level authorities has undertaken several measures to reduce the impact of rainfall variations on the city. Brihan Mumbai Storm Water and Drainage Report (BRIMDTOSWAD) drafted in 1993 directed the design and the capacity of the storm water drainage network, which can handle 25mm/hr down pour. However, recently the capacity of the drains has been revised and the new capacities of the network would be designed to sustain 50mm/hr rainfall as against the earlier capacities of 25mm. Further to this, after the flood event in 2005, Government of India enacted the Disaster Management Act which envisaged the creation of National Disaster Management Authority (NDMA) headed by the Prime Minister of India, whereas State Disaster Management Authority (SDMA) headed by the respective Chief Ministers of the State. This initiative spearheaded the drafting of the Disaster Management

[23] http://www.who.int/globalchange/publications/climatechangechap6.pdf

Plans, both at the state level as well as the district level, to confront, manage and mitigate the impact of Natural Disasters which may occur in the future.

Some of the Urban Local Bodies like the corporations and some of the councils also have drafted their Disaster Management Plans (DMPs), which details out the standard operating procedures and the emergency measures to be followed during any natural disaster. Thus, the response towards the disaster mitigation have been drafted by the authorities, but a deeper research pertaining to the implementation of these measures, identifying the gaps, and establishment of a Standard Operating Procedure (SOP) can help great deal.

Specific Recommendation

Research

1. To undertake a **detailed spatial study for assessing the vulnerability and resilience** of the region to flooding and heavy rainfall.
    a. Multi criteria assessment including parameters like tides, elevation, location geography, population and population density and so on could be undertaken to analyse compounded impacts on the region along with the correlation with flooding events occurred. Vulnerable hot spots could be identified in the region and a very context specific resilience plan could be drafted integrating the disaster management plans.

Policy

1. To internalise a **constant monitoring of the status of the rivers and lakes** especially with respect to siltation, as a regular procedure by the district as well as state authorities.
    a. There are many wetlands (like mangroves, salt pans, water bodies and so on), small rivers and their catchment areas are highly sensitive to siltation and damage by many anthropogenic activities like upstream deforestation and so on. A regular monitoring of such areas in terms of their status can help take timely actions to further safeguard them and help maintain the ecological flow.
2. To draft and circulate a detailed **Standard Operating Procedure (SOP)** to all the local bodies for better implementation of the Disaster Plans coupled with Standard Maintenance Procedure as well.
    a. Presently there is no specific guideline which the disaster management staff follows during the natural calamity. A detailed SOP can help the management to smoothen the functioning of the operation during all types of disasters.
3. To mitigate the issue of urban flooding**, pervious surfaces in the new developments should be made mandatory.**
    a. Paver block, grass joints are some of the design options, which the builders and developers can easily opt in the large development projects. This can prevent the water from flowing into the storm water drains and resulting in their flooding. Instead, the water can percolate into the ground naturally and significantly reduce the problem of urban flooding.

Implementation

1. **To establish state of the art climate monitoring stations at** ULBs to ensure accuracy in the data. These weather monitoring stations should be linked with the **National Data Center of IMD** to further strengthen the data bank in terms of the climatic data sets.

    a. Specialised training, identifying linkages between the disaster preparedness and climate change should be imparted to all the local bodies to make the knowledge of the staff more robust.

2. **To impart a very specific training** to ULBs **regarding the Climate Change, Disaster Management other environmental issues**, while further emphasising on their inherent linkages.

    a. During the consultative process of the study, it was observed that most of the ULB officials **do not have a very clear understanding about the distinction between climate change and its linkages with disaster**. Difference between other environmental issues and climate change also seemed very dubious. Thus, very specialised training could be imparted to the ULB officials regarding the aforementioned concerns so that very appropriate and region specific climate resilience plans could be drafted for the corporation.

3. **To levy stringent restrictions on the development in the eco-sensitive areas or areas falling under the Coastal Regulations Zone (CRZ).**

    a. In order to safeguard the natural ecosystems in the city, only infrastructure services should be allowed in these areas and no infrastructure development should be undertaken in these areas.

4.4.3 Temperature

4.4.3.1 Drivers and Pressures

Largely, the causes for the rise in the earth's surface temperatures could be attributed to the pumping of excess greenhouse gas emissions in the atmosphere, disturbing its balance, due to various anthropogenic activities. While globally these associations could be agreed upon, locally there could be multiple factors which contribute to the increase in the temperatures apart from just the greenhouse gas emissions. Especially in the urban areas, which are a complex system, it would be incorrect to hold responsible one factor which is contributing to the increase in the temperatures. It is also important to note that the urban heat island effect generated owing to the excess concrete and hard paved surfaces (both vertical as well as horizontal surfaces), which re-radiate heat back to the atmosphere, is one of the key drivers of the rise in local temperatures. In case of Land use and land use changes in the region, where the large open spaces often considered as the sinks of carbon and heat, are taken over for unplanned development or are converted for the real estate or other infrastructure development in the city. Such alterations also transform as drivers contributing towards disturbing the microclimate of the city/region.

4.4.3.2 Status

Average temperatures

Various studies which have used statistical methods for understanding the temperature over a region (K. Jain et al; 2012)[24] confirm that there is a conspicuous increase in rising temperatures over the country. However, it may also be noted that many a times, these temperature monitoring stations are located in or around the urban areas, which are also the pockets of heat islands. This may result in giving a false picture of the temperature trends. Moreover the results may be misguiding, unless there is a clear differentiation in the causes of temperature increase (Urban heat island or Global warming). Thus a very context specific methodology was formulated to overcome this discrepancy. Stations from urban (Santacruz and Colaba) as well as peri-urban pockets (Alibagh and Dahanu) of MMR were considered representing a good spread in terms of location as well as prevailing weather conditions.

Temperature for the region was analysed using annual data sets of maximum and minimum temperature for the period of 42 years (1971-2012) .Station wise long term averages derived from the climatological normals were then compared with the annual averages of the station to assess the variations if any. A decadal temperature variation analysis was also undertaken to map the variations across the decades. But at a local level, though trends can be established from observed data, precise impacts are difficult to quantify owing to dearth of specific tools/ indices, which can quantify the local level impacts and their direct correlation to climate change. For instance, without appropriately collated datasets, it is difficult to assess the impact of increasing temperatures on crops cultivated in MMR and consequently on the livelihood of the communities dependent on it. This would require focussed in-depth research, but some generalized inferences could be drawn from literature and community consultations, which the study also attempts to undertake. The observed temperatures (minimum and maximum) of the stations were plotted against the respective long term averages in order to map the variations. The graphs presented in the section show a dual axis comparison of the minimum temperature on the left axis, whereas the maximum temperature on the right axis of the graph with their long term averages with the corresponding year.

The graphs below clearly indicate the shifting averages of the minimum as well as maximum temperatures in the region. For instance, (Figure No. 4-12). Below, shows the temperature readings for 42 years for Santacruz station. The left axis indicates the minimum temperature readings, whereas the right indicates the maximum temperature readings for that station. It could be observed that post 1990s the region has started experiencing new higher averages for both minimum as well as maximum temperature. The shift in the averages is highlighted in the graph below. Similar exercise was undertaken for all the stations considered for the study.

[24] K. Jain and V. Kumar, 2013, Trends analysis of rainfall and temperature data for India, Current Science, vol. 102.

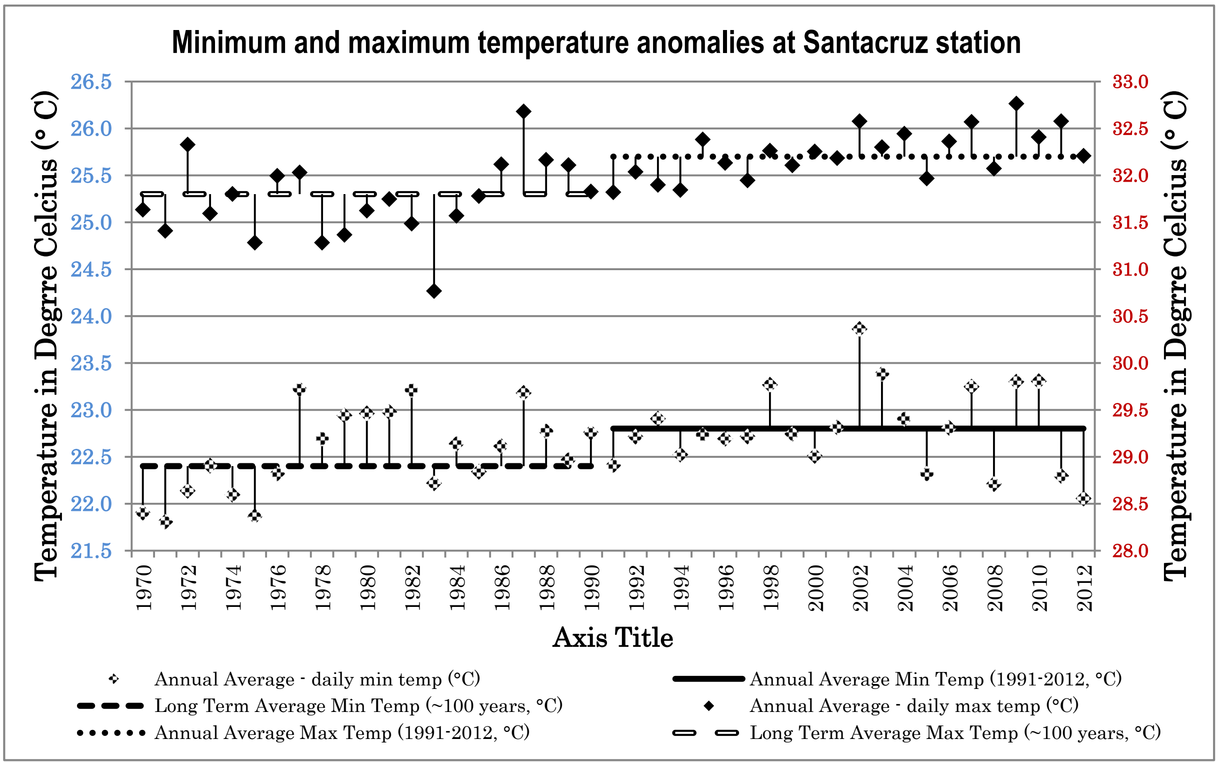


Figure No. 4-12: Minimum and maximum temperature anomalies at Santacruz station

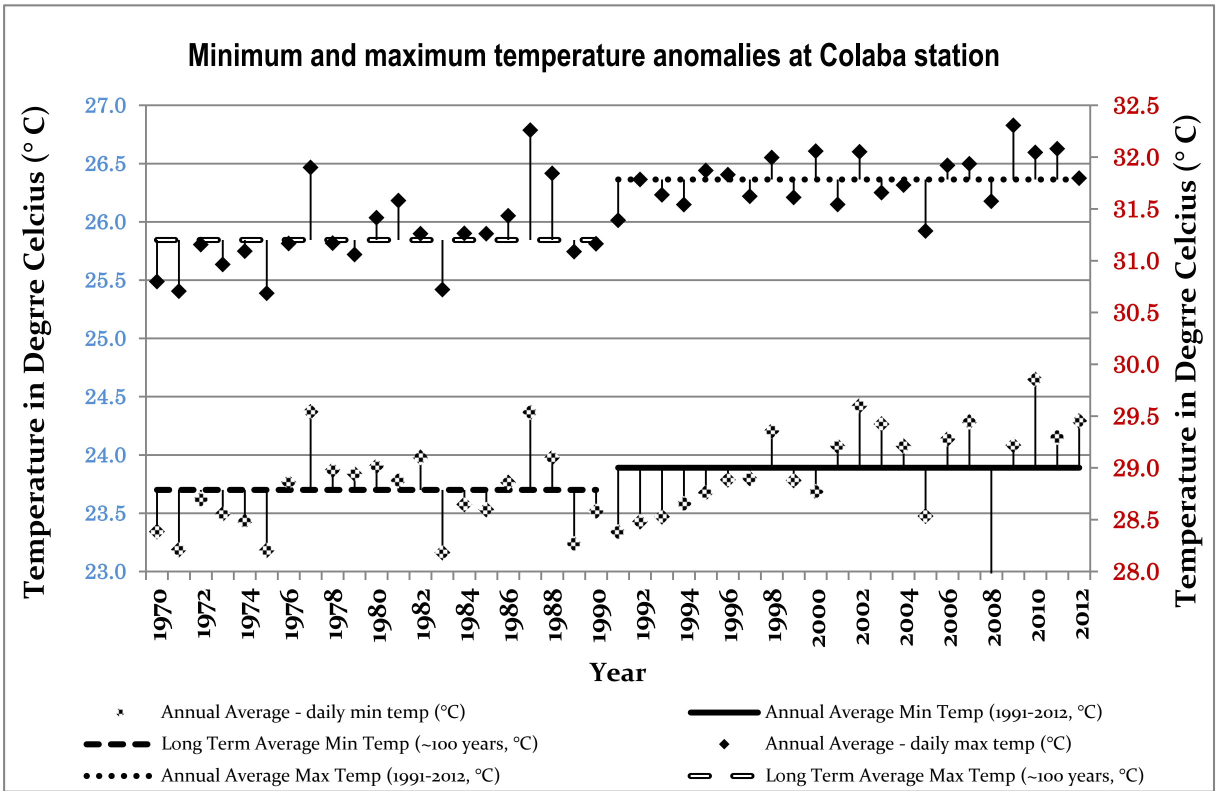


Figure No. 4-13: Minimum and maximum temperature anomalies at Colaba station

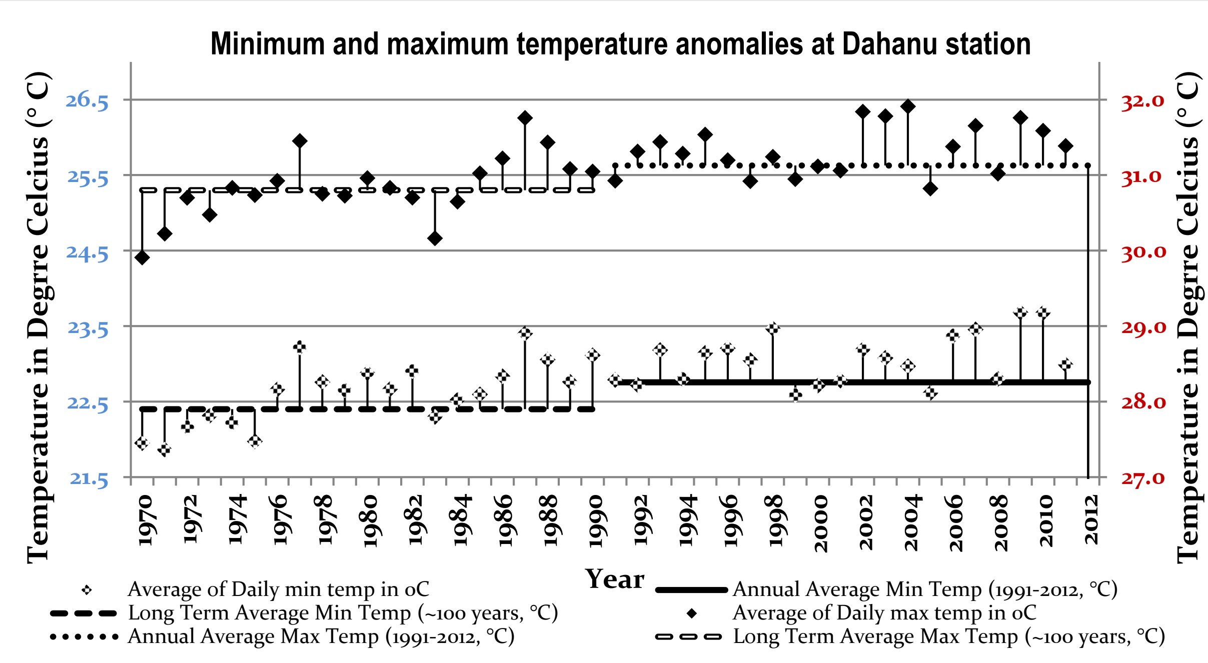


Figure No. 4-14: Minimum and maximum temperature anomalies at Dahanu station

Table No. 4-7: Station wise and decadal increase in the Minimum and Maximum temperatures

Decades	Santacruz		Colaba		Dahanu		Alibag	
	Min	Max	Min	Max	Min	Max	Min	Max
1970-1980	22.4	31.7	23.6	31.1	22.4	30.7	22.5	30.5
1980-1990	22.7	31.8	23.7	31.4	22.8	31.0	22.4	30.8
1990-2000	22.7	32.1	23.7	31.7	23.0	31.2	22.6	31.2
2000-2012	23.0	32.4	24.0	31.8	23.2	31.5	23.1	31.5
Increase (°C)	**0.6**	**0.7**	**0.4**	**0.7**	**0.7**	**0.8**	**0.6**	**1.0**

As also indicated in the Table No. 4-7, if we compare the stations, it can be observed that while Santacruz, Colaba and Dahanu show an average increase in the range of 0.4-0.7°C, Alibag shows a striking increase in maximum temperature by 1°C, which is presently the highest. It could be inferred from the table that, though there is not a prominent increase in the minimum temperatures there seems to be an increase in the maximum temperatures in the period of past 42 years. Various studies (G. Rao et al; 2003[25]) also confirm the positive trends in the temperature studies over urbanised areas like Mumbai, Pune and so on. While increase in the maximum temperatures is a case to worry about, increase in the minimum temperatures also cannot be neglected as, such changes would invite warmer nights and result in the direct increase in energy demand of the region. Thus, it is imperative to understand the trends in temperature parameters, to appropriately formulate the mitigation plans towards reducing the urban energy demand along with plans to mitigate the temperature rise.

[25] http://sa.indiaenvironmentportal.org.in/files/extreme%20events.pdf

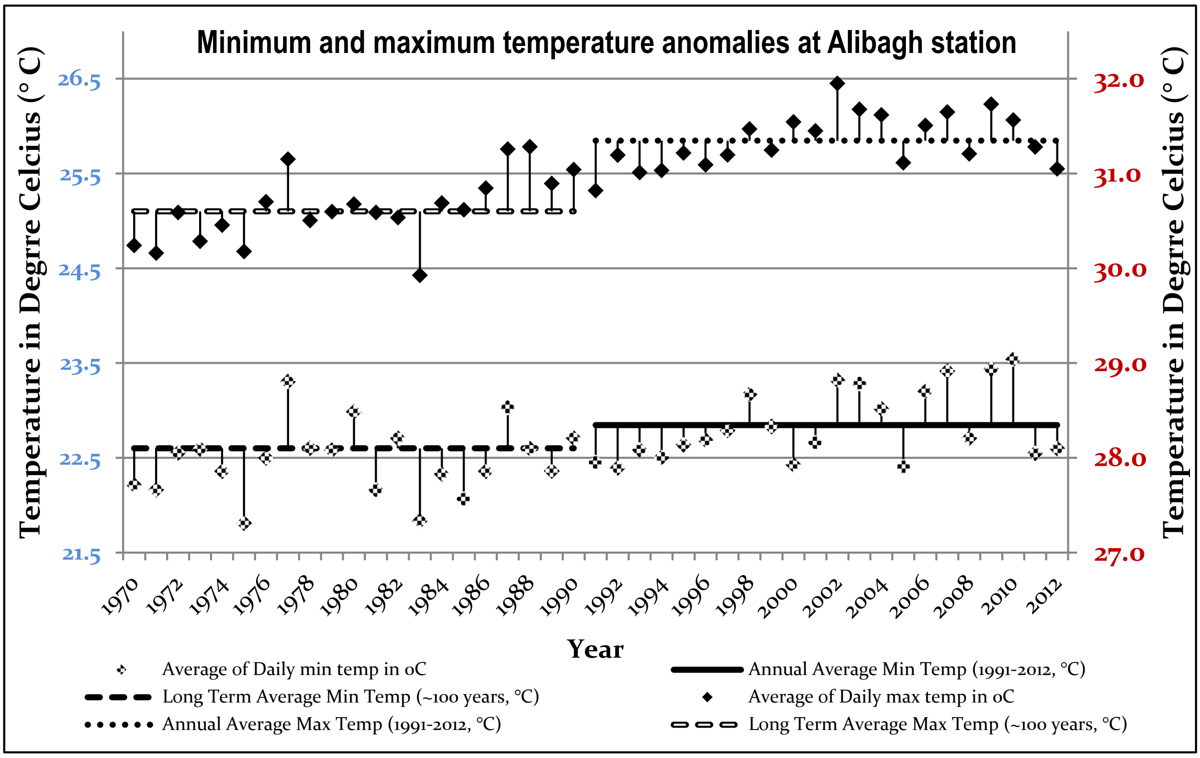


Figure No. 4-15: Minimum and maximum temperature anomalies at Alibagh station

4.4.3.3 Hot days

Along with the temperature increase, it is also essential to understand the increase or decrease in the intensity of the maximum temperatures in the form of hot days' analysis for the region[26]. The increase in the minimum temperatures is attributed largely to the urbanisation and land use changes in the city, where the large open spaces are converted into built up areas under the real estate development[27].

26 Hot day - When the maximum temperature departs by 5°C or more from the normal maximum temperature irrespective of threshold value of 40°C, the day can be described as 'Hot day'
Refer- http://www.imd.gov.in/doc/termglossary.pdf

27 Gadgil. A , Dhorde.A, 2005, Temperature trends in twentieth century at Pune, India, Atmospheric Environment, Vol.39, 6550–655

Table No. 4-8: Hot days observed (station wise and for MMR)

Stations	Normal Maximum Temperature (in °C)	Hot Day Temperature (in °C)
MMR (Except Bhira, Raigad)	31.4	36.4
Alibag, Raigad	31	36
Colaba, Mumbai	31.5	36.5
Santacruz, Mumbai	32	37
Dahanu, Thane	31.1	36.1

Source: IMD, Terminologies and Glossary

Thus, the Hot days were calculated station wise as well as for the overall region (Table No. 4-8). There is and observed increase in the trend of the number of Hot days in the region (Figure No. 4-16). The hot days have increased from 4 in 1971 to around 12 days in 2011. Thus the region is believed to have become hotter in the past years. By means of significance test, the trend is proved to be statistically significant at 99.7% confidence level.

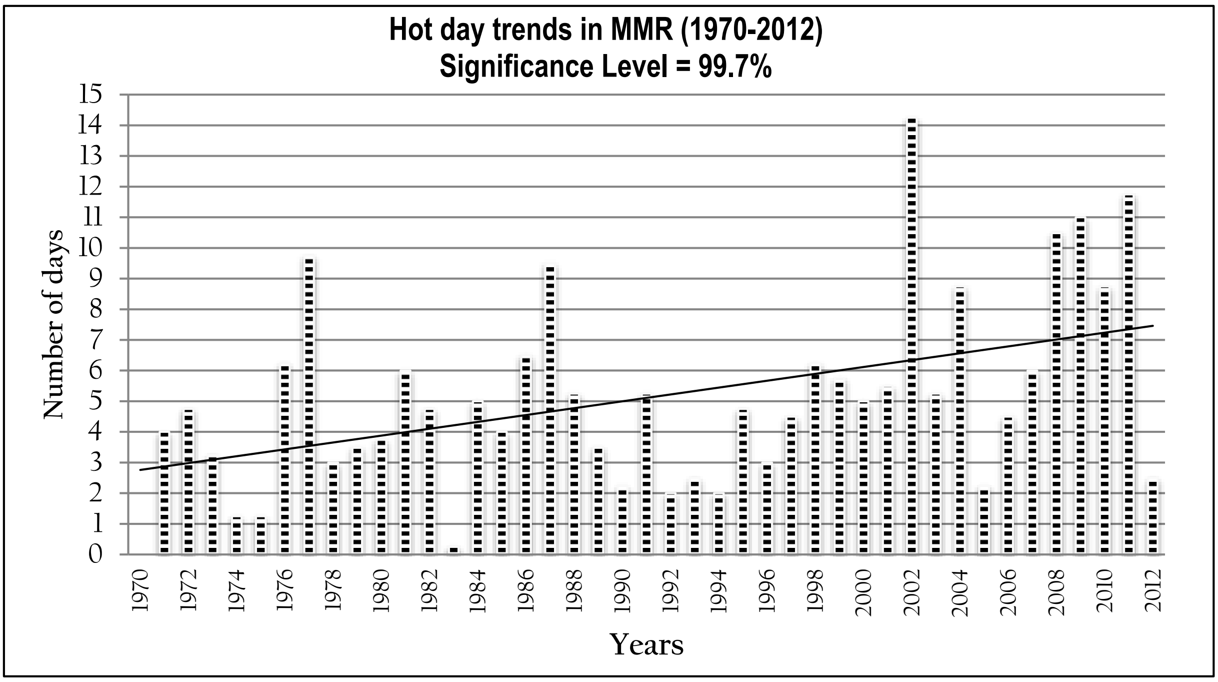


Figure No. 4-16: Hot day trends in MMR (1970-2012)

Seasonal temperature variations

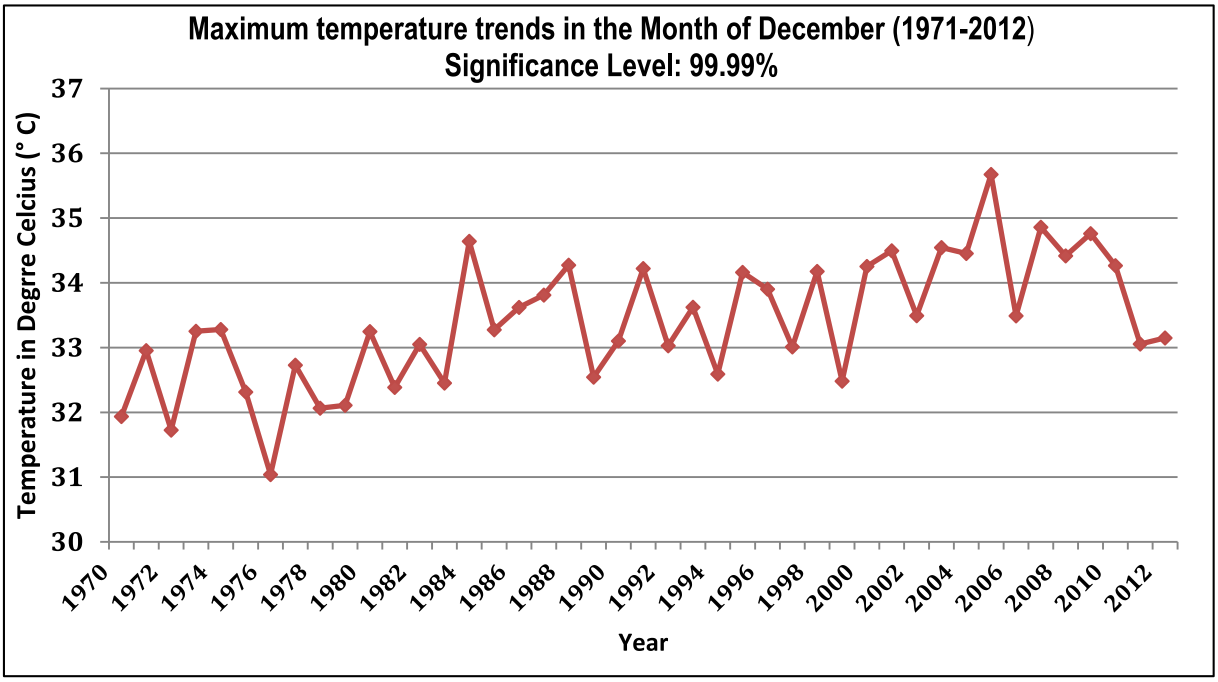


Figure No. 4-17 Maximum temperature trends in the Month of December (1971-2012)

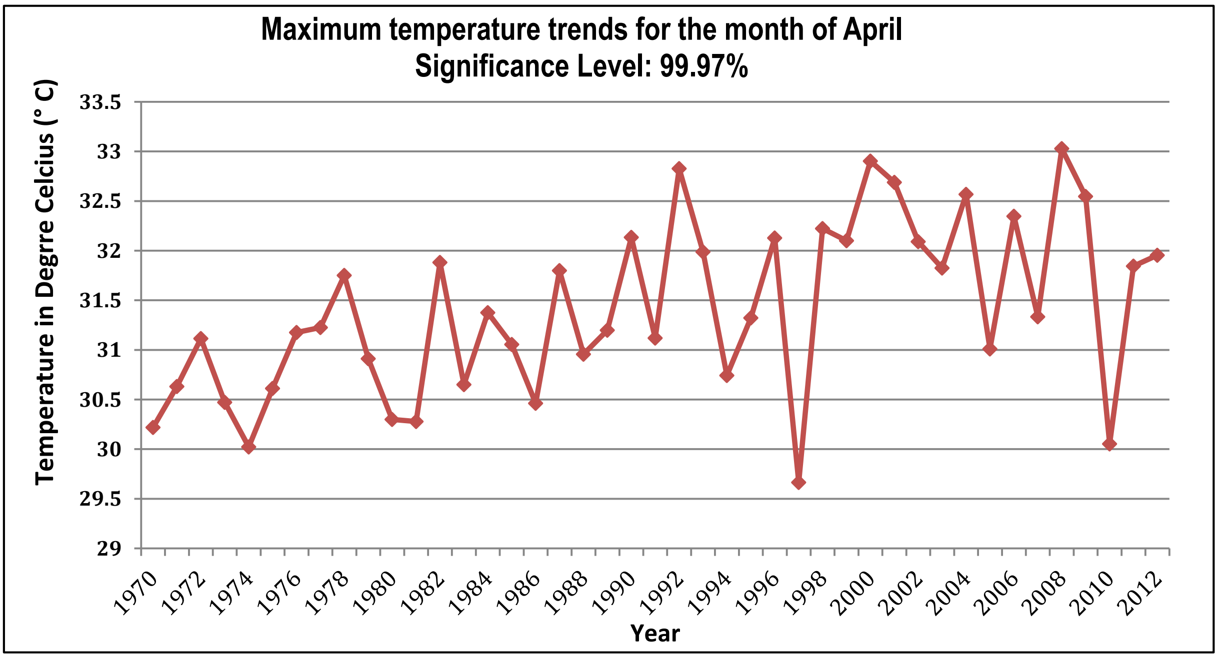


Figure No. 4-18: Maximum temperature trends for the month of April.

While the global literature is showing increasing evidences of warming, the local scenarios can also be seen aligning with the global trends, showing statistically significant increase. The winter month of the region (December) is seen to be experiencing higher temperatures over the years. As seen in (Figure No. 4-17), the average maximum temperatures are seen to be increasing by around 2°C in the past 42 years (30.7°C in 1971 to 32.25°C in 2013). The trend is observed to be statistically significant at 99.97% confidence level. Minimum temperatures, for the months were calculated, but no significant trend was established. The temperature is seen to be increasing steadily by 2°C in the past 42 years (32.42°C in 1971 to around 34.3 2°C in 2011) especially, for the peak summer month of April, there was a statistically significant trend established for the increase in the maximum temperature (Figure No. 4-19). Thus, it could be deduced that the regions has become hotter in the past years. Being an urban agglomeration, the increase in the temperatures, may have an impact directly in on the energy consumption, requiring for more demand side energy management in the sector.

4.4.3.4 Impacts

Table No. 4-9: Possible impacts of temperature variations of different sectors

Areas of impact due to Temperature variations	Impacts
Transport and Infrastructure	Increased temperature and solar radiation could reduce the life of asphalt on road surfaces, while inducing stress in the steel, through expansion especially in large bridges and rail tracks[28]. The infrastructure design needs to consider the climatic variations before designing for sustainability and durability. Lower temperature sensitive materials could be adopted for sustenance. Use of local materials should be encouraged as they are less sensitive to the local climatic fluctuations. (For example: use of Manglore tiles on sloping roofs in individual houses could be used instead of aluminium or steel to avoid heat reflectance and invite cooler environments.)
Urban Heat Island (UHI) Effect and increase in the Energy Demand	Urban areas tend to have higher air and surface temperatures and tend to retain heat more than their surrounding rural areas due to dense built-up areas having extensive impervious surfaces and surface materials which have low albedo[29]. To add to this, lack of adequate green and open spaces, higher density of population residing in smaller areas, other structural features of buildings such as glass materials used for the exteriors of the building, which tend to reflect heat into the atmosphere, aggravate the condition[30]. Increase in temperatures would add to this effect by increasing the overall urban temperatures, affecting directly the energy demand, especially in the peak hours. Thus, one of the major impacts of increasing temperatures is increased demand in cooling conditions and thus escalation in energy supply and consumption. This will further exert pressure on existing fossil fuel based energy supply in the region.
Agriculture	In MMR, the major crops grown include rice, vegetables such as leafy vegetables, brinjal, cabbage; fruits such like mango, papaya and flowers like marigold, roses and so on. Higher temperature can cause decrease in growth, yield, and quality of rice crop by affecting its yield components (Singh 2001, Sheehy et al. 2005, Peng et al. 2004[31]). Out of the total rice

[28] Climate change and Infrastructure, Planning ahead- A Victorian government initiative, p4
Link:
http://www.climatechange.vic.gov.au/__data/assets/pdf_file/0018/73242/ClimateChangeandInfrastructureSummary.pdf

[29] Wong. E et. al. (undated) Reducing Urban Heat Islands: Compendium of Strategies. Climate Protection Partnership Division, United States Environmental Protection Agency's Office of Atmospheric Programs. Retrieved from http://www.epa.gov/hiri/resources/pdf/BasicsCompendium.pdf

[30] TARU (undated). *Urban Heat Island Effect and its Mitigation Strategies: Cool Roof and Passive Ventilation – Progress Report*. Retrieved from http://www.thermalcomfort.co.in/sites/thermalcomfort.co.in/files/A%20Report%20on%20Urban%20Heat%20Island%20Effect.pdf

[31] Shrivastava P., Saxena R., Xalxo M., Verulkar S., (2012). *Effect of High Temperature at Different Growth Stages on Rice Yield and Grain Quality Traits*.Journal of Rice Research, 2012.Vol 5 No. 1 & 2.Retrieved from http://www.drricar.org/04%20JRR%20Vol%205_%20Shrivastava%20et%20al.pdf

Areas of impact due to Temperature variations	Impacts
	production in Maharashtra, MMR contributes to almost 12 % of the total share *(Agriculture department, Government of Maharashtra, 2009-10)* According to Shah et. al. (2011), the flowering and booting stage are said to be sensitive to higher temperatures which may result in sterility[32]. In vegetable and fruits, higher temperatures can impact the photosynthetic process by modulation of enzyme activity (Sage & Kubien, 2007[33]). Specifically, higher temperature prior to harvest can change ripening behaviour (Woolf and Ferguson, 2000; Chan, Tam, and Seo, 1981 and Picton and Grierson, 1988[34]). However, there is a paucity of information on the exact impacts of climatic anomalies of the varieties of vegetables, fruits and flowers grown in MMR. Rise in temperature may lead to change in production timings, pollination, floral and fruit drops and some photosensitive crops may mature faster[35]. A further research can help identify the region specific impacts of climate anomalies on crops.
Health	Increase in the temperatures along with the prevalent UHI is also known to intensify the heat wave effect, which is defined as the sudden increase in temperature for prolonged periods[36].Thus, human well-being is at stake with increasing UHI effect caused by increasing temperatures. This effect would be particularly significant on the most vulnerable population in MMR which are the urban poor/slum dwellers or people from low income group
Forest	Forests are major carbon sinks in the world. In MMR, the forest areas such as Sanjay Gandhi National Park, protected forest areas near Tungareshwar in northern MMR, part of Karnala Bird Santuary play a big role in offsetting the carbon emissions from the urban pockets of the region while also retaining the moderate temperatures. With the increase in the temperatures, studies indicate that there would be loss in the number of species as changes in climate would fundamentally alter the composition of species habitat. In some other cases, rise in temperature and CO_2 composition might accelerate the growth rates of

32Shah. F., Huang J., Cui K., Nie L., Shah T., Chen C., Wang K., (2011, February 3). *Impact of high-temperature stress on rice plant and its traits related to tolerance.*Climate Change and Agriculture Paper.Journal of Agriculture Science.Cambridge University Press. Retrieved from http://www.agri.ankara.edu.tr/fcrops/1289__IMPACT_OF_HIGH_TEMP_STRESS_TOLERANCE.pdf

33Moretti C. L., Mattos L. M., Calbo A. G., Sargent A. G., (2009, October 14). *Climate Changes and potential impacts on post-harvest quality of fruit and vegetable crops: A Review*. Food Research International, Journal of the Canadian Institute of Food Science and Technology. Retrieved fromhttps://www.uni-hohenheim.de/fileadmin/einrichtungen/klimawandel/Literatur/Moretti-etal-FRI2010.pdf

34 Ibid

35Datta S. (2013, August 3). *Impact of Climate Change in Indian Horticulture – A Review.International Journal of Science, Environment and Technology*.Vol. 2.No. 4. Retrieved fromhttp://www.ijset.net/vol-2-4/IJSET%2014.pdf

36 Ibid

Areas of impact due to Temperature variations	Impacts
	some species. Another impact could be loss in crop productivity, increase in pests and diseases, increase in invasive species[37] and so on.
Biodiversity	Studies indicate the northern Western Ghats are more vulnerable to climate change, especially due to the rise in temperatures, making it more vulnerable to incidences like forest fires and pest attacks (Chaturvedi et al, 2011). The study also predicts that forests dominated by tree members of family Lauraceae and Rubiaceae may potentially expand to grassland. This phenomenon may play its role in MMR due to presence of more than 60 species of family Lauraceae and more than 6 species of Rubiaceae (Unpublished data from biodiversity report of MMR prepared by Yuhina Eco-media sponsored by MMR EIS). These species may not be dominant in MMR but impact at a smaller scale might be seen. Apart from land biodiversity, marine biodiversity is also susceptible to various changes. A study by Institute of Community Organization Research (2011) has observed that two fish varieties Tarli (Sardines) and Bangda (Mackerel) which forms the staple food of poor people are migrating away from Mumbai due to increase in sea water temperature[38].As in any other urban areas, Mumbai too is facing the consequences of urban heat island effect[39]. This can create a severe impact on bird population of MMR. Thus MMR being facing the similar scenario there is high probability of impact on local as well as migratory bird population. The bird species present in low lying areas like MMR may migrate to other areas in search of their preferred microclimate[40].

[37]Acharrd F. et. al. (2009).*Vital Forest Graphics*. Chapter: Climate Change its impact on forests – will forest migrate. Published by United Nations Environment Programme, Food and Agriculture Organization of the United Nations and The United Nations Forum on Forests Secretariat.Retrieved from http://www.unep.org/vitalforest/Report/VFG_full_report.pdf

38Institute of Community Organization Research (2011). Vulnerabilities of fishing communities to ecological and climate change- a pilot study in Dharavi bet in Mumbai.

39 http://www.theguardian.com/global-development/poverty-matters/2013/jan/09/delhi-mumbai-urban-heat-islands-india last viewed on March 24, 2014 (How urban heat islands are making India hotter).

[40]Sekerciogolu et al (2011). The effect of climate change on tropical birds. Biological Conservation 148 (2012) 1–18

4.4.3.5 Responses

As also discussed in the previous sections, increase in the temperature could be attributed to various factors, especially in the urban areas. Various afforestation programs have been undertaken by the central and the state government to offset this effect. In a consortia, The Energy and Resources Institute (TERI), Maharashtra State Road Transport Corporation (MSRTC) and Ministry of Environment and Forests (MoEF), undertook the Ownership based and action oriented afforestation program in 2012-13, which aimed at encouraging ownership based participation in afforestation. Similarly various acts and policies are also drafted by the state government to ensure protection of trees which could be threatened under urbanisation. For instance, The Maharashtra state (urban areas) Protection and Preservation of Trees Act 1965, also aims at making better provisions for trees in urban areas in the State by regulating the cutting of trees and providing for planting of adequate number of new trees in those areas. Similarly, Development Control Rules at the corporation levels also enforce the preservation of minimum open spaces towards safeguarding the same in the city. Thus, it could be very well said that there exists appropriate framework, which indirectly would contribute towards regulating the urban temperatures. However attention is required towards spearheading its implementation.

Specific recommendations

Research

1. **To undertake a detailed study to measure and quantify the Urban Heat Island Effect (UHIE) undertaken for the region.**
    a. Rising temperatures in the city are further aggravated by the anthropogenic UHIE experienced in the cities. Intense concretisation and absence of green open spaces create such heat islands making urban areas hotter and uncomfortable. Such hot spots should be identified in the city limits and very context specific measures should be drafted in order to mitigate the same.
    b. Afforestation programs in association with relevant authorities along with climate responsive planning and appropriate urban design approach can significantly contribute towards mitigating the urban heating effect.
2. **To undertake research studies on understanding the impacts of climate change on the native biodiversity** in MMR. The study may also include the Urban heat Island Impacts and its consequential impacts on the local biodiversity.

Policy

1. **To incentivize Bureau of Energy Efficiency (BEE) labelled appliances should be** for their faster penetration at household level to reduce the increasing energy consumption in the cities.
    a. **Maharashtra Pollution Control Board (MPCB**) in collaboration with **Maharashtra Industrial Development Corporation (MIDC**) should make energy audits in industries (at least once in three years) mandatory to check the status of the energy consumption levels.
2. To **undertake local sea and creek temperature measurements** in order to prepare a data base for local conditions
    a. Global sea temperature changes are measured by various international organisations, but it is equally essential to monitor the local sea and creek temperatures changes (increase or decrease) in order to devise very context specific strategies, which could be further up scaled into the regional plans.
3. To make implementation of **Energy conservation Building Code (ECBC) and Solar Passive architecture** mandatory across the state to ensure sustainable building construction.
    a. With the **rapid development in the region and the ever growing housing demand,** it is essential to ensure sustainable development in the region.
    b. Construction industry could be made sustainable with the **implementation of ECBC and solar passive architecture in both rural as well as peri urban areas.** By making it as a mandatory requirement for the new constructions (residential, commercial, government and hospitality sector), efficient use of valuable resources could be ensured.

Implementation

1. To promote **concept of urban agriculture,** where terraces and open spaces of large town ships could be adopted for undertaking the urban agriculture. This can effectively safeguard the agricultural interest
   a. This can effectively reduce the heat reflectance from the terraces and open concrete spaces in the city. Further the reduction in the heat reflectance can contribute towards inviting cooler environments.
2. To **encourage the use of water ways** in order to reduce the load on existing modes of transport.
3. To **encourage buffer zones around the wetlands/sensitive ecosystems** in order to prevent any physical development in these areas, thus preventing damage caused to these ecosystems.
   a. A minimum **buffer of say 15 to 20 meters** on all the sides of the wetland should be no development zone. Any development in this buffer should be strictly prohibited.

4.4.4 Humidity

4.4.4.1 Drivers and Pressures

Humidity is the key component of the climate of MMR region. Located in close proximity to the sea, the climate of the region remains moderate throughout the year with very few extreme situations. Thus humidity plays a crucial role in keeping the temperatures optimum. The study however shows some variation in the humidity levels across the past few years. An increase in the relative humidity is observed in the region. Study conducted by Deosthali. V. 2000[41] infers that one of the important causes for this increase in the humidity could be attributed to the changes in the thermal gradient between the urban areas and the fringe areas of the city, which could be well agreed upon for the region like MMR. Apart from few urban pockets, large patches of land in the region are still under developed or rather developing. Although the built up area appears to account for 14%, there is enormous vertical growth in the city resulting in dense urban pockets like Mumbai and Thane, where the population density is 5304 persons per sq. m. Dense populations and vertical growth directly exerts pressure on resources, municipal infrastructure especially in the context of solid waste management and sewage treatment plants. Given that with only 14% of built up area, at present as per the Statistical report 2011-12, MPCB,MMR has a capacity to treat 75% of the total residential sewage, any further enhancement in the built up area should be very carefully planned.

41 Deosthali. V. 2000 Impact of rapid urban growth on heat and moisture islands in Pune City, India, Atmospheric Environment, vol43, p 2745-2754

4.4.4.2 Status

For assessing the Humidity variations over the region, the study attempts to analyse annual relative humidity trends for the region over a period of 42 years, while also understanding the various causes for the changes in the trends (if any). Annual humidity readings, both morning as well as evening from four stations were procured from NDC and IMD in Mumbai and Pune respectively. These trends were analysed for their changes while also understanding the significance levels of such trends. There is an observed increase in the humidity levels by nearly 2% especially during the day whereas 3% decrease in the evening humidity levels (Figure No. 4-19) with the variations remaining more or less the same over the years. Rao, Jaswal & Kumar (2004)[42]studied the effects of urbanization on meteorological parameters over fifteen cities (with a population of more than one million) and concluded that in general bright sunshine hours, wind speed, total cloud cover and radiation values were showing a decreasing trend while relative humidity and rainfall had an increasing trend.

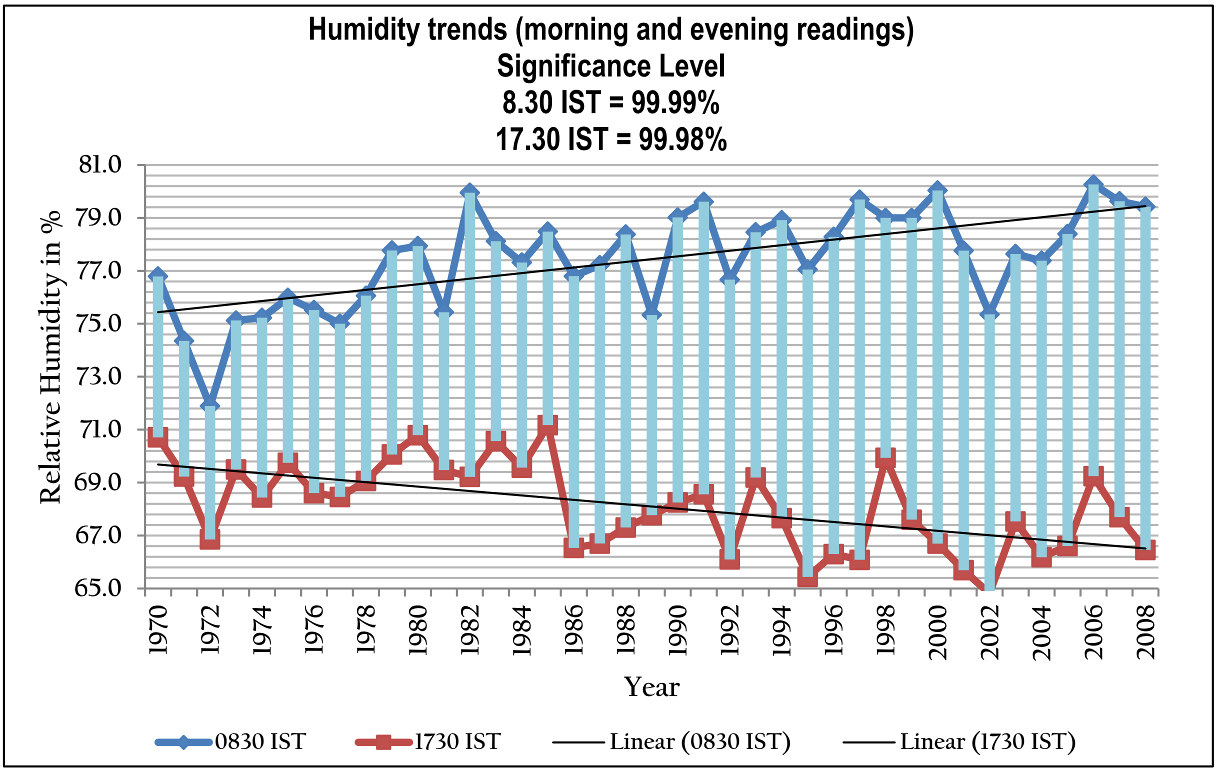


Figure No. 4-19: Humidity trends (morning and evening readings)

[42]Rao G.S, Jaiswal. A.K, Kumar M.S, 2004, Effects of urbanisation on meteorological parameters, Mausam, Vol 55, p 429-440

4.4.4.3 Impacts

Table No. 4-10: Possible impacts of variations on Humidity on different sectors

Areas of impact due to humidity variations	Impacts
Agriculture	Relative humidity (RH) directly influences the water relations of plant and indirectly affects leaf growth, photosynthesis, pollination, occurrence of diseases and finally economic yield. The incidence of insect pests and diseases is high under high humidity conditions. High RH favours easy germination of fungal spores on plant leaves[43].Other possible impacts are: • Reduced evapotranspiration • Increased heat load of plants • Stomatal closure • Reduced CO_2 uptake • Reduced transpiration influences translocation of food materials and nutrients. • Moderately high RH of 60-70% is beneficial. • Low RH increases the evapotranspiration
Health	On one hand, low-humidity levels can lead to dehydration and promote the spread of airborne diseases, like influenza[44]. On the other hand, high-humidity levels exacerbate the effects of heat stress because humidity impairs the body's ability to sweat and cool itself (Donald, 2009[45]). High-humidity levels can also affect respiratory health since they promote the spread of bacteria, fungi, and dust mites (Baughman and Arens, 1996 [46]). Despite these hypothesized mechanisms, the impacts of humidity on mortality have not been well established in the epidemiological literature (Schwartz et.al.2004[47]).
Atmospheric cycles:	As temperatures continue to rise, more and more water vapour could evaporate into the atmosphere and thus triggering storms[48]. On a global scale, the combined result of increased temperatures over land, decreased equator-versus-pole temperature differences, and increased humidity could induce intense cycles of droughts and floods as more of a region's precipitation falls in a single large storm rather than a series of small ones[49].

43http://agritech.tnau.ac.in/agriculture/agri_agrometeorology_relativehumidity.html
44Lowen A. C., Mubareka S., Steel J., Palese P (2007, October 19).Influenza virus transmission is dependent on relative humidity and temperature. Proceedings of the National Academy of Sciences of the United States of America. PLoS Pathog 3(10): e151. doi:10.1371/journal.ppat.0030151. Vol. 3, Issue 10. Retrieved from http://www.plospathogens.org/article/fetchObject.action?uri=info%3Adoi%2F10.1371%2Fjournal.ppat.0030151 &representation=PDFand Shaman J., Kohn M. (2009, January 7) Absolute humidity modulates influenza survival, transmission, and seasonality. Proceedings of the National Academy of Sciences of the United States of America. Retrieved from http://www.pnas.org/content/early/2009/02/09/0806852106.full.pdf+htmland Xie X., Li Y., Chwang A.T.Y., Ho P.L., Seto W.H. (2007, June).How far droplets can move in indoor environments—revisiting the Wells evaporation-falling curve. Indoor Air,17: 211–225. doi: 10.1111/j.1600-0668.2007.00469.x. International Journal of Indoor Environment and Health.Vol. 17 Issue 3.Published by Blackwell Wiley. Printed in Singapore. Retrieved from http://onlinelibrary.wiley.com/doi/10.1111/j.1600-0668.2007.00469.x/abstract
45Quoted from Barreca A. (2011, September 29).Climate change, humidity, and mortality in the United States. Journal of Environmental Economics and Management. Elsevier
46http://www.cbe.berkeley.edu/research/pdf_files/ArensBaughman1996_Pt2.pdf
47Schwartz, J., et al., 2004. Hospital admissions for heart disease: the effects of temperature and humidity. Epidemiology 15, 755–761
48http://earthobservatory.nasa.gov/Features/RisingCost/rising_cost5.php
49http://eric-clapton-old-sock.weebly.com/blog/category/all/14

Though the possible and observed impacts are listed above, very few studies have been conducted specifically in context of MMR region. There is an urgent need to conduct research studies assessing the impacts of the observed changes and thus help in drawing inferences. This can further help policymakers in developing suitable and feasible policies and regulations.

4.4.5 Wind

Differences in the surface covers, infrastructure like tall buildings and so on affect the airflow over the region (Deosthali. V 2000)[50]. The topography of the land surfaces in Mumbai is varied. With forest area/hills accounting for 20.7% of the total area in MMR, the wind flow/pattern is very specific to the region. Proximity of the region to the Arabian Sea, further affects the local wind patterns. In order to analyse the trends in the wind speeds over 42 year period, wind speed data for the four stations in MMR was acquired from NDC, Pune and IMD, Mumbai.

The data analysis of the urban pockets revealed a sharp decrease in the wind speed. (Figure No. 4-19) attached in Annex 16) The wind speeds were observed to be decreased from 12 km/h in 1970 to around 7 km/h in 2012, which is close to 50% decrease. It could be the high rise structures or other urban infrastructure which practically acts as an obstruction for the winds and results in their diversion or drop in their speed. Results from trend analysis study undertaken by Rao, Jaswal & Kumar (2004[51])[42] also suggest similar results for Mumbai, where the wind speeds have seen to be decreasing by considerable 59%.

Wind rose diagrams have been further formulated based on the data obtained from IMD, Pune which indicate the average annual wind direction and speed for 5 years (2005- 10) recorded at 4 monitoring stations (Table No. 4-11). The readings were obtained 2 times a day i.e. at 0830 hrs and 1750 hrs respectively. For example, the wind rose diagram for Alibaug station, at 0830 hrs, is provided below in Figure No. 4-20.

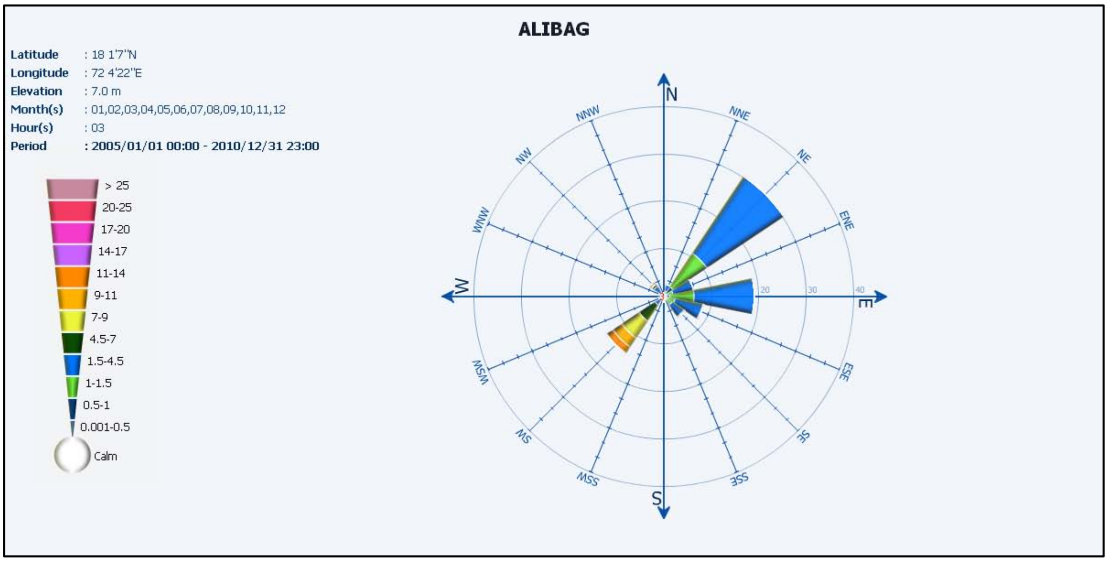


Figure No. 4-20: Wind speed and direction at 0830 hrs at Alibaug station

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50 Deosthali. V. 2000 Impact of rapid urban growth on heat and moisture islands in Pune City, India, Atmospheric Environment, vol43, p 2745-2754

51 Rao G.S, Jaiswal. A.K, Kumar M.S, 2004, Effects of urbanisation on meteorological parameters, Mausam, Vol 55, p 429-440

The wind rose diagrams for other three stations for two time points have been provided in Annex 16. The inference drawn from all the 4 stations have been provided below in Table No. 4-11.

Table No. 4-11: Wind status from 4 stations in MMR

Station Name	Time (hrs.)	Wind Direction	Wind Speed	Calm days (%)
Alibaug	0830	Maximum % wind is flowing from the NE direction while some wind can also be observed to be flowing from SW direction.	Mainly ranging between 1.5- 4.5 m/s but variable speed maximum up to 9-11 m/s can also be observed.	3
	1730	Maximum % wind is from the NW direction while 15-20% wind is flowing from SW direction.	Maximum speed up to 4.5- 7 m/s while almost 50% of the wind is flowing the speed of 1.5-4.5 m/s.	0
Colaba	0830	Maximum wind flowing from WSW direction	Mainly ranging between 1.5- 4.5 m/s	35
	1730	90% wind can be observed to be flowing in WNW-NWN direction	Maximum speed of 1.5-4.5 m/s	3
Dahanu	0830	Maximum wind flowing from the E direction while some % wind can also be observed to be flowing from SW and WSW direction.	Wind flowing at 1.5- 4.5 m/s reaching a maximum up to 7- 9m/s on some days	26
	1730	Mainly from SW and NW.	Wind flowing at 1.5- 4.5 m/s reaching a maximum up to 7- 9m/s on some days.	11
Santacruz	0830	Almost from all the directions.	Average speed of 1.5- 4.5 m/s.	50
	1730	Mainly NW direction.	Average speed of 1.5- 4.5 m/s.	3

However it may be noted that, the accuracy of the data collected could be subject to the location of these monitoring stations. While the literature indicates a decline in the trend of the wind speed over Mumbai region, it is strongly recommended that a further research, using multi criteria assessment require to be undertaken in order to deduce conclusive findings as the monitoring stations were found to be surrounded by newly constructed high rise buildings. Independent assessment of wind speeds would not be sufficient enough to assess the changing trends of the wind speeds over the region and could be misleading.

4.5 Discussions

While the region is observing high rainfall incidences, there have also been years of low rainfall in the region, with respect to the long term averages. However it may be noted that the incidences of rainfall exceeding the long term averages are higher than the incidences of the rainfall below averages. MMR region being a coastal region, it is also essential to understand that, the impact of rainfall is essentially a function of tide and time of the rainfall when these climatic factors combine to create an impact.

A collective assessment can help understand the compounded impacts of climatic factors on the urban systems rather than just assessing the rainfall in isolation. As discussed in the previous sections, the areas, which flooded during the high rainfall event on 25th July 2005, were essentially the most sensitive areas, by the virtue of being low lying. More over the rainfall that took place in 2005 was a rare event, combined with the high tide which created a flood like situation in many areas. It then becomes significant to analyse the preparedness levels of the city infrastructure and identify the gaps.

Changes in the distribution of the rainy days can also significantly impact the city life. The increase in the categories of moderate and heavy rainy days and decrease in the number of light rainy days (Table No. 4-3) also signifies that without appropriate planning measures, the city could be exposed to flash floods or water logging in low lying areas thus disrupting the normal life in the city.

While city is turning out to be hotter, a deeper insight into the exact causes of the increase is required. Although the warming has been observed globally, the local rise in temperature could be subject to multiple factors like Urban Heat Island Effect, decrease in the vegetative cover, vehicular and industrial pollution and so on. Thus after assessing the changes in the trends, a detailed cause-impact analysis is required to drive closer to the conclusion Assessing impacts of the changes emerging from trend analysis is significant to this study in order to understand the likely risks. The assessment cannot be restricted to impacts on urban areas or populations residing in built-up areas (both urban and rural) but also on agriculture, forest, wastelands and wetlands as they do have a large contribution in the land use pattern.

The following table gives a glimpse of the share of the major types of land uses

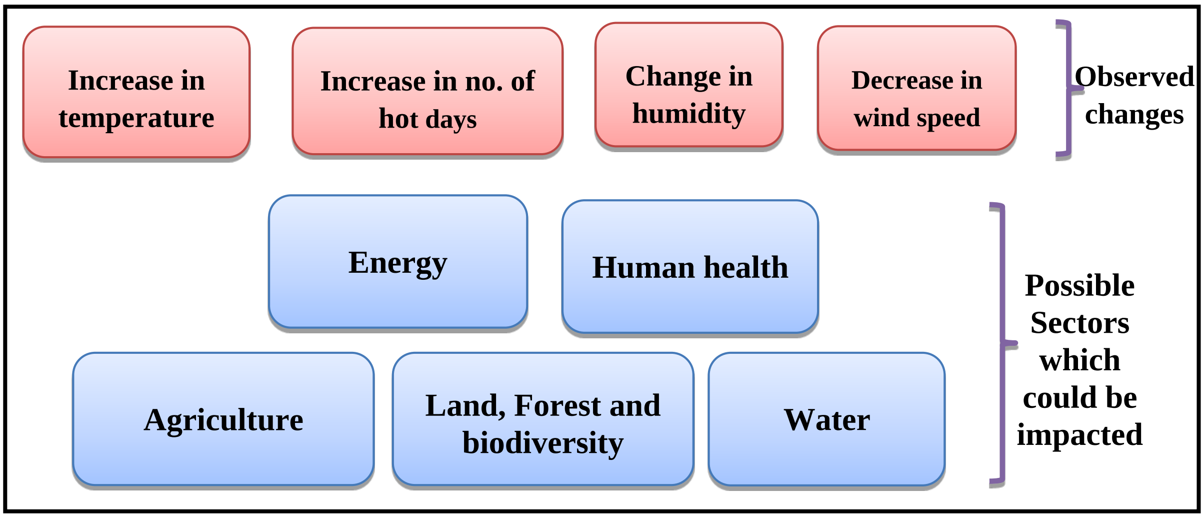


Figure No. 4-21: Possible vulnerable sectors to climatic variations.

4.6 Highlights of the consultations

4.6.1 Councils and corporations

4.6.1.1 Awareness about climate change

The officials from the Municipal Corporations seemed quite aware about the global climatic deliberations. But the consultations revealed that, there seemed to be ambiguousness about the core understanding of the subject and its linkages with environment around us. Most of them believed that the cause to the global issue is anthropogenic with handful believing it to be natural.

4.6.1.2 Observations and perceptions

The respondents definitely observed conspicuous changes in the patterns of climatic parameters like rainfall and temperatures. Shift in onset of monsoon, increase in the discomfort levels especially during the night along with the decrease in winter seasons were some of the key observations of the respondents. Further, the corporations believed the fact that the future impacts can be reversed with proactive measures. Following chart represents the nature of the responses from the ULB's

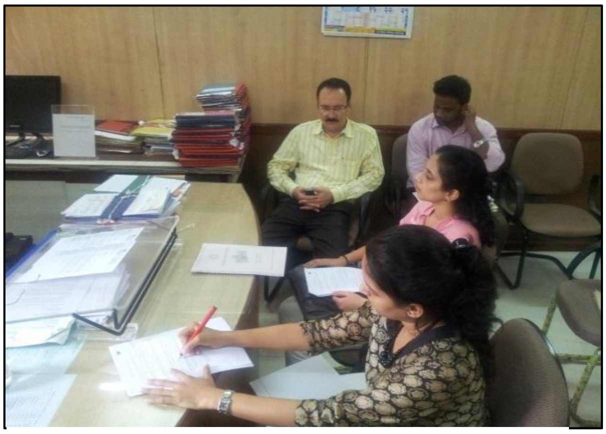
4.6.1.3 Mitigation measures and initiatives undertaken

Apart from documentation of the ESRs the consultations did not reveal any climate change specific assessments or initiatives undertaken at their level. Disaster Management cell existed in the corporation, but presently looks after disasters like fire incidences, tree falls, landslides floods etc. and does not really undertake any climate specific assessments. Some of the corporations like Thane Municipal Corporation, Navi Mumbai Municipal Corporation and Municipal Corporation of Greater Mumbai regularly prepared the disaster management plans especially after the 2005 floods.

4.6.1.4 Preparedness of the region towards future climate disasters

The key findings of the Maharashtra State Climate Change Adaptation Action Plan, prepared by TERI for Government of Maharashtra were discussed with the respondents. While vulnerabilities and future impacts of climate change were discussed, the present situation of the corporation and its preparedness towards such events was also assessed. Many corporations expressed concern over the increasing urban flood situations frequenting the region. But the consultations revealed that the corporations believed in taking proactive measures which when implemented in organized and timely manner together can reduce the impact of future climate variability.

Picture No. 4-1: TERI's Consultation with Uran Municipal Council



Picture No. 4-2: TERI's Consultation with Ulhasnagar Municipal Council

4.6.2 Communities- Fishing

Awareness and perceptions about the changes observed in climate.

- The community was well-versed with the changes in the climatic parameters like wind and rainfall.
- The community agreed to the fact that there has been a definite change in the rainfall patterns especially with respect to quantity and distribution of the rainfall in the past 5-7 years.
- Further, the communities also stressed on the changes in the wind direction. They find the winds to be harsher as compared to few years back. Unlike this, the data assessments show a contradictory finding, where the wind speed is decreasing. Thus, the data gaps in this case need to be assessed critically.
- The community was affirmative on the increase in the local sea level rise in their region (*especially the Uran fishing community*).
- One of the major reasons attributed to the rise in the sea level were the unprecedented reclamations taking place around the regions.

4.6.2.1 Impacts of the climatic changes on fishing activity.

- The community mentioned about a decline in fish catch over 5-8 years.
- Possible reasons were attributed to the changes in the tidal flows, the winds and the increasing fishing population.
- Stricter norms and their monitoring for compliance is absent in the region. Further, they expressed concerns over the changes occurring in the climate as it directly affects the fish catch.
- Warmer climate affects the fishes, their breeding and ultimately their fish catch. While acknowledging the reception of information on the extreme weather situations they expressed their need to receive more detailed information about the same.


Picture No. 4-3: Consultation with the Agriculture Communities in Thane

4.6.3 Communities- Agriculture

4.6.3.2 Awareness and perceptions about the changes observed in climate.

- Significant change in the overall rainfall pattern
- Shifting seasons and reduction in the average number of rainy days and variations in their distribution. While these changes were prominent, losses in the cash crops as well as other crops have also increased proportionately.
- Experienced a definite increase in the night temperatures along with day temperatures
- Gradual increase in diurnal temperature differences affecting Rabi crop the most
- Increasing erratic nature of the climate is forcing farmers to opt for hybrid seeds leading to overall increase in the input cost.

4.6.3.3 Impacts of the climatic changes on agriculture activity.

- Increased seasonal migration to nearby cities.
- Increased use of hybrid seeds to enhance yield resulting in increased input costs and use of fertilizers.
- Observed change in cropping patterns and shift towards water intensive cash crops.
- Losses in the actual yield of the farmers owing to unaccounted damages and crop failures resulting out of erratic weather conditions.

4.6.4 Initiatives by ULBs towards disaster preparedness

Table No. 4-12: Various initiatives undertaken by Corporations towards disaster preparedness

Name of the ULB	Mitigation measures undertaken
	• Plastic is banned in the region. • Awareness generation about Reduce, Reuse and Recycle concept. • Afforestation program, especially on the nearby hills. Plantation drive

Name of the ULB	Mitigation measures undertaken
Vasai Virar Municipal corporation (VVMC)	for around 7,00,000 trees is in pipeline. Tree saplings are made available free of cost to the aspiring individuals in order to encourage the citizens to plant more trees in the vicinity. • Other voluntary guidelines like if one tree is cut for any developmental purpose 5 trees needs to be planted elsewhere to mitigate the impact. • Disaster Management cell exists in the corporation, but presently looks after disasters like fire incidences, tree fells, landslides etc.
Mira Bhayander Municipal Corporation (MBMC)	• Houses a Disaster Management Cell comprising of 4-5 people and is active only for the four months of monsoon. • Disasters like, tree fall, blockages, flood rescue and so on are covered. • The personnel in the department send alerts to all the ward offices regarding any of the aforementioned disaster.
Bhiwandi Nizampur Municipal Corporation (BNMC)	• There is a functional disaster management cell for the region. Presently it works for 4 months. The corporation aims to make it work throughout the year.
Kalyan Dombivali Municipal Corporation (KDMC)	• There exists an early warning system for the region. Alert messages are sent by the corporation to all the district officials and ward officials through walkie talkie. Further this information is disseminated in the wards through a moving vehicle (often an auto rickshaw) and the masses are made aware. • In addition to this, the corporation houses a separate Disaster Management cell, which looks after various types of disasters. • A very detailed disaster management plan is prepared by KDMC, based on participatory methods like transect walks and discussions with the communities to mark the vulnerable flood spots.
Ulhasnagar Municipal Corporation (UMC)	• There is an active disaster management cell which is responsible for dissemination of the alerts in the city. The alerts are sent through SMS and voice messages through moving vehicles. • Disaster management plan, highlighting all the emergency numbers and persons in charge is prepared. Apart from these measures, there are other disasters like fire, landslides, drowning etc. are addressed by the cell.
Navi Mumbai Municipal Corporation (NMMC)	• Houses a dedicated disaster management cell. • The corporation in collaboration with UNDP-GEF has initiated a Climate Risk Management project in urban areas. It is a part of another umbrella project comprising of cities like Gangtok, Shimla, Bhubaneswar, Trivandrum, Madurai, Navi Mumbai, Visakhapatnam and Vijayawada. • The project aims to reduce disaster risk in urban areas by enhancing institutional capacities to integrate climate risk reduction measures in development programs. • Enhance community capacities to manage climate risk in urban areas by enhancing the preparedness
Uran Municipal Council	• Tree plantation and ban on the plastic are the only strategies initiated under the broader umbrella of environmental conservation • For disaster management, state collector office section has an emergency cell which has 4 officers they work 24 hours.

Source: Primary surveys and consultations by TERI

4.6.5 Linking observations with perceptions

Climatic parameters	Data analysis and observations	Consultations (Community and ULBs)	Linking observations with perceptions	Contribution in Regional Plan
Rainfall	Increase in the variations. No significant shift in the rainfall days. Increase in the number of Moderate, heavy and heavy rainy days with no significant increase in the annual rainfall.	Shift in the onset of monsoons, longer dry spells along with increase in the intensity of the rainfall.	Though the data sets do not show any major trend in the rainfall, there is increase in the variations. Also, the data observation do not reveal any shift in the onset dates forth region Framework required to manage variations in the rainfall exists. But requires further assessment in terms of its capacity to cope with the future variations.	Appropriate provisions, in terms of soft as well as hard policies could be drafted to integrate the rainfall variations in the regional plan. If the communities as well as the civic authorities are aware about the variations, the cities could be made more climate resilient in future.
Temperature	Increase in the overall temperatures. Minimum temperatures are increasing, inviting warmer nights. Increase in the number of hot days, making the region hotter and uncomfortable.	Increase in the overall temperatures and discomfort level. Winters have almost vanished and summers have extended. The authorities presently do not have any specific program to reduce the urban temperature, though there are some policies in place pertaining to afforestation.	The data observations are in alignment with the consultations, where there is a prominent increase in the temperatures (Urban as well as peri-urban). In peri urban areas, issues like pest attacks on the select crops can aggravate given, even a marginal increase in the temperatures. This might add to crop failure affecting the food security of the region.	Appropriate planning and zoning can contribute largely in reducing the urban temperatures, which can also have a global impact. Interventions like design based policies (Urban agriculture, terrace gardens, solar passive techniques etc.); Green building ratings, energy conservation

			Further there is a definite increase in the discomfort levels as revealed during the consultations.	measures and so on could be mainstreamed in order to mitigate this effect.
Humidity	The day time humidity is seen to be increasing whereas the evening humidity is decreasing.	The increase in the humidity levels are adding significantly to the discomfort levels given the increase in temperatures. The discomfort is leading to the increase in the demand for air conditioning and energy consumption.	The data observations are in alignment with the consultations, where there is an observed increase in the humidity levels and the discomfort amongst the community.	Climate responsive urban planning while including the solar passive design measures like orientation, zoning as per the land use and so on, can make the regional plan adaptive to climatic variations like temperature as well as humidity increase. Apart from soft policies, hard policies like afforestation programs encouraging the native plantations could also contribute in reducing the overall discomfort levels in the city.
Wind	The observations show a significant decrease in the wind speed over the region. However, this conclusion may carry certain inherent discrepancies subject to the location of the	Discussions with the fisher folk communities did reveal some variations in the wind speeds and direction post tsunami, however, there has not been any prominent change observed apart from this.	No significant linkages have been identified.	An appropriate analysis can feed in the directing the high rise development in the region. Optimisation of wind energy also could be made possible with the proper understanding of

	weather monitoring station and its surroundings. Thus, the wind speed assessment would require a further research to understand the changes/variations in the wind parameter of the climate.			the wind of the region. The fishermen communities could benefit, if the variations in the wind speed and direction is known beforehand.

4.6.6 Overall recommendations

Policy

1. A **communication channel could be established between MPCB and IMD** to send weekly alerts to the authorities regarding various issues like rising pollution levels and so on.
2. Stringent measure to regulate the traffic should be undertaken. Actions like **congestion tax during peak hours and in peak zones** should be levied to discourage the use of private vehicles.

Implementation

1. **Electric vehicles system with solar hybrid system** (grid supply acting as backup and for monsoon region) should be explored for the Mumbai region.
    a. Charging station with solar and wind will be much more difficult considering design issues and cost aspects. **The typical charging station of 4 kWp capacity will cost around Rs.10 lakhs (**including solar PV panels, hybrid inverters, installation cost) This charging station will typically charge three golf carts over entire day (10 hours). The golf carts can typically cover distance of about 40 km with average speed of 20-25 km/hr. The electric golf cart with seating capacity of 6-8 people typically costs about Rs 8 - 10 lakhs each. The project will cost about Rs.70 lakhs (Assuming one charging station + six electric golf carts). The project will not have much viability as a commercial application and therefore can be implemented as a demonstration case.
2. All the **major oil companies** having the **petrol pumps should house the electric vehicle charging stations within the MMR limits.**

Environmental Status Report of Mumbai Metropolitan Region

Section
5 Land Resource

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5.1 Land Resource – An Irreversible Transition From Natural to Built-up

Urbanization induces demand for resources. One such limiting resource which is often neglected is the use of Land as a resource. Infrastructure development in the form of rapid construction activities for housing, transportation, industries, commercial activities and so on demand use of land on a large scale and with an increase in population and urbanization land resource is under pressure. As per demographic projections made by UNESCO (United Nations Educational, Scientific and Cultural Organization) almost 60 percent[1] of the world population will be urbanized by 2030. The process of urbanization invites population migration from other smaller cities or rural and peri-urban areas to larger cities, in search of employment, higher living standards, comfort of urban services and access to facilities, which directly requires proper infrastructural development which is again dependent on land resources.

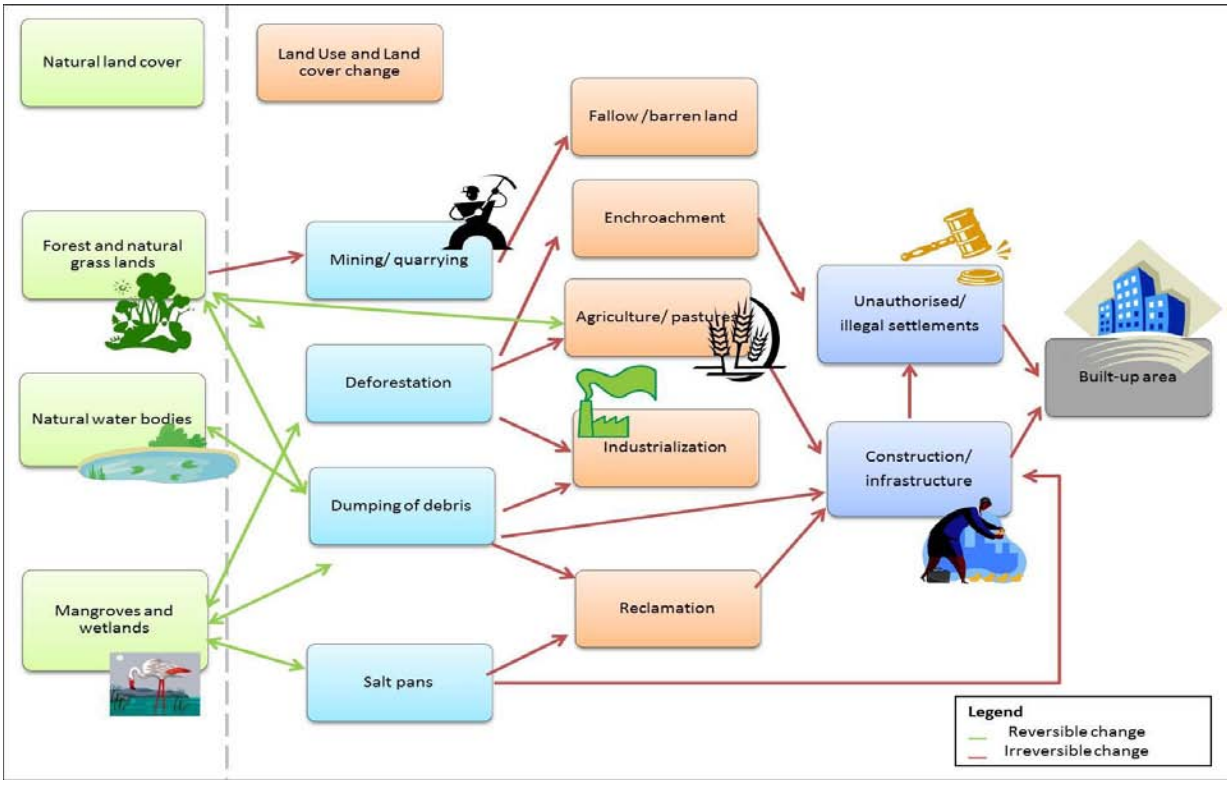
The natural land cover comprises of forests, wetlands and water bodies. However, to meet the human needs the land resource and natural land cover is converted for different use (Figure No. 5-1). This transition of the land use pattern is often unidirectional (Picture No. 5-1) and the natural cover is converted to economic and resource benefits like agriculture, mining, quarrying, salt pans and concretized infrastructure development, which changes the use of land cover for ever. This is often a slow transition from the forest, to agricultural land, through deforestation, which is then left as a wasteland or scrub since agriculture is no more practiced and then that land is taken up for urbanization. However, this conversion now takes rapidly in an organized manner, leading to unsustainable development. This rapid growth would favour economic growth, but directly impact aspects related to food security, microenvironment and socioeconomic status of marginal communities. It is recognized that over 70 percent of the growth currently takes place outside the formal planning process[2].

MMR possesses many important natural features like forests, wetlands and water bodies and has a very unique terrain across its region. However, being one of the most dense and populous metropolis in the globe, the MMR faces a similar threat due to increasing urbanization. The population of MMR is increasing tremendously (197% in 4 decades) and as mentioned in the Drivers section (Volume-I of this report) the increase has shown a doubling pattern in each decade. This has led to a direct increased demand for space for accommodation, industries, infrastructure, ports, dumping of solid waste, quarrying activities, open spaces and so on. Several natural areas, including forests, wetlands and water bodies, have been cleared off for construction activities. Also, since the resource demand of all cannot be easily and it leads to increase in slums.

Given the significance of the land as a resource and the dynamic growth of MMR the status of these resources in MMR is discussed in the following sections. Since the land use and land cover comprise of a lot of aspects and given the complexity of the MMR, a separate approach and methodology was adopted for the data collection and analysis of each of the subsections.

[1] The United Nations World Water Development Report, *Demographic Drivers*

[2] The International Federation of Surveyors, *Rapid Urbanization and Mega Cities: The Need for Spatial Information Management*, Research study by FIG Commission 3, Executive Summary, pps 7



Picture No. 5-1: Unidirectional flow of change in natural land cover in land use (Source: TERI)

5.1.1 Approach and Methodology

The section has been developed considering land as a resource for agriculture, forest cover, and wetlands. The pressure on land resources includes urbanization, quarrying and mining activities, destruction of forest area and wetlands (mangroves, salt pans, lakes, ponds and so on.). Since solid waste dumping also exerts pressure on land resources, a special section in solid waste management in ULB's by MMR has been presented in this section. The specific methodology and data source for each sub-section has been discussed below.

5.1.1.1 Land Use and Land Cover

In this section the change in land use and land cover pattern over a period of 20 years was analysed. The baseline data were considered as per data from the Regional Plan for Mumbai Metropolitan Area, 1996-2011 vis-a-vis the land use and land cover remote sensing data developed by MRSAC (Maharashtra Remote Sensing Application Centre) in the year 2006. The analysis has been done using GIS (Geographical Information System) based shape files procured from MRSAC. The sketch of the work is described below.

The following GIS shape files were procured from MRSAC-

1. Village-level boundary map of 4 districts namely Thane, Raigad, Mumbai city & Mumbai suburban encompassing whole of MMR. The file contains '*Geo -referenced*' shapes (representing the village on GIS platform). The meta-data or the attributes of the file has information on village such as the name of the village, Taluka name, geographical area, perimeter and so on
2. Land use & Land cover (LULC) of above mentioned four districts: The metadata included the area, perimeter and the description of the land (51 different categories of LULC). For the purpose of simplification the land description's was grouped in 6

broader arrays; as Agricultural land, Built-up, Forest, wasteland, Water-body and wetland. A detailed description is given in Table No. 5-1 ;

To generate the MMR map a listing of the villages in MMR was referred from the map of Regional Plan for Mumbai Metropolitan Area, 1996-2011 and through correspondence with MMRDA. Selections of villages were done to carve out the boundary of Mumbai Metropolitan Region. The map thus generated provided a preliminary sketch of the region and was approved by the authority to be used for the purpose of study pertaining to ESR report for MMR. Using the Overlap tool (# *Geo-processing tools>Clip*) of '*QGIS*' software a combined LULC layer of the 4 districts and section of the LULC shape file for the MMR was generated. This new layer represented LULC of MMR along with the attributes. Based on this information the report analyses the status of Agricultural land, Forest land and Wetlands.

Table No. 5-1: Classification of the sub-groups of Land use pattern for the study as per MRSAC

	LULC category					
	Agricultural Land	**Built Up**	**Forest**	**Wastelands**	**Water bodies**	**Wetlands**
LULC sub-group	• Crop Land-Kharif Crop • Crop Land-Kharif Crop-Agri. in. Forest • Crop Land-More than two crop • Crop Land-Rabi Crop • Crop Land-Two crop area • Fallow-Current Fallow • Plantation-Agro Horticulture Plant. • Plantation-Horticulture Plant	• Built Up (Rural)-Built Up area (Rural) • Built Up (Urban)-Commercial • Built Up (Urban)-Mixed Built Up area • Built Up (Urban)-Recreational • Built Up (Urban)-Residential • Built Up (Urban)-Transportation • Built Up (Urban)-Vegetated Area • Scrub land-Dense scrub • Mining / Industrial area-Industrial • Mining / Industrial area Industrial/Mine dump • Mining / Industrial area-Mine/Quarry	• Evergreen / Semi Evergreen-Dense/Closed • Evergreen / Semi Evergreen-Open • Forest Plantation • Littoral/Swamp Forest (Mangrove/Forest Water Swamp)-Dense • Littoral/Swamp Forest (Mangrove/Forest Water Swamp)-Open • Scrub Forest • Tree Clad Area-Dense • Tree Clad Area-Open	• Barren Rocky/Stony waste • Gullied/ Ravinous land-Gullied • Salt affected land-Moderate • Salt affected land-Slight • Salt affected land-Strong • Sandy area-Coastal • Coastal Natural(Mangrove-Open) • Scrub land-Open scrub	• Lakes/ponds -Perennial • Reservoir/Tanks-Dry-Kharif extent • Reservoir/Tanks-Dry-Rabi extent • Reservoir/Tanks-Dry-Zaid extent • Reservoir/Tanks-Perennial • River/Stream -Perennial	• Coastal Manmade • Coastal Manmade(Salt pans) • Coastal Natural • Coastal Natural(Creek) • Coastal Natural(Mangrove) • Coastal Natural(Mangrove-Dense) • Coastal Natural(Mud flats) • Coastal Natural(Salt Marsh) • Coastal Natural(Tidal Area)

Source: As per data attributes shared by MRSAC

5.1.1.2 Agricultural Land

The data attribute for different agricultural land has been used for the data attributes derived from the MRSAC data. The Taluka wise data for production and land under cultivation has been procured from the Agriculture department of Government of Maharashtra. Any other data used in the report have been specified in the source as per the data referred.

5.1.1.3 Forest land and Biodiversity

Since the forest area has been analysed a special section on the forest resource and forest land has been included. Also the highlight of the biodiversity, a natural resource, has been presented based on the report titled 'MMR Biodiversity Project', sponsored and published by MMR – EIS. The information on SGNP (Sanjay Gandhi National Park) and Tungareshwar Sanctuary has been sourced from the Management Plan for SGNP Division for the duration 2013-14 to 2022-23, Forest Department, GoM, unless and otherwise specified in the source.

5.1.1.4 Wetlands

The data for various categories of wetlands in MMR has been retrieved from data attributes shared by MRSAC. Various studies and published papers have been referred to study the coverage of mangroves in the past and the relevant sources have been acknowledged. For the salt pans in MMR the district wise data for the districts of Mumbai, Mumbai Suburban a, Thane and Raigad, as published in the Annual Report of Salt Department, Department of Industrial policy and Promotion, Ministry of Commerce and Industry, Government of India, has been considered. Other references have been acknowledged in the report as relevant.

5.1.1.5 Solid Waste

The data for municipal solid waste generation, collection and management has been compiled from the Environmental Status Reports, Service level Benchmarks compilations, City Sanitation plans, Data posted on the website of Performance Assessment System developed by AIILSG (All India Institute of Local Self Government) and CEPT (Centre for Environmental Planning and Technology) University.

The data for biomedical waste, hazardous waste and E-waste has been sourced from MPCB (Maharashtra Pollution Control Board). The five RO's (Regional Offices) of MPCB namely Mumbai, Thane, Navi Mumbai, Kalyan and Raigad have been considered for the study. The other sources used have been acknowledged as relevant.

5.2 Land Cover

MMR (Mumbai Metropolitan Region) has a variety of land cover types such as the coastal front, mangroves, forest area, hillocks, agricultural land and numerous water bodies within its jurisdiction. Owing to urbanization and development in the region, there is a significant pressure on the land use pattern and its coverage. The existing land use share in MMR, as per remote sensing data obtained from MRSAC, GoM, is presented in Figure No. 5-1. More than 35 percent (1536 sq.km) of the land in MMR is classified as agricultural land and accounts for the maximum share of the land use in MMR. This is followed by land under forest which is almost 21 percent. Being a coastal city, MMR is bestowed with huge sections of wetlands, comprising of mangroves, salt pans, marshes, tidal zones and mud-flats which account for a total of 13 percent (~565sq.km) of the land use.

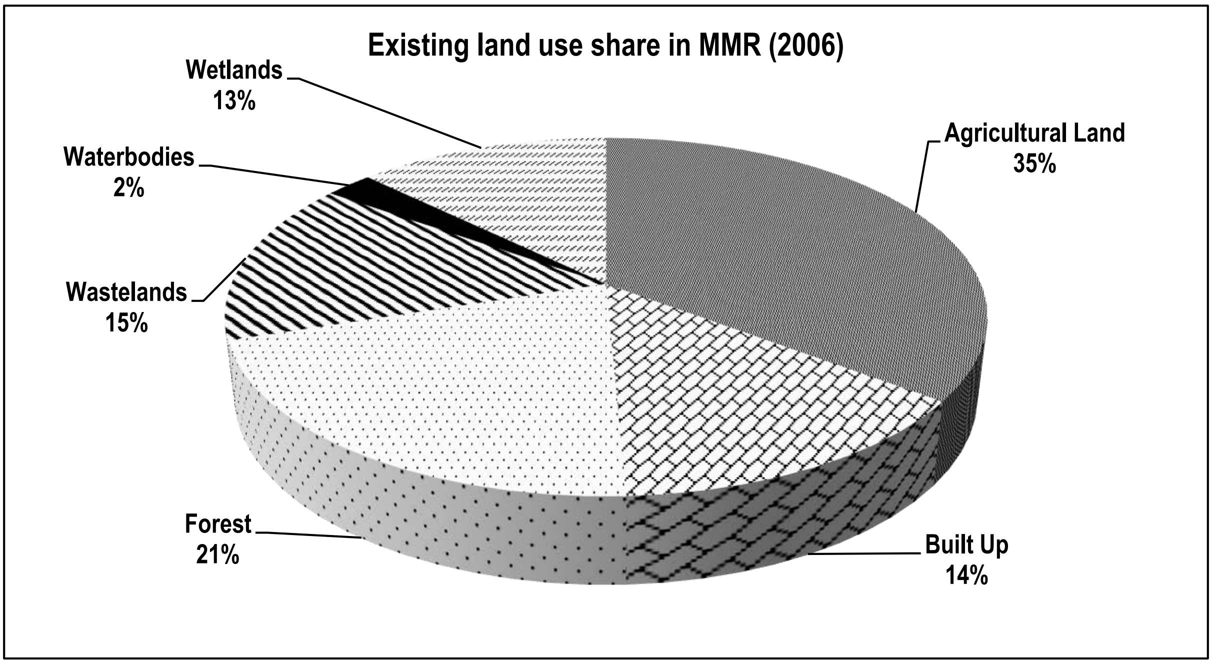
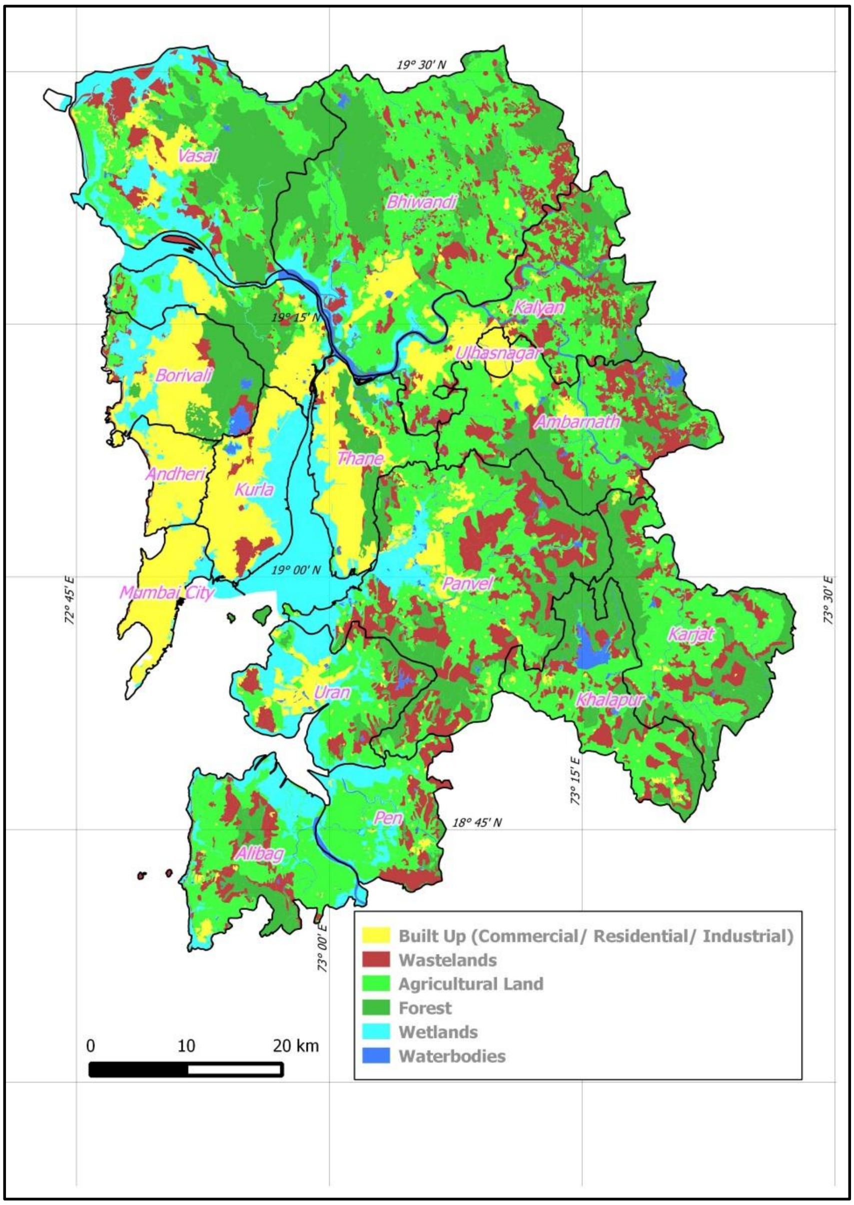


Figure No. 5-1: Existing land use share in MMR (2006)

Source: MRSAC, GoM

As seen in Map No. 5-2, the area under residential, commercial, transportation, recreational and similar categories have been considered under built up area and accounts for almost 14 percent of land use in MMR. It is the built up area which accommodates more than 23 million individuals residing in MMR, thus indicating a high population density, which is, more than 37 thousand persons per sq.km of built-up area[3]. The spatial distribution of existing land use in MMR and the corresponding share of the area have been tabulated in Table No. 5-2.

[3] Population of MMR 2,31,33,424 divided by built up area of 619.2 Sq.km as per data from MRSAC



Map No. 5-1: Spatial representation of existing land use in MMR

Source: MRSAC, GoM

Table No. 5-2: Existing land use share in MMR

Land use type	Area (Sq. Km)	Share (percent)
Agricultural Land	1563.3	35.3
Forest	917.1	20.7
Wastelands	656.2	14.8
Built Up	619.2	14.0
Wetlands	564.7	12.8
Water-bodies	106.5	2.4
Grand Total	**4427.0**	**100.0**

Data Source: As per attributes provided by MRSAC, GoM, 2006

Various ULBs in MMR have varied and unique patterns of land use within their jurisdiction. The municipal corporations account to more than 84 percent share of the built up area. Being the most urbanized corporation MCGM has the highest share of built up area (283.96 sq.km.), accounting to more than 56 percent of the area under its jurisdiction. The built up area within Ulhasnagar Municipal Corporation accounts for almost 97 percent out of the total in its jurisdiction, which is spread across 14 Sq. Km. The share of land use across various ULB's of MMR is tabulated in Table No. 5-3.

The rapidly growing municipal corporations, VVMC and MBMC, still have an open space share of 87 and 82 percent respectively. These regions are rapidly developing and have registered maximum growth in the last 5 years. Given the strategic locations of these corporations, and them being bestowed with resources like mangroves, salt pans, beaches, a sustainable plan for these cities needs to be developed with immediate effect.

Table No. 5-3: ULB wise share of Land use in MMR

	Agricultural Land	Forest	Waste lands	Built Up	Wetlands	Water-bodies	Total
Rest of MMR	**1282.33**	**697.27**	**538.38**	**63.6**	**238.49**	**75.98**	**2891.4**
Municipal Corporation	**211.83**	**195.98**	**97.35**	**521.34**	**320.78**	**27.9**	**1375.18**
BNMC	13.56	1.98	1.84	21.13	0	1.02	39.53
KDMC	47.85	1.09	15.65	34.8	4.4	7.66	111.45
MBMC	17.1	16.18	2.96	18.01	43.14	0.26	97.65
MCGM	7.34	48.06	25.8	283.96	128.69	8.12	501.96
NMMC	17.87	23.38	5.57	64.32	63.93	0.54	175.62
TMC	22.97	36.65	8.61	44.38	15.03	7.32	134.95
UMC	0.06	0	0.01	13.4	0	0.35	13.82
VVMC	85.08	68.64	36.91	41.35	65.59	2.63	300.19
Municipal Council	**69.14**	**23.85**	**20.47**	**34.26**	**5.43**	**2.62**	**155.77**
Alibag MC	0.22	0	0.13	0.51	2.45	0	3.32
Ambernath MC	27.59	0.22	6.08	15.53	0	0.43	49.86
Karjat MC	6.13	0.01	0.87	0.9	0	0.33	8.24
Khopoli MC	9.19	10.36	7.91	2.25	0	0.02	29.73
Kulgaon Badlapur	18.63	5.25	3.76	6.9	0	1.29	35.83
Matheran MC	0	6.4	0	0	0	0.04	6.44
Panvel MC	3.47	0	0	5.73	2.44	0.34	11.97
Pen MC	3.52	1.61	1.71	1.76	0	0.17	8.76
Uran MC	0.4	0	0	0.68	0.54	0.01	1.63
Grand Total	**1563.3**	**917.1**	**656.2**	**619.2**	**564.7**	**106.5**	**4427**

Source: As per attributes provided by MRSAC, GoM, 2006 ***Units: Sq.km***

5.2.1 Forest Land and Biodiversity

5.2.1.1 Status of Forests in MMR

A forest is a land area of more than 0.5 ha, with a tree canopy cover of more than 10 percent, which is not primarily under agricultural or other specific non-forest land use[4]. Forests form an integral part of livelihood for humans for their day to day lives. All the basic needs of humans, such as food, clothing and shelter can be met through forests. Ecologically forests are of great significance as they are an important provider of oxygen. They also help in the process of phytoremediation i.e. they absorb harmful chemicals and pollutants in the soil & also filter the sewage and runoff water. Forest acts as an important air cleansing agents by acting as a carbon sink. Further, they also act as a windbreaker and reduce soil erosion by acting as barriers during floods. They also play an important role by providing food and habitat for a variety of organisms. Thus forests are not only important to human beings but also to a variety of other organisms.

Lately growing urbanization has resulted in severe deforestation reducing the forest covers. Urbanization has impacted forests in various ways as it has caused fragmentation and edge effects further reducing the corridors for animals. Various studies have proved that urbanization has also reduced the diversity of birds and increased bird density favouring only specific species of birds. With habitat fragmentation, many amphibians and reptiles exist in localized distributions rather than one continuous population. Urbanization tends to exclude specialized reptiles and amphibians, while species with broad ecological tolerances and more general habitat are more successful[5]. Thus urbanization plays a significant impact on the forests and its biodiversity by disturbing its natural balance. MMR is one such example where urbanization has reduced the forest cover to a large extent thereby affecting the biodiversity of the area. Thus it is important to study the existing forest land and biodiversity of this region for future conservation.

MMR region falls under the tropical zone known for being biologically diverse than the temperate regions[6]. Given its complex coastal region of the Konkan, as well as its mountainous traits shared with the Western Ghats, the MMR region has several zones providing a conducive climate for tree species to grow in. The forest type found in MMR typically consists of tropical semi-evergreen, tropical moist deciduous, tropical dry deciduous, littoral & swampy forest and mangrove forest[7].

MMR has several Protected Areas (PA's) (Table No. 5-4) within its limits which act as the last refuge to the natural ecosystems of the region. There are 3 PAs within MMR and 1 eco-sensitive zone. In addition, 2 PAs lie along the periphery of MMR. In order to get an overview of the region with respect to its natural ecosystems, an attempt has been made to identify the PAs as per the predominant composition of its forest type and other ecosystems.

4 http://www.cbd.int/forest/definitions.shtml
5 http://www.srs.fs.usda.gov/sustain/report/terra3/terra3-13.htm
6http://www.wienslab.com/Publications_files/Wiens_et_al_2009.pdf
7 The forest type is as per the classification provided in "Vegetation types of India following Champion and Seth 1968" (http://www.sikkimforest.gov.in/docs/Forestry/Vegetation percent20Types.pdf) Please note that mangrove forest are no considered in this type of classification however have been included in this report for its significance to the region.

Table No. 5-4: Protected Areas and prominent forest ecosystems in and around MMR[8,9]

Sr. No.	Protected Areas (PA)	Year of notification	Area (sq. km)	Semi-evergreen	Moist deciduous	Dry deciduous	Littoral & Swampy	Mangrove
1.	Sanjay Gandhi National Park, Borivali	1996	86.59	NA	✓	✓	✓	✓
2.	Karnala Bird Sanctuary, Karnala, Panvel	1968	12.11	NA	✓	✓	NA	NA
3.	Tungareshwar Wildlife Sanctuary, Vasai	2003	85.70	✓	✓	✓	NA	NA
	Eco-sensitive zone:							
4.	Matheran Eco-sensitive Zone, Karjat	2002	214.73	✓	NA	✓	✓	NA
	PAs on periphery (outside of MMR):							
5.	Tansa Wildlife Sanctuary, Thane	1970	304.81	NA	✓	✓	NA	NA
6.	Phansad Wildlife Sanctuary, Alibaug	1986	69.79	✓	✓	NA	✓	NA

Source: Forest Department Government of Maharashtra[10] and Champion, H.G., and Seth, S.K. 1968. A Revised Survey of the Forest Types of India, Government of India, New Delhi

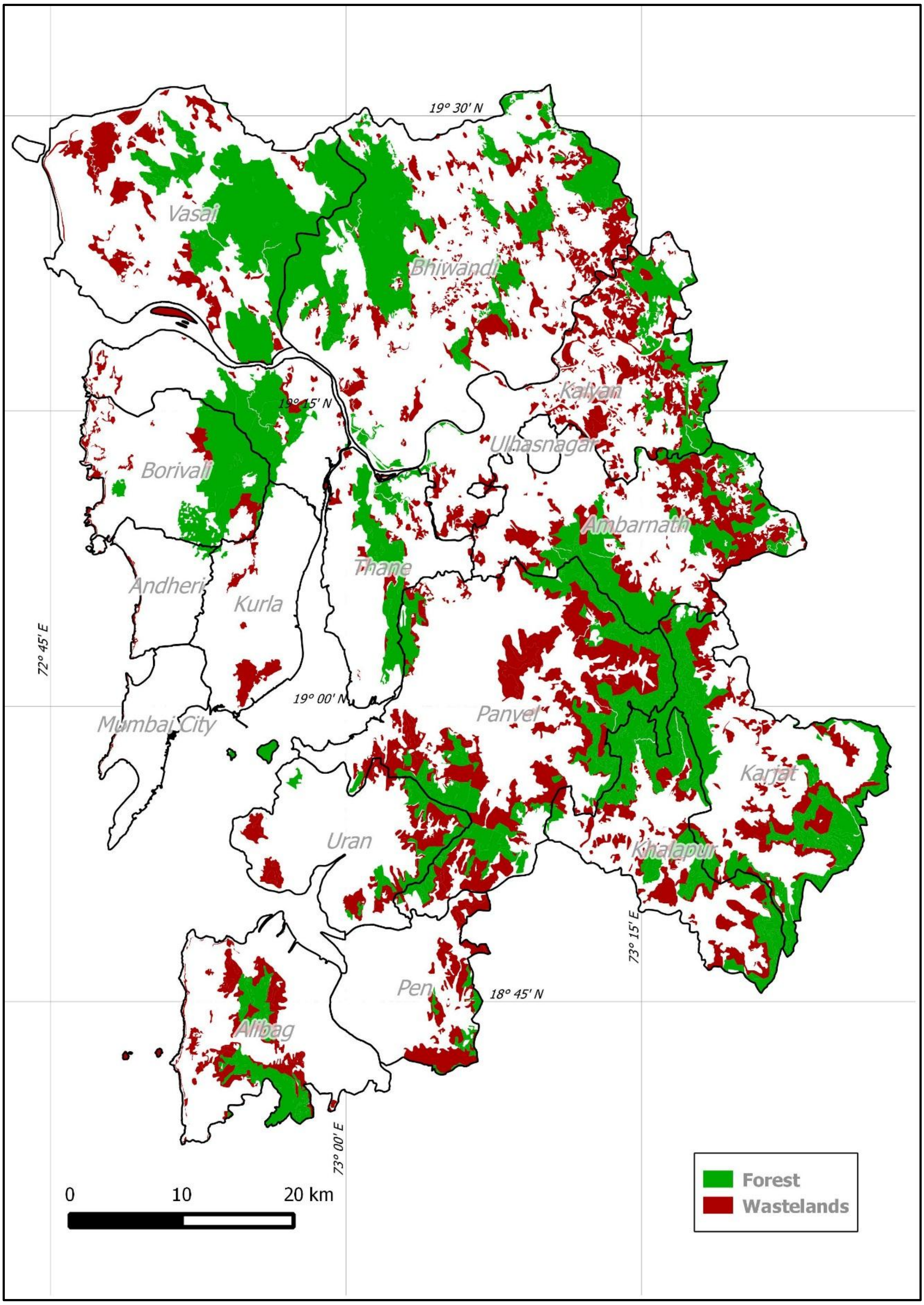
8 Here, the classification of the ecosystems is primarily based on the type of vegetation cover.
9 It is important to note that given the different biogeographic factors within MMR, multiple types of forest ecosystems may be found within a particular area.
10 http://www.mahaforest.nic.in/fieldoffice/internal.php?MID=2&oid=44

The forest cover of MMR is estimated to be around 21 percent (~917sq.km) of total land area. The difference in forest cover and green cover is because of the fact that forest cover generally comprises of protected areas and reserved forests, constituting mainly the natural forest growths, whereas the green cover constitutes to trees natural and/or planted, and may not constitute to a forest ecosystem. Other than the forest ecosystem, MMR also proves to be a home for a variety of habitats such as grass and scrub, agriculture and plantations, coastal wetlands (creeks, estuaries, and mangroves), freshwater wetlands (lakes, ponds, rivers) and urban parks/gardens/avenues. The PA's and other habitats prove to be a home for a variety of faunal species consisting of mammals, birds, herpeto-fauna (class of amphibians and reptiles) and so on, of which many are found to be belonging to the International Union for Conservation of Nature and Natural Resources (IUCN) red data book categories and also endemic to the western Ghats.

In 1987, the forest cover of MMR accounted for almost 1142 sq.km, i.e. more than 1/3rd area of MMR was under forest cover. However, there has been a drastic change in the same and the absolute area under forest cover has reduced by around 225sq. km. The overall share of forest area with respect to the total MMR area has decreased by 5 percent, while in comparison to the forest cover there has been a decrease of nearly 25 percent in the last 20 years. The forest areas are usually lost due to deforestation, forest fires, and encroachment, the deforested area is then left unused and is left as a wasteland for a long time before taking it up for development and concretization. As seen in Map No. 5-2, the majority of the forest areas is patched with by wastelands, indicating a slow transition from forest cover to wastelands.

An anthropogenic activities like encroachment in forest land is a sensitive issue. As per data from SGNP, the period from December 2008 to October 2009 shows 9.9 sq. km. of forest area has been encroached in Thane division. Similarly, the PAs (Protected Areas) within MMR are facing an imminent threat of encroachment along the buffer zone. About 2 sq. km. (2 percent of the total area) of reserved forest land of SGNP has been encroached upon[11] leading to destruction of natural habitats as well as an increase in man-animal conflict. Forest land use change is thus a serious issue in MMR.

[11] http://sgnpmumbai.com/problems.php



Map No. 5-2: Forest cover and Wasteland in MMR

Source: As per data procured from MRSAC, GoM

Sanjay Gandhi National Park (SGNP) and Tungareshwar

SGNP popularly known as Borivali National park covers an area of 6176.88 hectares of reserved forest and 8.581 hectares of protected forest. It is one of the few major national parks existing within metropolis limits and is most visited tourist destination. This area represents unique and fragile "fenced island" ecosystem with very high anthropogenic and biotic pressures and it belongs to one of the least represented biogeographic zone i.e. Malabar Coast of Western Ghats. The Park also contains the 2,000-year-old Kanheri Caves, a complex of 104 Buddhist caves carved out of a hillside. SGNP belongs to 5A- Malabar plains. The present coverage of Malabar plains is only 0.4 percent against the proposed area of 1.1 percent by the Wildlife Institute of India, Dehradun in 1988. No other national park exists in this biogeographic zone except SGNP hence it is unique. In the last few decades, there has been a massive loss of the area of this Park to the illegal constructions and slums.[12]

Animals act as natural indicators of the ecosystem and its environment. All the statistical graphs indicate decline in population of animals during the year 2012. The reason seems to be clear rise in the anthropogenic pressures which has severely disturbed the natural balance causing a decline in population of animals in SGNP.

It is home to 59 species of mammals, 283 species of migratory land and water birds, about 145 species of butterflies, 50000 species of insects, 76 species of herpeto fauna (Reptiles and amphibians,)[13], and over 1000 species. of plants[14]. Sanjay Gandhi National Park harbours, populations of large mammals such as Leopard (*Panthera pardus fusca*), Chital (*Axis axis*), Barking deer (*Muntiacus muntjak*), Sambar (*Rusa unicolor*), and primates such as Langur (*Semnopithecus sp*.) and Macaques like Bonnet macaque (*Macaca radiata*) and Rhesus macaque (*Macaca mulatta*) (Table No. 5-4)

Carnivores are known as a keystone species playing an integral role maintaining healthy ecosystems by regulating population of the lower tropic level consisting of herbivores and other small mammals. The population of leopard as per census conducted by forest department has seen a decline in the past few years, which has rather been steep in the past 2 years. Extinction may result soon, if proper conservation measures are not undertaken, which ultimately may result in disturbance of food cycle and the food web. Also other animals such as deer's which play the part as primary consumers also show a declining trend. Also omnivores such as mongoose and wild boars show a decreasing trend as per the Management Plan for SGNP Division for 2013-14 to 2022-23. However the reasons for the same could be variable. Thus, all the animals included in the census can be seen to be impacted. The reason for the same is due to the growth of urbanization, poaching due to lack of monitoring, forest fires and deforestation.

[12] http://www.indiawaterportal.org/sites/indiawaterportal.org/files/environmental_conflicts_in_coastal_metropolitan.pdf

[13] http://www.mumbaikarsforsgnp.com/docs/Reptiles_and_Amphibians_of_SGNP_Mirza percent20and_Pal_2008.pdf

[14] Preliminary study on the diet composition of the leopard (*Panthera pardus fusca*) in Sanjay Gandhi National Park

Table No. 5-5: Population of animals in Sanjay Gandhi National Park as per census conducted by Forest Department from year 2009, 2011 and 2012(Census was not conducted for the year 2010)

Sr. No.	Name of Animal	Scientific Name	2009	2011	2012
1.	Leopard	*Panthera pardus fusca*	23	21	8
2.	Spotted Deer	*Axis axis*	390	494	-
3.	Barking Deer	*Muntiacus muntjak*	21	12	5
4.	Monkey	*Macaca spp.*	435	530	239
5.	Langur	*Semnopithecus dussumieri*	280	305	
6.	Wild Boar	*Sus scrofa*	26	24	52
7.	Hare	*Lepus nigricollis*	21	07	9
8.	Mongoose	*Herpestesed wardsii*	14	19	1
9.	Jungle Fowl	*Gallus spp.*	59	106	12
10.	Peafowl	*Pavo cristatus*	28	35	1
11.	Sambar Deer	*Rusa unicolor*	27	37	17
12.	Palm Civet	*Paradoxurus hermaphroditus*	04	Nil	-
13.	Jungle Cat	*Felis chaus*	02	07	-

Source: Management Plan for SGNP (Sanjay Gandhi National Park) Division for 2013-14 to 2022-23, Forest Department; GoM

Tungareshwar Wildlife Sanctuary

Tungareshwar wildlife sanctuary, which neighbours SGNP, is located in between Virar and Vasai. Due to the growing concerns related to conservation of biodiversity in the Mumbai area, this area was declared as a sanctuary in 2003. The total area of the sanctuary is around 85.70 sq. km. The sanctuary is a famous destination for trekkers, bird watchers and so on. Tungareshwar temple also proves to be a famous destination for Lord Shankar devotees[15].

The biodiversity of this area is unexplored and not extensively studied, but it can be assumed to be similar with SNGP due to same ecosystems and availability of corridors. The major forest types present in this sanctuary are semi evergreen and moist deciduous forests supporting the related diversity like:

1) **Flora of sanctuary:**

- Approximately 800 species of plants are present in the sanctuary and is majorly dominated by Kadamba (*Neolamarckia cadamba*), Teak (*Tectona grandis*), Karanj (*Pongamia pinnata*), Shisam (*Dalbergia sissoo*) and species of *Acacia*, *Ziziphus*, *Euphorbia*, Palas (*Butea monosperma*).
- Karvi (*Strobilanthes callosa*) which blooms once in 7 years is also found in this sanctuary.

[15]http://wikimapia.org/19310748/Tungareshwar-Wildlife-Sanctuary

- *Cordyceps militaris*, a parasitic, fungal species was first time collected from Tungareshwar Sanctuary during July 2010[16].

2) Fauna of Sanctuary:

- The sanctuary is home to approximately 20 species of mammals and 150 species of bird population.
- The sanctuary is also famous for harbouring a small population of about 5 (Table No. 5-6) leopards (*Panthera pardus fusca).*
- The area is quite rich in its herpeto fauna with approximately 60 species of reptiles and 14 species of amphibians are reported to be present.[17].
- 127 species of butterflies are also present in the sanctuary.
- The census figures are doubtful as they were not calculated using scientific approaches[18]. But still a decreasing trend in the population of all the animals can be clearly seen. The reason for the same is due to the anthropogenic pressures similar with SGNP.

Table No. 5-6: Population of animals in Tungareshwar Wildlife Sanctuary as per census conducted by Forest Department from year 2009 to 2011

Sr. No.	Name of Animal	Scientific Name	2009	2011
1.	Leopards	*Panthera pardus fusca*	5	5
2.	Spotted Deer	*Axis axis*	24	13
3.	Barking Deer	*Muntiacus muntjak*	11	04
4.	Monkey	*Macaca spp.*	128	37
5.	Langur	*Semnopithecus dussumieri*	90	41
6.	Wild Boar	*Sus scrofa cristatus*	28	23
7.	Hare	*Lepus nigricollis*	31	12
8.	Mongoose	*Herpestes edwardsii*	18	10
9.	Jungle Fowl	*Gallus spp.*	20	10
10.	Peafowl	*Pavo cristatus*	13	05
11.	Sambar	*Rusa unicolor*	-	-
12.	Palm Civet	*Paradoxurus hermaphroditus*	-	-
13.	Jungle Cat	*Felis chaus*	Nil	01

Source: Management Plan for SGNP (Sanjay Gandhi National Park) Division for 2013-14 to 2022-23 Forest Department; GoM

(Census was not conducted for the year 2010)

[16]http://bionanofrontier.org/wp-content/uploads/2013/06/VOL5-2JULY-DEC.2012/224-225 percent20 percent20VISHAL percent20KAMBLE.pdf
[17]http://www.mumbaikarsforsgnp.com/docs/Reptiles_and_Amphibians_of_SGNP_Mirza percent20and_Pal_2008.pdf
[18]http://envis.maharashtra.gov.in/envis_data/?q=biodiversity_11

Karnala bird Sanctuary

The Karnala Bird Sanctuary is located in Panvel Taluka of Raigad District (18°54′31″N and 73°6′9″E), outside Mumbai near Matheran and Karjat. The sanctuary is situated on the banks of Patalganga River. The sanctuary is quite small with an area of 4.48sq. km but along with the Sanjay Gandhi National Park and Tungareshwar sanctuary is one of the few sanctuaries to be within reach of the city of Mumbai. The area was declared as wildlife sanctuary in year 1968[19].The sanctuary is present around the Karnala Fort which has a lot of historical significance. The sanctuary is also known for the thumb shaped pinnacle on top of the fort which is a favourite spot for rock climbers. The bird sanctuary is a popular destination for avid bird-watchers, trekkers and paradise for butterfly watchers in the Mumbai area. In just 3 months, a total of 78407 tourists were recorded to visit the park in the year 2012[20]

The sanctuary is home to over 150 species of resident and 37 species of migratory birds visiting the sanctuary during winter. Three uncommon birds i.e. Ashy Minivet (*Pericrocotus divaricatus*), three toed kingfishers (*Ceyx erithaca*) and Malabar Trogon (*Harpactes fasciatus*) have been sighted here[21].Many animals like hyena (*Hyaenidae carnivora*), fox (*Cannis vulpes*), jackal (*Canis aureus*), wild boar (*Sus scrofa*), and monkeys (*Macaca spp*.) are also seen[22].

In future the sanctuary may face serious threats from Navi Mumbai Airport project as it is just 9.5 km away from the sanctuary. Usually bird strikes occur when an airport is in close vicinity with a high bird density area[23]. Airports also prove to be a reason for light pollution which may impact the navigation of migratory birds.

Matheran - Eco-sensitive Zone

The Western Ghats of India is one of 34 biodiversity hot spots all over the world.*24*. Matheran is the smallest hill station of India situated in the Western Ghats. Geographically, it is located at an elevation of 800m above sea level and lies between 18° 55′N Latitude and 73° 51′E Longitude to the west of the main range of Western Ghats. It is declared as an ESZ in 2001 by the Ministry of Environment and Forests (MoEF), Government of India due to the pressures from various environmental organizations. Tropical evergreen forest is the major forest type found in Matheran which serve to be a home for a variety of flora and fauna of which many are endemic. It is also a high level lateritic plateau, which encompasses the rocky outcrop habitat*25*. Matheran is the only automobile free hill station resulting in less vehicular pollution. The forest area of Matheran is rich in its biodiversity as it supports evergreen forest of *Memecylon-Syzigium-Actinodaphne* type*26*.Matheran is also a place for 3 tribal communities like the gavlis, thakars and katkaris.

[19] http://www.envfor.nic.in/sites/default/files/protected-area-network.pdf
[20] http://www.maharashtratourism.gov.in/mtdc/HTML/MaharashtraTourism/images/pdf/TourismStatisticsofMaharashtraApl2011_Mar2012.pdf
[21] http://en.wikipedia.org/wiki/Karnala_Bird_Sanctuary
[22] http://shodhganga.inflibnet.ac.in/bitstream/10603/6703/11/11_chapter percent206.pdf
[23] http://www.aef.org.uk/uploads/PlanningGuide2.pdf
[24] http://www.nature.com/nature/journal/v403/n6772/fig_tab/403853a0_T6.html
[25] http://threatenedtaxa.org/ZooPrintJournal/2013/March/o337226iii133935-3962.pdf
[26] http://ces.iisc.ernet.in/hpg/envis/cesecolFH.html

Considering such unique factors Matheran was declared as an eco-sensitive zone on July 2001 comprising an area of 241sq. Km which proved to be helpful for conservation and reduction of threats through formation of high level monitoring committee[27].

1) Flora of Matheran

- 945 species of plants are approximately present at Matheran consisting of various herbs, shrubs, trees, fungi and lichen species.
- Tree species commonly seen on the plateau are *Oleadioica*, *Mangifera indica*, *Eugenia jambolana*, *Ficus glomerata*, *Heterophragma roxburghii*, *Bridelia retusa* and *Memecylon umbellatum*.
- Predominant tree species on the slopes are *Terminalia tomentosa*, *Lagerstroemia parviflora*, *Adina cordifolia*, *Garuga pinnata*, *Dillenia pentagyna*, *Pongamia glabra*, *Schleichera trijuga*, *Bombax malabarica* and so on[28].
- Several medicinal herbs and shrub species are also present like *Clorodendrum spp*.
- A variety of ground orchids like *Habenariaspp*.is also found which is endemic to Western Ghats.

2) Fauna of Matheran

- Matheran is rich in biodiversity, with a lot of faunal diversity, supporting approximately 74 species of birds, 48 species of butterflies, 20 species of mammals and 21 species of herpeto-fauna.
- It is also a home to endangered endemic mammal species such as *Ratufa indica elphinstonii* (Giant squirrel), which is Scheduled-I species and also the state animal of Maharashtra[29].
- Caecilians (type of Amphibian) like *Indotyphlus battersbyi* which comes under data deficient category as per IUCN red rata books is also present here.
- Various migratory birds also visit Matheran.
- Trapdoor tarantula spider *Haploclastus validus* was described from Matheran[30].
- Vulnerable species of frogs endemic to Matheran are also present like *Indirana leithi*[31].
- Regular sighting of leopards (*Panthera pardus fusca)* are also reported by the locals.

Current threats to Biodiversity[32]:

1) **Tourism**: Matheran is a very famous tourist spot for the people of Pune and Mumbai due to its proximity. Each year increase in tourist population has been reported which has indirectly resulted in deforestation for the construction of new hotels, shops, buildings and also an issue of non-degradable solid waste generation. Other indirect threat is in terms of wildlife road kills happening due to heavy vehicular traffic due to increased tourism.

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[27]http://assets.wwfindia.org/downloads/indias_notified_ecologicallysensitive_areas.pdf
[28]http://ankurpatwardhan.com/esamatheran.pdf
[29]https://www.google.co.in/search?q=medicinal+plants+on+kass&hl=en#hl=en&q=Status+and+Distribution+of+Malabar+Giant+Squirrel+Ratufa+indica+in+Western+Ghats+of+Maharashtra percent2C+India
[30]http://scholar.google.co.in/scholar?hl=en&as_sdt=0,5&q=scorpions+of+matheran
[31]http://www.zoosprint.org/zooprintjournal/2002/march/735-740.pdf
[32]http://ankurpatwardhan.com/esamatheran.pdf

2) **Occupational Shift**: People have completely shifted their occupation to tourism, which was earlier agriculture.

3) **Natural threats**: the major natural threat faced by Matheran is severe landslides[33].

4) **Loss of habitat**: Deforestation has resulted in loss of corridors. Scarce corridor can be seen in between Matheran and Karnala bird sanctuary.

5.2.1.2 Status of Biodiversity in MMR

Forests:
The overall forest habitat biodiversity comprises of nearly1484 species of flowering plants, 52 species of mammals, 169 of birds, 64 of herpeto-fauna (52 reptiles and at least 12 amphibians) and about 115 of butterflies.

Grass and scrub:
These habitats were spread over 2,707 sq. km or 64 percent of the land area under MMR. This remains the most seriously affected habitat type across the MMR, with an estimated 80 percent of its original extent having been lost or severely degraded.

Agriculture and plantations:
The biodiversity for the MMR Grass/scrub and agriculture/plantations habitat complex comprise of at least 614 species of plants, 40 species of mammals, 176 bird species, 44 species of herpeto-fauna (40 reptiles, 04 amphibians) and about 90 of butterflies.

Coastal wetlands (creeks, estuaries, mangroves):
This habitat covers 358 sq. km or about 8 percent of the total area under the MMR. Altogether, an area of about 95.43 sq. km, i.e., 2.25 percent of the MMR area was under mangroves in the year 1991. The biodiversity of the MMR's coastal wetland habitat, along with the creeks, comprises of at least 300 species of flora, over 200 species of marine fauna, including about 160 of marine fish, about 122 bird species, at least 15 of herpeto-fauna and about 40 of butterflies.

Freshwater wetlands:
This habitat covers 78 sq. km or about 2 percent of the total area under the MMR. The reported biodiversity for freshwater wetland habitat comprise of about 90 species of plants, though with very few species of aquatic flora, 88 species of fish, 07 species of mammals, 120 bird species and 15 species of herpeto-fauna.

Urban built-up areas, parks/gardens/avenues:
This habitat covers 523 sq. km or about 12 percent of the total area under the MMR. The biodiversity for the urban habitat comprise of at least 761 species of plants, 18 species of mammals, more than 80 bird species, 20 species of herpeto-fauna, and nearly 100 species of butterflies.

[33] http://matheran.mumbaigetaways.com/weather.html

Flora

MMR is rich in its floral diversity encompassing around 1484 species of trees, shrubs, herbs and so on. Several habitats serve as a natural haven for a number of native floras. The urban flora (township vegetation) of MMR comprises of at least 828 species of higher plants, the angiosperms or flowering plants. A very distinct pattern is evident across the urban areas of the MMR, especially ornamental and exotic trees that have become a common part of the MMR.

But some areas in MMR are subjected to issues such as exotic plants and monoculture, which means extensive plantation of a single species. An example of extensive monoculture plantation is at the foothills of Matheran near a village called Jummapatti, where a hillside was vegetated using *Accacia auriculiformis*, an exotic species from Australia. Large plantations of exotic species modify the native flora and fauna substantially*34*, giving the notion of a green forest which is often devoid of biodiversity. Pollination and seed dispersal via insects, birds, or wind can also accidentally introduce exotic species in natural forests, leading to their permanent establishment and spread, affecting the natural forest growth of an area.

The exotic species of trees of preferences as identified during preliminary survey include *Accacia auriculiformis*, *Delonix regia*, *Peltoforum pterocarpum*, *Caesalpinia spp*., *Samanea saman*, and *Glyricidia maculata*. Although data for sites of plantation within MMR are not available, the plantation of the above mentioned trees was commonly undertaken in the past for beautification and to increase the green cover of the region. The Forest Department has undertaken plantation of indigenous plants such as Teak (*Tectonagrandis*) and Khair (*Acacia catechu*) in areas around Sanjay Gandhi National Park[35].

Recommendation:

It is important to undertake plantations using native trees which are known to grow in the climatic conditions of MMR. Tree plantation on wastelands and for beautification should be undertaken with a mixture of a variety of native trees.

MMR has a large number of coastal and marine ecosystems such as estuaries, salt marshes, bays, creeks, sandy beaches, mud flats, marshes and mangrove forests that support variety of migratory birds like Flamingo's (*Phoenicopterus spp*.), various ducks, other waders and so on. Thane creek which is designated as an Important Bird Area is a part of this region. Thus such important areas should be conserved on priority basis which proves to be important for migratory birds.

Birds

About 413 species of birds have been documented within MMR[36], with an addition of two species, one of which, the Ashy Minivet, sighted in Sanjay Gandhi National Park in 2012 after 47 years[37]; and a record of Orange Breasted Green Pigeon in 2012, a new species for

[34] htt1615p://www.ibiblio.org/london/agriculture/general/1/msg00074.html

[35] Management Plan for Sanjay Gandhi National Park Division. 2013-14 to 2022-23. Pp. 17

[36] SunjoyMonga. 2003. Birds of Mumbai. ISBN 81-7508-391-3

[37] http://articles.timesofindia.indiatimes.com/2012-02-27/flora-fauna/31103695_1_birding-hotspots-hsbc-mumbai-bird-race-amateur-bird

Sanjay Gandhi National Park[38]. MMR thus harbours about 68 percent of bird species found in Maharashtra. According to one study, about 77 species of birds have been recorded in Uran area[39], a Special Economic Zone, which contains estuarine ecosystems comprising of mangroves, mudflats, salt pans, and paddy fields. A study titled "Study of Biodiversity of IIT-Bombay Campus" found 104 species of birds within IIT-Mumbai campus[40], and another study recorded 76 species in Aarey Milk Colony[41], both of which are adjoining the Sanjay Gandhi National Park.

Reptiles and Amphibians

The reptilian fauna of MMR comprises of 45 species of serpents belonging to 8 families, 19 species of saurian (lizards) of 7 families, 1 species of crocodile and 8 species of testudines (turtle, terrapin, tortoise) of 5 families. All the other key forest habitat sites reported between 28 and 41 species of reptiles. The grass, scrub and agricultural habitats across the MMR harbour 38 species of reptiles. This includes 27 species of snakes and 11 of saurians. Wetland habitats reported 22 species of reptiles for these habitats. This includes 13 species of snakes, 1 lizard species, 1 crocodile and 7 species of terrapins and turtles. One of the two main divisions of the herpeto-fauna is the Amphibians. In the MMR, a total of 16 species of amphibian were reported. Of these, 11 species were observed in the hilly areas and hill ranges, with the Matheran Range having the highest diversity. According to the Forest department planning report, 38 species of reptiles and 9 species of amphibians have been recorded in Sanjay Gandhi National Park[42].

Recommendation: As these species are facing the threats of road kills and loss of habitat, more awareness should be generated about these lesser studied fauna specifying their significance in the ecosystem.

Invertebrates

Studies related to invertebrates within MMR are largely restricted to insect orders such as Lepidoptera (more specifically butterflies) and Arachnida (more specifically spiders and scorpions). There exists a lacuna with respect to studies pertaining to some of the economically important insect groups such as Diptera (consisting of house flies, mosquitoes, and fruit flies), Hymenoptera (bees, wasps and ants), and Coleoptera (beetles and weevils). Studying the invertebrate fauna is of utmost importance because they play a pivotal role in the food web and are economically important as disease-agents, pests on crops, as well as natural pest-controllers of other insects.

[38]http://articles.timesofindia.indiatimes.com/2012-11-29/flora-fauna/35434093_1_bird-survey-green-pigeon-borivli-park

[39]Malwadkar, A. M. 2011. A contribution to avifauna of Uran (Raigad), Maharashtra, India.*In* Journal of Aquatic Biology. 26(1). Pp. 21-25

[40]GoldinQuadros, GauriGurav,KaustubhBhagat, Alok Chorghe, Aniruddha Dhamorikar, Kashmira Khot andManoj Nagarkar. 2009. Report of the Study of the Biodiversity of IndianInstitute of Technology Bombay Campus. Published by WWF-India MSO for IIT Bombay.Pp158

[41]Mirza, Zeeshan; Sanap, Rajesh. 2010. Biodiversity of Aarey milk colony and film city.

[42]Management Plan for Sanjay Gandhi National Park Division. 2013-14 to 2022-23. Pp. 18

A total of 153 species of butterflies have been documented from MMR. Out of which, 140 species of butterflies have been recorded in Sanjay Gandhi National Park, constituting about 8 percent of butterfly species recorded in India. Patwardhan and Kurve (2008) mention that 95 species were recorded by Aitkin and Comber in 1903, 105 species were recorded by Best (1951), and they recorded 123 species in Thane city[43]. In addition, 5 new species of butterflies were added to the list in 2010[44], taking the number of species to 145. According to one study, urban areas such as Maharashtra Nature Park, harbours 72 species of butterflies[45]. In case of spiders, Bastawade and Khandal (2006) state that there have been no reports of Aranae (spiders) of Sanjay Gandhi National Park. The study records 61 species of spiders belonging to 18 families[46]. In addition, about 13 species have been added to the checklist[47]. In case of scorpions, 8 species have been recorded in Sanjay Gandhi National Park, including the recently discovered *Lychas aareyensis* in 2010[48].

Mammals

A total of 71 species and sub species of mammals have been recorded from MMR. Large mammals like the leopard, deer's and so on are mostly confined to the protected areas present in MMR. Lesser faunal species such as bats, rodents and so on are less studied from MMR area. Mammalian diversity is currently facing major impacts due to habitat loss/ degradation/ disturbance, poaching / hunting and superstitions and roadkills & electrocution.

Freshwater Fish

Around 88 species of primary and secondary freshwater fish representing 34 families are recorded in the MMR, with Cyprinidae family being the dominant, accounting for almost 36 percent of this fish fauna. The other key families are Cichlidae (10 percent) and Bagridae (5 percent). Of the 88 species reported, 63 are known to be indigenous to India. Of these, 16 species observed are known to be endemic to the Western Ghats. The freshwater fishes are currently facing the threats from exotic species of fish which have been introduced by the people either accidentally or purposely.

Marine Biodiversity in MMR

MMR has a large number of coastal and marine ecosystems such as estuaries, salt marshes, bays, creeks, sandy beaches, mud flats, marshes and mangrove forests that support a rich biodiversity. Under marine ecosystem, salt tolerant grasses associated with mangrove habitats are found along Thane creek and some other areas of MMR. Various phyto-planktons, zoo-planktons, marine benthic organisms, fishes have been documented along the MMR coast line.

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[43]Patwardhan, Amol; Kurve, Poonam. 2008. Preliminary study of butterfly diversity from Thane city and forests around Thane, Maharashtra. *In*Proceedings of the seminar on wonderful world of insects. Pp. 53

[44]Patwardhan, Amol. 2010. Sightings of rare butterfly species and a new record for Sanjay Gandhi National Park, Mumbai and Tungareshwar Sanctuary, Thane, India. *In* Zoos' Print 25(5). Pp. 19-20

[45]Gokarankar, Prashant; Chorge, Sachin; Rajbhar Anil. 2008. Butterfly biodiversity in Maharashtra Nature Park, Dharavi, Mumbai. *In*Proceedings of the semina r on wonderful world of insects. Pp. 63

[46]Bastawade, D. B; Khandal, Dharmendra. 2006. Arachnida: Aranae (Spiders). *In* Fauna of Sanjay Gandhi National Park (Invertebrates).Conservation Area Series 26. Pp. 139-184. Retrieved from http://www.mumbaikarsforsgnp.com/docs/Arachnida_Araneae_Spiders.pdf

[47]AniruddhaDhamorikar, unpublished data

[48]Mirza, Zeeshan; Sanap, Rajesh. 2010. Description of a new species of scorpion of the genus Lychas C. L. Koch, 1845 (Scprpiones: Buthidae) from Maharashtra, India. *In* Journal of Threatened Taza.2(4). Pp. 789-796.

Phytoplanktons and Zooplanktons

Jaiswal (2002) studied the phytoplankton diversity of 4 locations, namely Uran estuary, Thane creek, Ulhas river estuary and Dharmatar creek. A total of 52 species were recorded from all the areas. Highest phytoplankton diversity was found in Dharmatar creek.[49]. A number of studies on phytoplankton were conducted in 1999-2000 by NIO at Thane Creek, Ulhas River estuary, Versova Creek and Mahim Creek under COMAPS (Coastal Ocean Monitoring and Prediction System). Studies on zooplanktons are present from the Dharmatar Creek which indicates a high diversity of these species[50].

Fishes

MMR area is famous for its fish due to the presence of the fisher community known as "Koli" since the historic times. Thus, fishing is one of the main livelihood options of MMR. 32 varieties of fish such as shrimps, Bombil (*Harpodonneherias)*, Ribbon fish, *Otalithes*, pomfrets, *Anchoviella*, mackerel and cattle fish put together account for over 70 per cent share in total fish production[51]. A total of approximately 206 species of marine fish can be seen in MMR, which comprise 161 species of fin-fish and 45species of shellfish. The population of fishes visiting MMR coast seems to be reducing due to the growing pressures. Studies dealing with proper management of coastal issues or policy development lacks for this region, which results in a bit of mismanagement of the available fish resources.

Recommendation:

Currently the fishes face severe threat from 2 important causes namely overfishing and climate change. It has been reported by Central Marine Fisheries Research Institute (CMFRI) that common fishes such as Bombay duck and Pomfret are decreasing from the waters due to overfishing and rise in water temperature. Thus such issues need to be addressed urgently.

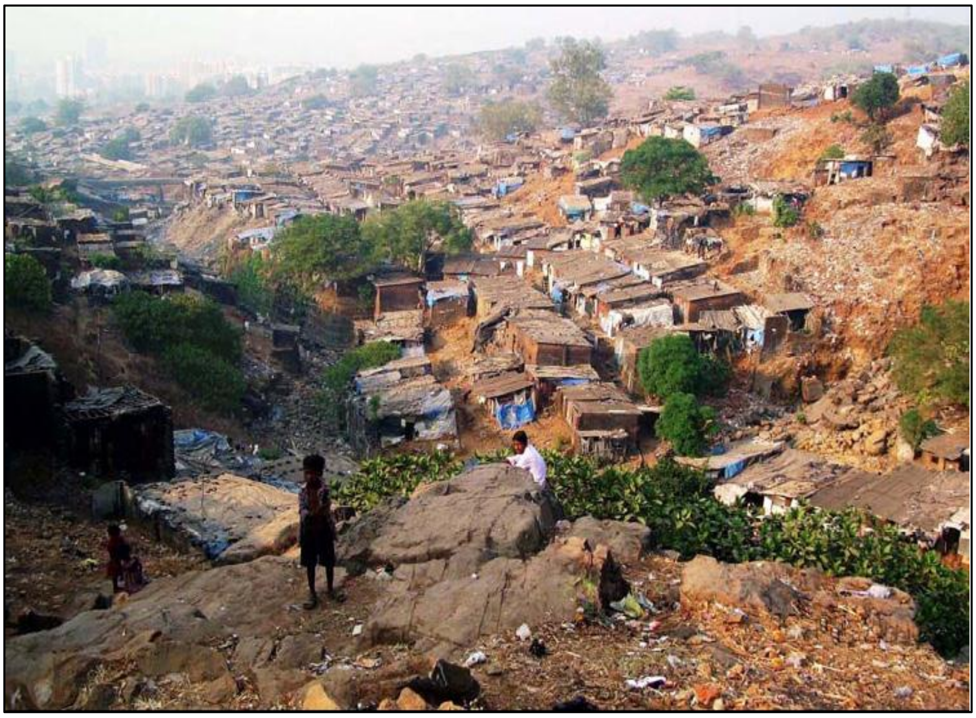
5.2.1.3 Pressure on Forests National Park

Encroachment

Over the period of years, there has been some serious encroachment in the national park from various quarters such as slum shanties, stone quarries, housing colonies, timber mafias and so on. Encroachment has come from both migrating as well as a residing population that is engaged in environmentally destructive activities such as tree felling. The encroachment initially began in 1970s and by the mid-1980s the growth became rapid. After 1990 there was a steep rise in the number of hutments and land encroachment had already taken place, mainly by the hutments. Several factors were at play to initiate and accelerate the pressure placed on the Park, the most prominent being its location between two of the fastest growing cities in the country, namely, Greater Mumbai and Thane. Whereas the population of Greater Mumbai increased from 5.9 to 11.9 million between 1971 and 2001, the population of Thane increased from 0.2 to 1.2 million between the same periods. Thane

[49] Jaiswar M J R.2002. *Impacts of wastewater on phytoplanktons. In Proceedings of The National Seminar on Creeks, Estuaries and Mangrove Pollution and Conservation, Nov 2002: 19-20.*
[50] http://drs.nio.org/drs/bitstream/2264/1356/1/Proc_Natl_Semin_Creeks_Estuar_Mangroves_2002_96.pdf
[51] *Department of Fisheries, GoM*

remains one of the fastest growing neighbourhoods, reflecting the mounting importance of the suburbs, which house more than 40 percent of the Mumbai population in 2001[52]
With the ongoing changing pattern of population migration, the Park has now become embedded in the middle of dense populated urban settlements. This has become the prime factor behind the encroachment within the peripheries of the park. The encroachments, including quarries, covered an area of over 700 ha. By mid-1995, 27 ha of forest were lost to 800,000 new settlers. The forest department has been razing illegal shanties, huts and pucca houses in the vicinity. However, in the past 3 decades, since 1995, more than 15,000 such structures have come up[53]. Forest department had initiated a drive to remove encroachments from SGNP and were successful in removing 407 encroachments from the area[54]. This illegal encroachment has also proved to be a major reason of solid waste being dumped inside the park (Picture No. 5-5). At times the waste also includes carcasses of animals from the nearby animal sheds and this becomes a reason for attracting the leopards near the vicinity of humans increasing the risks of man- animal conflicts[55].



Picture No. 5-2: Nagars/padas encroaching SGNP[56].

52 http://www.indiawaterportal.org/sites/indiawaterportal.org/files/environmental_conflicts_in_coastal_metropolitan.pdf

53 http://archive.mid-day.com/news/2013/jan/020113-Encroachments-at-SGNP-intensifies-man-animal-conflict.htm

54 http://timesofindia.indiatimes.com/city/mumbai/Drive-to-clear-encroachments-from-Sanjay-Gandhi-National-Park/articleshow/20729391.cms

55 http://gulfnews.com/news/world/india/mumbai-clear-garbage-to-co-exist-with-leopards-of-sanjay-gandhi-national-park-1.1206007

56 http://www.mumbaikarsforsgnp.com/docs/preliminary_study_on_the_diet_composition_of_the_leopard.pd)

Forest Fires

SGNP is facing a severe threat due to forest fires .From 2005 to 2010; a whopping 1,001.47 hectares were burnt at the Sanjay Gandhi National Park (SGNP), according to reports prepared by the forest department[57]. Many of these fires are usually artificial fires mainly due to human's intentions of clearing the land, so that it can be further used for agricultural purposes. But many fires in the park go unreported and cause a lot of damage to the wildlife of the area (Table No. 5-4)

In the last decade, there have been more than 600 cases of forest fires at the SGNP affecting a cumulative total of about 957 hectares of forest crop. While in the recent three years the number of forest fires has increased drastically. The forest faces this threat also in future due to the growing encroachments and settlements inside the park. Such activities can only be reduced by opting stringent management policies.

Table No. 5-7: Data on forest fires and losses to forest crop at Sanjay Gandhi National Park

Sr. No.	Financial Year	Number of fire cases during the year	Damage of forest standing crop (in Ha.)
1	2002-03	23	32.06
2	2004-05	38	82.9
3	2005-06	56	90.52
4	2006-07	67	131.6
5	2007-08	54	97.1
6	2008-09	48	65.92
7	2009-10	35	40.7
8	2010-11	87	132.3
9	2011-12	103	149.88
10	2012-13	92	131.99
	Total	**603**	**957.97**

Source: Management Plan for SGNP (Sanjay Gandhi National Park) Division for 2013-14 to 2022-23 Forest Department; GoM

[57]http://articles.timesofindia.indiatimes.com/2011-03-26/mumbai/29191821_1_forest-fires-forest-officials-forest-dwellers

5.2.1.4 Impact- Man-Animal Conflict

In 2005 with extensive media coverage, the park, once again revived the interest of the public with the outbreaks of numerous leopard attacks that took place in the summer of 2004 and the beginning of 2005. Shrinking habitat has forced these cats to stray from the park and enter nearby neighbourhoods. From 1998 to 2005, the total number of people injured by leopard was 42 and over 100 people were killed during this period. In between year 2004 to 2006, itself 84 people were attacked.[58] The state administration announced steps to tackle the leopard problem, first by installing micro-chips and solar fencing to stop the wild cats from encroaching within the city limits. However, as the city's boundaries crept further in, the leopard's habitat shrunk and prey dwindled. At least 37 straying leopards were caught in 2004. Plans are afoot to release them into the wild with electromagnetic chips so that they could be tracked and permanently locked up if they attacked people again. Until the proper management measures are not taken the fear of more such attacks linger. Dogs, pigs, goats form an important part of the leopards diet in SGNP indicating that the feral animals and untended livestock are probably important prey of leopards and is the major reason for man wildlife conflict.

5.2.1.5 Recommendations

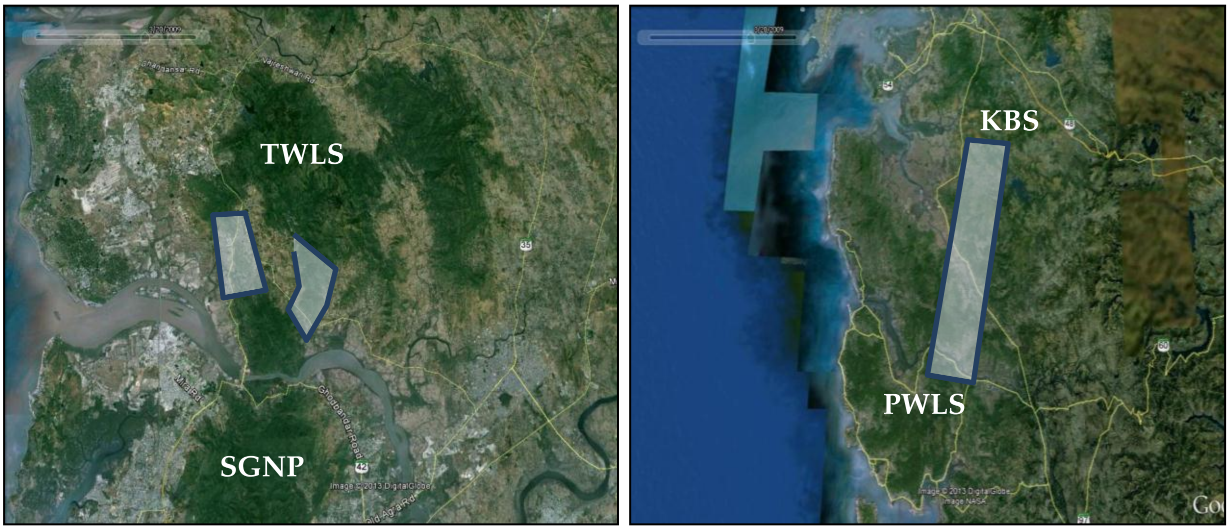
Recommendations:

1. Establish Wildlife corridor in between Sanjay Gandhi National Park (SGNP) and Tungareshwar Wildlife Sanctuary (TWLS).
2. Establish Wildlife corridor in between Karnala Bird Sanctuary (KBS) and Phansad Wildlife Sanctuary.

Background Information:

- During this study, two crucial wildlife corridors were identified which connect the PAs within MMR as well as those on the periphery of MMR (Picture No. 5-3).
- These corridors presently comprise of fragmented forestlands, farmlands, villages and roads. Although urbanization in these regions is low compared to neighbouring cities, there are currently no protection measures which may preserve these corridors, thereby helping in a genetic flow especially amongst large mammals such as leopards and deer's.
- In 2003, forest officers discovered pug marks and scat of a tiger in Nagla Block.[59] With the last tiger sighted in 1929, the signs of a tiger in the park led to the extension of boundaries of Sanjay Gandhi National Park and Tungareshwar was declared a wildlife sanctuary. This initiative has been crucial to expand the protected area under MMR and forms a crucial wildlife corridor. Beyond Tungareshwar wildlife sanctuary (Picture No. 5-4), the closest PA is Tansa Wildlife Sanctuary, which lies approximately 30 km from Tungareshwar Wildlife Sanctuary.

[58] http://environmentportal.in/files/Conflict percent20management percent20manual.pdf
[59] http://articles.timesofindia.indiatimes.com/2003-07-05/mumbai/27211623_1_nagla-block-elusive-tiger-forest



Picture No. 5-3: Google images indicating the wildlife corridors for joining Sanjay Gandhi National Park (SGNP) with Tungareshwar Wildlife Sanctuary (TWLS) (Left) and joining Karnala Bird Sanctuary (KBS) with Phansad Wildlife Sanctuary (PWLS) (Right)

Picture No. 5-4: Google image showing the proximity of Tungareshwar Wildlife Sanctuary (TWLS) with Tansa Wildlife Sanctuary (Tansa)

Significance:

- A habitat corridor, wildlife corridor or green corridor http://en.wikipedia.org/wiki/Wildlife_corridor - cite_note-1is an area of habitat connecting wildlife populations separated by human activities or structures (such as roads, development or logging). This allows an exchange of individuals between populations, which may help prevent the negative effects of inbreeding and reduced genetic diversity (via genetic drift) that often occur within isolated populations. Corridors may also help facilitate the re-establishment of populations that have been reduced or eliminated due to random events (such as fires or disease).[60]

[60] http://en.wikipedia.org/wiki/Wildlife_corridor

- The corridors act as natural freeways, allowing animals to explore larger areas in search of territories, food, as well as a mate. Thus, they are crucial for gene flow between populations of the same species, which, if non-existent, can result in inbreeding amongst siblings and therefore result in loss of genetic diversity.
- The importance of wildlife corridors with respect to gene flow is highlighted by the plight of the Royal Bengal Tiger (*Panthera tigris*). As tiger populations are shrinking, the areas that harbour tigers are also shrinking and fragmenting[61].
- Designing wildlife corridors can be an arduous task. There is no set prescription on design parameters and adopting the right strategy depends on a multitude of factors which include species requirements, geographical setting, land availability and human interference amongst other things. This phenomenon can be clearly studied in case of Asiatic lions of Gir, which have interbred due to available limited resources and isolation of the population, resulting in serious genetic variations[62].
- Some of the best examples of artificial wildlife corridors are the ones that are situated in Netherlands and Canada.[63]
- Recently in September 2014; MCGM has proposed 5 wildlife crossings to be constructed on Aarey Road that is to be widened as part of the proposed Goregaon-Mulund Link Road.[64]

The ideal artificial corridors recommended for MMR should have following features:

- Multiple crossing structures should be constructed at a crossing point to provide connectivity for all species likely to use a given area. At least one crossing structure should be located within an individual's home range.
- Suitable habitat for species should occur on both sides of the crossing structure.
- Where possible, protect or restore a continuous strip of native vegetation at least 200m wide along each side of the channel. Buffer strips can protect and improve water quality, provide habitat and connectivity for many species.
- Enforce existing regulations restricting dumping of soil, agricultural waste, and trash in streams, and restricting farming, gravel mining and building in streams and floodplains. [65]
- Monitoring is an important to the planning and after construction of the project. Monitoring is required to evaluate the optimal location for a passageway and to evaluate the function of the wildlife crossing.
- Maintenance of any and all structures within the wildlife passageway must be done on a regular basis to ensure the ongoing success of the wildlife crossing. Maintenance needs to be included in planning as well as in mitigation measures.[66]

[61] http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3568842/
[62] http://dobzhanskycenter.bio.spbu.ru/pdf/sjop/MS134_Wildt_Nature.pdf
[63] http://robertgrooms.wordpress.com/2011/11/09/46/
[64] http://timesofindia.indiatimes.com/city/mumbai/5-wildlife-crossings-on-cards-in-Aarey-Colony/articleshow/42400057.cms
[65] http://corridordesign.org/dl/docs/corridordesign.org_BMPs_for_Corridors.pdf
[66] http://www.dot.ca.gov/dist07/resources/envdocs/docs/H118css_LRP.pdf

5.2.1.6 Response-Forest and Biodiversity:

1. Owing to rapid habitat degradation and associated biodiversity loss, MMR-EIS in the year 2009 had appointed Yuhina Eco-Media for preparation of an in-depth inventory on biodiversity of MMR. This is supposed to serve as a baseline for mapping as well as help conserve biodiversity rich areas in MMR.
2. Mangroves are specialized coastal plants that have tremendous ecological and socio-economic significance, but these are being threatened by encroachers and developers. It is believed that about 70 percent of Mumbai's mangroves have been destroyed due to various development activities. [67] The Mangrove Cell was created by the Government of Maharashtra on January 05, 2012 to protect, conserve and manage the mangroves of the State. The creation of the Mangrove Cell is an important step in the conservation and management of mangroves in the State. The Cell has also been given the additional responsibility of conservation of coastal biodiversity; an area seldom paid the attention it deserves.[68]
3. In one of the pioneering initiative to map mangrove and study the associated ecosystem for Mumbai; MMR has sponsored a project to document flora and fauna as well as mangrove cover at Mira Bhayander. The total mangrove cover of 20.7 km2 was estimated using satellite imageries followed by ground truthing. A plan was laid down for the conservation of the mangroves of Mira Bhayander and preservation of species.[69]
4. The Environmental Improvement Society (EIS) provides funds for innovative projects in solid-waste management, afforestation, installation of toilet blocks, etc. that help improve the quality of life in the MMR. A major initiative of MMR EIS for biodiversity conservation is developing an environmental management plan for Sanjay Gandhi National Park, Borivali.[70]
5. **Matheran Eco-sensitive Zone:** Matheran has been declared as eco-sensitive zones by the MoEF. Matheran and its surroundings declared as the Eco-Sensitive Zone (ESZ) cover an area of about 498 Sq. Km. On February 4, 2003, the MoEF has issued the final notification covering 215 sq.km (against 498 sq.km.) of Forest Zone (F Zone) as shown on the sanctioned Regional Plan for Mumbai Metropolitan Region, 1996-2011. A Monitoring 187 Committee constituted by the MoEF shall oversee the development of the ESZ. Within the ESZ, the development activities shall be permitted as per the State and Local laws (MMRDA, 2005).[71]
6. **Maharashtra Nature Park:** The MMRDA has converted 35-40 H a of land in 'H' block of Bandra-Kurla Complex, which earlier was a garbage dump, into a nature park in close association with the World Wide Fund for Nature (WWF). This nature

[67] http://www.moef.nic.in/soer/state/SoE%20report%20of%20Maharashtra.pdf
[68] http://mangrovecell.org
[69] http://www.terraconindia.com/portfolio/mangrove-biodiversity-survey-and-conservation-plan/
[70] http://www.moef.nic.in/soer/state/SoE%20report%20of%20Maharashtra.pdf

[71] http://www.moef.nic.in/soer/state/SoE%20report%20of%20Maharashtra.pdf

park has magical woodland with 14 thousand trees, 300 varieties of plants with few as herbs, a lake, 100's of varieties of migrating birds, insects, beautiful butterflies, reptiles and few mammals too.[72] For the development and management of the Park, MMRDA has promoted a society, known as Maharashtra Nature Park Society, which is responsible for its day-to-day management and activities.[73]

7. World Bank is also looking at partnering India for strengthening of pollution control boards and biodiversity conservation.[74]
8. Rachana Sansad's Institute of Environmental Architecture has undertaken two initiatives the first one on Dahisar River Restoration project in collaboration with Bombay First, National Environmental Engineering Research Institute (NEERI), local NGOs & Municipal Corporation of Greater Mumbai (MCGM); whereas the second on the revitalization of Charolette Lake in the hill station town of Matheran in collaboration with the Matheran Municipal Council, Grassroots consultancy and MMRDA.[75]

9. **Proposed Aarey colony wildlife crossings:** Recently in September 2014 as an initiative to minimize human wildlife conflict as well as wildlife road kills; MCGM has proposed 5 wildlife crossings to be constructed on Aarey Road that is to be widened as part of the proposed Goregaon-Mulund Link Road.[76]
10. Terracon Ecotech™ an environmental consultancy company has partnered with the Convention on Biological Diversity (CBD) to bring the City Biodiversity index to India and is in the process of bringing the first index for the City of Mira Bhayender.[77]
11. To conserve the biodiversity of the Navi Mumbai City and Industrial Development Corporation (CIDCO) has proposed Navi Mumbai Nature Park.[78]

[72] http://www.mumbai77.com/city/1018/gardens-parks/maharashtra-nature-park/
[73] http://www.moef.nic.in/soer/state/SoE%20report%20of%20Maharashtra.pdf
[74] http://www.causebecause.com/news-detail.php?NewsID=290
[75] http://enviorment.rachanasansad.edu.in/doc/final_brochure.pdf
[76] http://timesofindia.indiatimes.com/city/mumbai/5-wildlife-crossings-on-cards-in-Aarey-Colony/articleshow/42400057.cms
[77] http://www.terraconindia.com/initiatives/city-biodiversity-index/
[78] http://timesofindia.indiatimes.com/city/mumbai/Nature-park-for-Navi-Mumbai/articleshow/5011827.cms

5.2.2 Wetlands (Natural)

Wetlands are areas that are seasonally or perennially covered by water, which determines the soil type of that region and associated plant and animal life. The Ramsar Convention defines wetlands as: "areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters".[79]

In wetlands, water is the primary factor controlling the environment and the associated plant and animal life. They occur where the water table is at or near the surface of the land, or where the land is covered by water[80]. Examples of natural wetlands are lagoons, rocky shores, mangroves, lakes, rivers, marshes, paddy fields and so on. While the examples of man-made wetlands are fish and farm ponds, salt pans, reservoirs, canals and so on.

Wetlands contribute significantly to a region's economy by providing water, fishery resources, agricultural products and tourism opportunities. They also serve as habitats for several species of flora and fauna, some of which are endangered and many species are harvested for food and as a source of income. They also have environmental significance, such as groundwater replenishment, retention of nutrients and sediments, water purification as well as helping to adapt to changes in climate by controlling flood and providing protection from storms. Since wetlands are of such varied nature, the exact and real extent of different types of wetlands on the earth's surface is unknown. According to UNEP World Conservation Monitoring Centre, the global estimate of areal extent of wetlands is approximately 570 million hectares, which contribute to 6% of the earth's land surface[81].

5.2.2.1 Status of Wetlands in MMR

Although wetland ecosystem consists of various types, the major habitats found in MMR include mangroves and salt pans. Other habitats present are mudflats, freshwater lakes, rivers and creeks. The total area of wetland present in MMR area is around 564.7 sq. km,[82], and majority of the wetland area is under mangrove cover. As per remote sensing data procured from MRSAC, GoM, the mangrove (open and dense) area in MMR has a share of about 36% of the total wetlands area (Figure No. 5-2). This is closely followed by the coverage of natural creek area, tidal area and tidal zone which accounts for about 32% of the total wetland area in MMR. The manmade wetlands, mainly saltpans and salt marsh contribute to about 4% share of all the wetland area in MMR. A break up of the share and the total estimated coverage of different wetlands in MMR is presented in Table No. 5-8 while the spatial distribution of those wetlands is presented in Map No. 5-3 below.

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[79] Based on Article 1.1 of Ramsar Convention.

[80] http://www.ramsar.org/cda/en/ramsar-about-faqs-what-are-wetlands/main/ramsar/1-36-37%5E7713_4000_0__

[81] The Ramsar Convention Website

[82] As per data attributes shared by MRSAC, Maharashtra Remote Sensing Application Centre, GoM

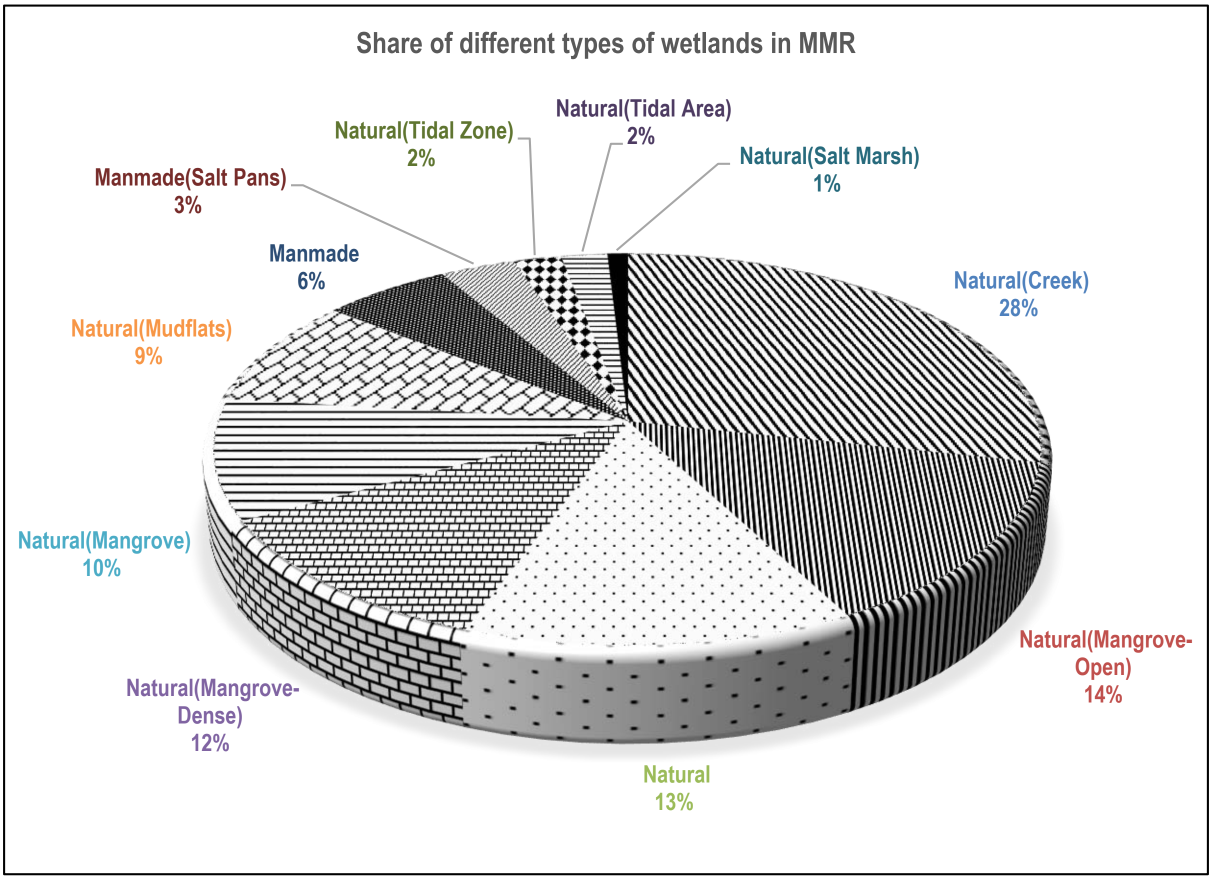


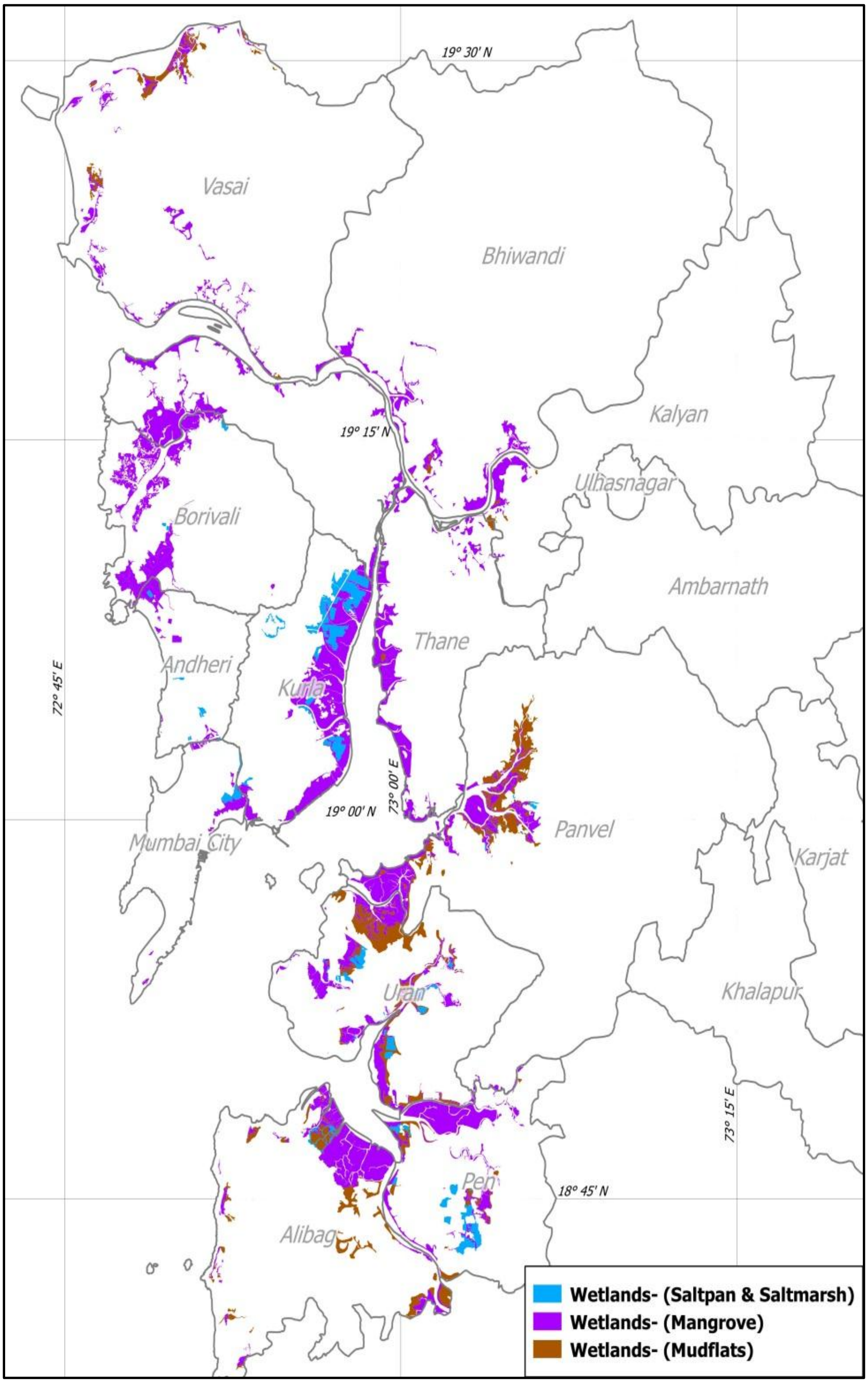
Figure No. 5-2: Share of different types of wetlands in MMR

Source: As per data attributes shared by MRSAC, GoM

Table No. 5-8: Share and absolute area under various types of wetlands in MMR

Type of Wetland	Area (Sq. Km)	Share (%)
Natural (Creek)	155.23	28.34
Natural (Mangrove-Open)	76.24	13.92
Natural	72.88	13.31
Natural (Mangrove-Dense)	62.38	11.39
Natural (Mangrove)	54.33	9.92
Natural (Mudflats)	48.94	8.94
Manmade	31.23	5.70
Manmade (Salt Pans)	18.44	3.37
Natural (Tidal Zone)	11.67	2.13
Natural (Tidal Area)	11.32	2.07
Natural (Salt Marsh)	5.03	0.92
Total	**547.69**	**100**

Source: As per data attributes shared by MRSAC, GoM



Map No. 5-3: Mangroves and Saltpans in MMR area

Source: As per data attributes shared by MRSAC, Maharashtra Remote Sensing Application Centre, GoM

5.2.2.2 Status of Mangrove cover in MMR

As per Geological Survey of India[83] Mangroves are defines as 'Woody plants and shrub that inhabit the upper intertidal zones of saltwater (30 to 90ppt) areas, primarily in tropical and subtropical coastal regions within 30° of the equator and form low diversity forests with complex food webs and unique ecosystem dynamics. Mangroves form a characteristic saline woodland or shrub land habitat, called mangrove swamp, mangrove forest, in coastal depositional environments where fine sediments often with high organic content collect in areas protected from high energy wave action. They occur both in estuary and along open coastlines. Mangroves dominate three quarters of tropical coastlines and cover roughly 172,000 sq. km. of the earth's surface in the large river deltas, estuaries and barrier islands. The Mangrove ecosystem usually refers to a tidally influenced wetland complex, consisting of mangrove forests, tidal flats, salt flats and other associated habitats within the intertidal zone of tropical and subtropical latitudes.

Mangroves represent a precious biological resource, which confer a variety of benefits to mankind. Most significant among these benefits are their ability to bring greenery to places where no other species can thrive, the supportive role they play in enriching our coastal biodiversity, their proven value in climate change mitigation and their matchless utility in protecting our coastal communities from natural disasters like tsunamis, cyclones and storm surges.

The Indian mangroves are represented by approximately 59 species (inclusive of some mangrove associates) from 29 families. There are a few species of which are indigenous to the west coast like *Sonneratia caseolaris, Sueda fruticosa, Urochondra setulosa* and so on[84].Of the 59 species, 34 species belonging to 21 families are present along the west coast. In India, the total number of mangrove-inhabiting faunal species is 3111 which includes prawns, crabs and mollusks, fish, fish parasites, insects, reptiles, amphibian and mammals. Fiddler crabs and fish like mud skippers are animals which can be easily spotted in mangroves.

However, Mangroves are under tremendous stress owing to various pressures from developmental changes, pollution, dumping of debris, solid waste, reclamation, deforestation and so on. Realizing these pressures on the mangrove ecosystem, there have been various initiatives taken at policy level as well as ground level to save the mangrove ecosystems. Some of the initiatives taken in India have been discussed below.

5.2.2.3 Importance of Mangroves[85]

- Mangrove species have maximum potential to sequester atmospheric carbon and form carbon sinks which in turn helps in maintaining the balance of the ecosystem by absorbing and storing excess carbon from the atmosphere. Mangroves can sequester carbon 8 times more than any species on earth.
- Creation of critical breeding habitat for various fish, mollusk, crustacean species and coastal bird populations. Establishment of restrictive impounds that offer protection for maturing offspring.
- Filtering and assimilating pollutants from upland run-off. Stabilization of sediments and protection of shorelines from erosion.

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[83] www.portal.gsi.gov.in/portal/page?_pageid=127,723772&_dad=portal&_schema=PORTAL&linkId=1213
[84] http://www.mangroves.godrej.com/MangroveVegetation.htm#MangroveVegetation
[85] http://mangrove.org/video/Mangrove.pdf

- Mangroves also act as a transition zone between land and sea, thus playing a valuable role as nature's shield against cyclones, ecological disasters and as protector of shorelines.
- Mangroves are buffers between the land and the sea. Coastlines throughout the world are facing serious problems of coastal erosion and threat of rising sea levels due to global warming has increased the threats by several folds. To control such assault of the sea on land the nature has provided what is called as Mangroves, a tropical littoral ecosystem which is more dynamic than the sea itself.
- Harbour a variety of life forms like invertebrates, fish, amphibians, reptiles, birds and mammals.

5.2.2.4 Pressure and Impacts on Mangroves

- A study conducted by Central Institute of Fisheries Education, ICAR and IIT (Indian Institute of Technology) Mumbai[86], states that around 36.54 km^2 of mangrove forest was lost in Mumbai suburban area (Greater Mumbai) within a decade, between 1990-2001.
- Systematic dumping of all kinds of waste and debris in the mangrove areas destroys them. Land reclamations and industrial effluents are the major causes of mangroves degradation. Aerated lagoons for treating sewage, at Ghatkopar and Bhandup, and their discharges are located right in the mangrove areas which are causing a major disturbance to the ecosystem[87]. Dumping Sites at Mulund, Kanjurmarg are located right in the mangrove belts. This waste/debris creates a barrier preventing the sea water from entering the mangroves and eventually kills the mangroves. In many instances, this is done intentionally to reclaim land for construction activity. There is an urgent need to stop this systematic degradation of mangroves.
- Areas like Vikhroli, Kanjurmarg, Vitava and Mankhurd along the Thane creek show high values of industrial and domestic solid waste accumulation in mangrove swamps. Plastic carry bags and Styrofoam are most common forms of plastics found in thane creek. Anthropogenic activities are the main reason for exerting tremendous pressures on the mangrove habitat. Reclamation of land for urbanization has caused tremendous destruction of mangroves[88]. Mahim, Versova, Gorai and Ghodbunder, with sporadic patches in places such as Bandra, Malabar Hill and Colaba. Mumbai has probably lost 40% of all its mangroves in the past decade or so, largely because of reclamation for housing, slums, sewage treatment and garbage dumps. Rapid developments like housing, industrialization, pollution and increasing population of Mumbai has resulted into degradation of mangroves. Between 1997 and 1998 about 3,400 m^2 of mangrove in Malad was reduced to 1,400m^2. At a number of places, like Versova, Bandra-Kurla Complex, Millat Nagar, Mumbra, Andheri and Charkop, there have been blatant violations of the Coastal Regulation Zone (CRZ).[89]

[86] V. Vijay et.al, *Mangrove Mapping and Change detection around Mumbai (Bombay) using remotely sensed data*, Indian Journal of Marine Sciences, Vol. 34(3), September 2005, pp. 310-315
[87] Chapter 13 Urban Basic Services, *Mumbai City Development Plan 2005-2025*, MCGM
[88] http://www.mangroves.godrej.com/ThreatstoMangroveecosystem.htm
[89] V. U. Joshi, et al., Chapter 8, *Environmental Conflicts in Coastal Metropolitan Cities in India: Case Studies of Mumbai and Chennai Metropolitan Regions*, Solutions for Environmental contrasts in Coastal Areas, Vol. 4. Environmental Conflicts in Coastal Urban Areas, pps. 320-354

- Oil Spillage from freight movement and oil refineries in MMR is also a major threat to mangrove destruction in MMR. Due to ship collision of two cargo ships MSC Chitra and MV Khalijia 3 on 7 august 2010 resulted in leakage of 600 to 800 Tons of furnace oil. Overall, more than 20% mangroves in the nearby areas were affected due to the oil spillage. Mangrove patches in Navy Nagar area were the most to be affected[90]. Recently oil leaks from Mahul pipelines have also proved to be reason for its destruction of almost 30 acres of mangroves[91]. Oil spills form a coat around the prop roots and pneumatophores which results in reduction in the ability of the plant to exchange gases with the environment. The long term persistence of the oil coat on the roots causes' leaf loss and possibly death in case of heavily oiled trees. A similar impact of the oil spill at Mahul site is presented below in Picture No. 5-5.

Picture No. 5-5: Heavily oiled mangrove roots which severely damaged the mangrove tree at Mahul

Source: TERI

5.2.2.5 Response for Mangrove Protection (Legislative framework)

In India, a legislative framework for the conservation and management of mangroves is already in place. The Indian Forest Act, 1927 and the Wildlife (Protection) Act, 1972 provide protection to flora and fauna. Although they do not specifically mention mangroves, these acts can also apply to the conservation of the flora and fauna of mangrove ecosystems. Since 1927, the Indian Forest Act has been applied to the mangrove forests of the Sundarbans, which have been declared as a reserved area[92]. The Forest Conservation Act, 1980 states that no forest area shall be diverted for any non-forestry purpose without prior approval of the

90 http://timesofindia.indiatimes.com/city/mumbai/Oil-spill-damage-to-soil-irreversible-Report/articleshow/7288327.cms?
91 http://www.mumbaimirror.com/mumbai/cover-story/Oil-spill-destroys-30-acres-of-mangroves-fish-off-Mahul-coast/articleshow/25335468.cms
92 Mandal and Naskar 2008, *Diversity and classification of Indian mangroves: a review, International Society for Tropical Ecology*, Tropical Ecology 49(2): 131-146, ISSN 0564-3295

Government of India. This act has proved very effective in preventing diversion of mangrove forest areas for non-forestry purposes.

The Environment (Protection) Act, 1986 has had a crucial role in the conservation and management of mangrove ecosystems. It declares a Coastal Regulation Zone in which industrial and other activities such as discharge of untreated water and effluents, dumping of waste, land reclamation and bunding are restricted in order to protect the coastal environment. Coastal stretches are classified into four categories, and mangroves are included in the most ecologically sensitive category. Enforcement of the legislative mandates is a prime need (Untawale, 1992).[93]At the state level a Mangrove Cell was created by the Government of Maharashtra on January 05, 2012 to protect, conserve and manage the mangroves of the State. The creation of the Mangrove Cell is considered as an important step in the conservation and management of mangroves in the State. The Cell has also been given the additional responsibility of conservation of coastal biodiversity; an area seldom paid the attention it deserves. The Cell is headquartered in Mumbai and headed by a Chief Conservator of Forests.

All mangroves are protected under Coastal Regulation Zone (CRZ) - 1. They are protected legally under the following Acts:

- Maharashtra Tree Act of 1975
- Forest Conservation Act 1980
- Environment Protection Act 1986
- Coastal Regulatory Zone Notification of 1991 and 2011.

In 2005, Bombay High court banned and froze destruction of Mangroves in Maharashtra and construction within 50 m of CRZ area. Mangroves Society of India (MSI) and Conservation Action Trust (CAT) are two major organizations who strongly protest against destruction of mangroves in Mumbai city.The seven islands of Mumbai were reclaimed and linked to a continuous land mass after destroying mostly mangrove forests and salt pans, since then the development and subsequently population pressure rapidly increased and being the coastal area, it took the toll on mangrove land. Mumbai has gone through many cycles of mangrove deforestation and land reclamation which has resulted in loss of more than two third of the original mangrove cover. However, large continuous areas of mangrove cover are still seen today in parts of Mumbai, especially along Thane Creek. The Koli fishermen community in Mumbai worships mangroves as they serve as breeding ground for fishes.[94] The total area covered by mangroves in MMR is approximately 193 km^2 in 2006[95]; which is mainly confined to areas around Thane creek. Around 20 out of the 35 species of true mangroves found in India have been identified along the Maharashtra coast and 15 species of these are found in Mumbai. *Avicennia marina* dominates the mangrove population in MMR. This species also tolerates pollution including heavy metals such as lead, mercury and chromium[96].

[93] http://www.fao.org/docrep/x8080e/x8080e07.htm
[94] V. U. Joshi, et al., Chapter 8, *Environmental Conflicts in Coastal Metropolitan Cities in India: Case Studies of Mumbai and Chennai Metropolitan Regions*, Solutions for Environmental contrasts in Coastal Areas, Vol. 4. Environmental Conflicts in Coastal Urban Areas, pps. 320-354
[95] As per data retrived from data attributes shared by MRSAC
[96] http://www.mangroves.godrej.com/MangrovesinMumbai.htm

5.2.2.6 Recommendations

- Adherence to the CRZ norms should be stringent in the MMR.
- Develop a mangrove park to highlight the significance of this unique ecosystem and its benefits
- Develop nurseries for conservation of mangrove species
- Desiltation of holding ponds in NMMC area, and use the saline silt for maintaining mangrove nursery and restoration of damaged habitats
- Ensure active involvement of citizens and students for spreading awareness on significance of mangroves.
- Spatial mapping and timely monitoring of the mangrove coverage along with its associated biodiversity in MMR

5.2.3 Water bodies

There are various water bodies including lakes, water reservoirs, rivers, streams and so on in MMR. The total land cover under these water bodies is approximately 106 sq.km. Owing to pressures of urbanization on water bodies there has been a loss of about 17.55 sq.km in the past 20 years.

The quantitative and qualitative status of the water bodies and the recommendations for their conservation has been discussed separately in the section on water resources of this report.

5.3 Land use and land use change

Given the rapid growth in MMR the land resources and the land use has undergone various changes over time. A comparison of the land use change over 20 years has been presented in this section. As seen in Figure No. 5-3, one may note a remarkable reduction in the share of agricultural and forest land by 7 percent and 5 percent respectively. The same has been counter balanced by an increase in the scrub land coverage in MMR which registered a growth of about 7 percent during the same period. The built-up area in MMR has increased by 2 percent accounting to an absolute change of about 58sq.km. The absolute change in the land use type is presented below in Table No. 5-9.

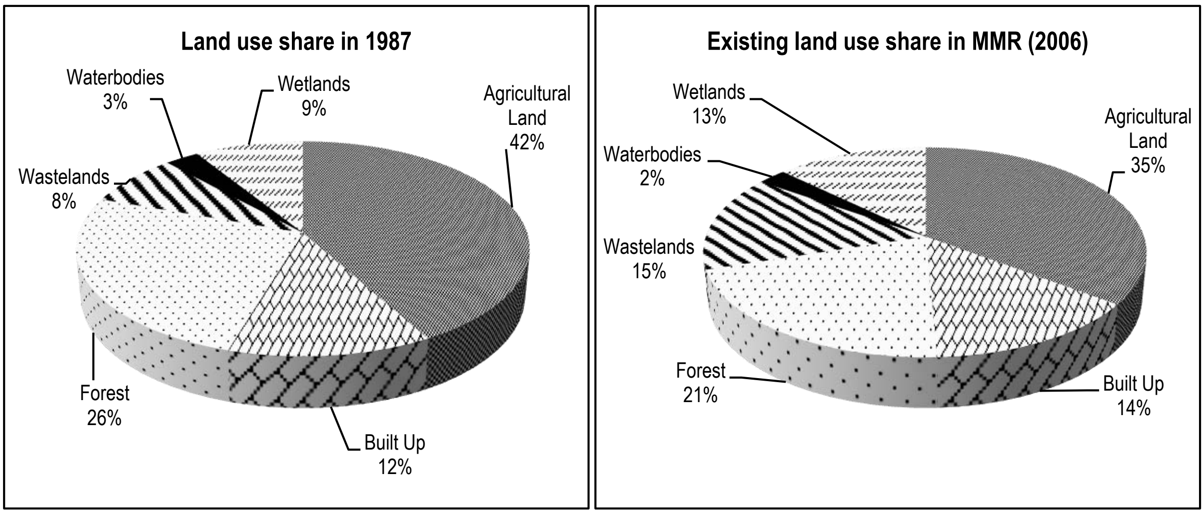


Figure No. 5-3: Land use share of MMR in 1987 and 2006

Source: Regional Plan for MMR 1996-2011 and as per attributes provided by MRSAC, GoM, 2006

Table No. 5-9: Absolute change in land use pattern in MMR (1987 – 2006)

Heads	1987	2006	Change	
	Area (Sq.Km)	**Area (Sq.km)**	**Area (Sq.km)**	**(percent)**
Agricultural Land	1856.9	1563.3	-293.61	-18.8
Built Up	561.5	619.2	57.74	9.3
Forest	1142.6	917.1	-225.47	-24.6
Wastelands	348.2	656.2	307.98	46.9
Water bodies	124.0	106.5	-17.55	-16.5
Wetlands	395.2	564.7	169.59	30.0
Grand Total	**4428.3**	**4427.0**		

Source: Regional Plan for MMR 1996-2011 and as per attributes provided by MRSAC, GoM, 2006

5.3.1 Agricultural Land

5.3.1.1 Status of agricultural land

Although predominantly an urban metropolis, MMR still has 35 percent of its land classified as agricultural land. Almost all the talukas of Raigad district in MMR are involved in agricultural activities. One may note from Map No. 5-4 that Khalapur, Karjat, Pen and Alibaug talukas have the major share of agricultural land in MMR. Also it is interesting to note that the abandoned agricultural lands have been converted to wastelands in MMR, indicating a transition in its land cover and potential use. More than 72 percent of the agricultural land in MMR is under Kharif crop cultivation and that too with 100 percent dependency on rain-fed agriculture. This is followed by the share of land used for horticultural products accounting to more than 16 percent of the land share. Rabi crops cultivated in talukas of MMR include pulses of Gram and *Vaal (Field beans)* which account for a share of 2 percent agricultural land use in MMR (Figure No. 5-4).

Paddy is the main kharif crop cultivated in MMR and contributes significantly to the production of rice in the state. One may note from Figure No. 5-5 that on an average MMR has been contributing to about 10-11 percent of the state's rice production in the past few years. In the year 2009-10 MMR accounted for almost 12 percent (2500 tons) of the rice production in Maharashtra. Also it is interesting to note that in terms of productivity of paddy, 7 talukas (Bhiwandi, Alibag, Pen, Thane, Kalyan, Panvel and Vasai) have productivity at par with the average productivity of all the talukas of Raigad and Thane taken together (Figure No. 5-6).

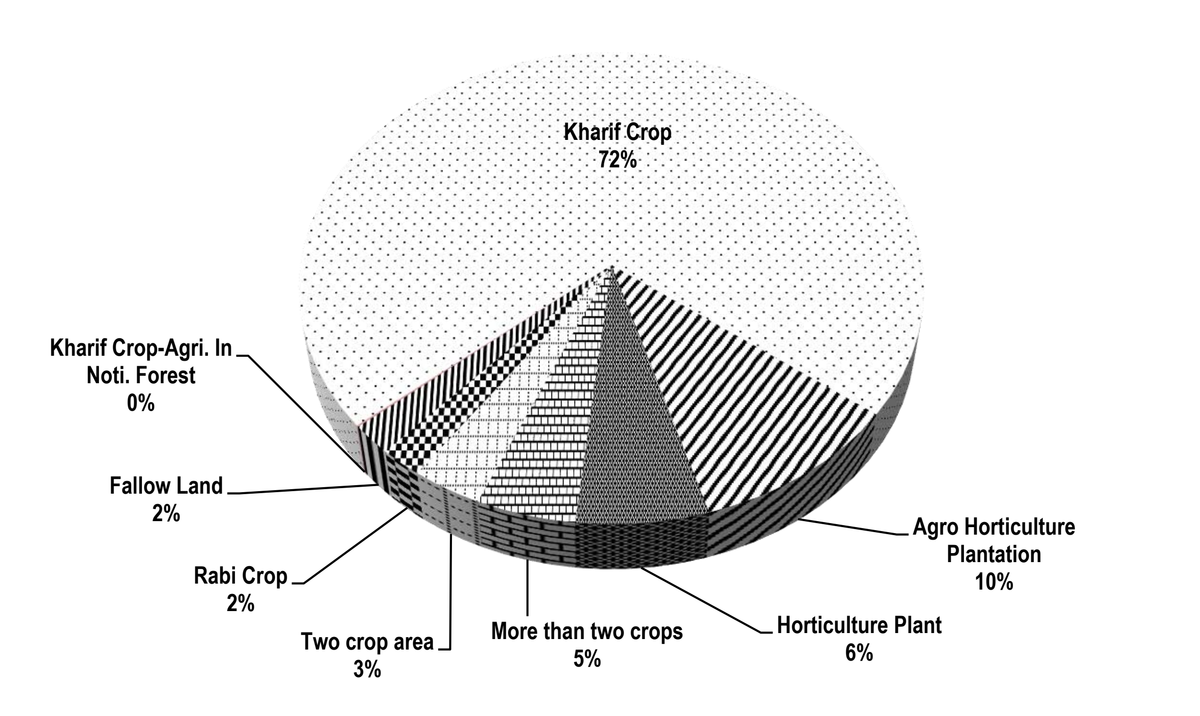
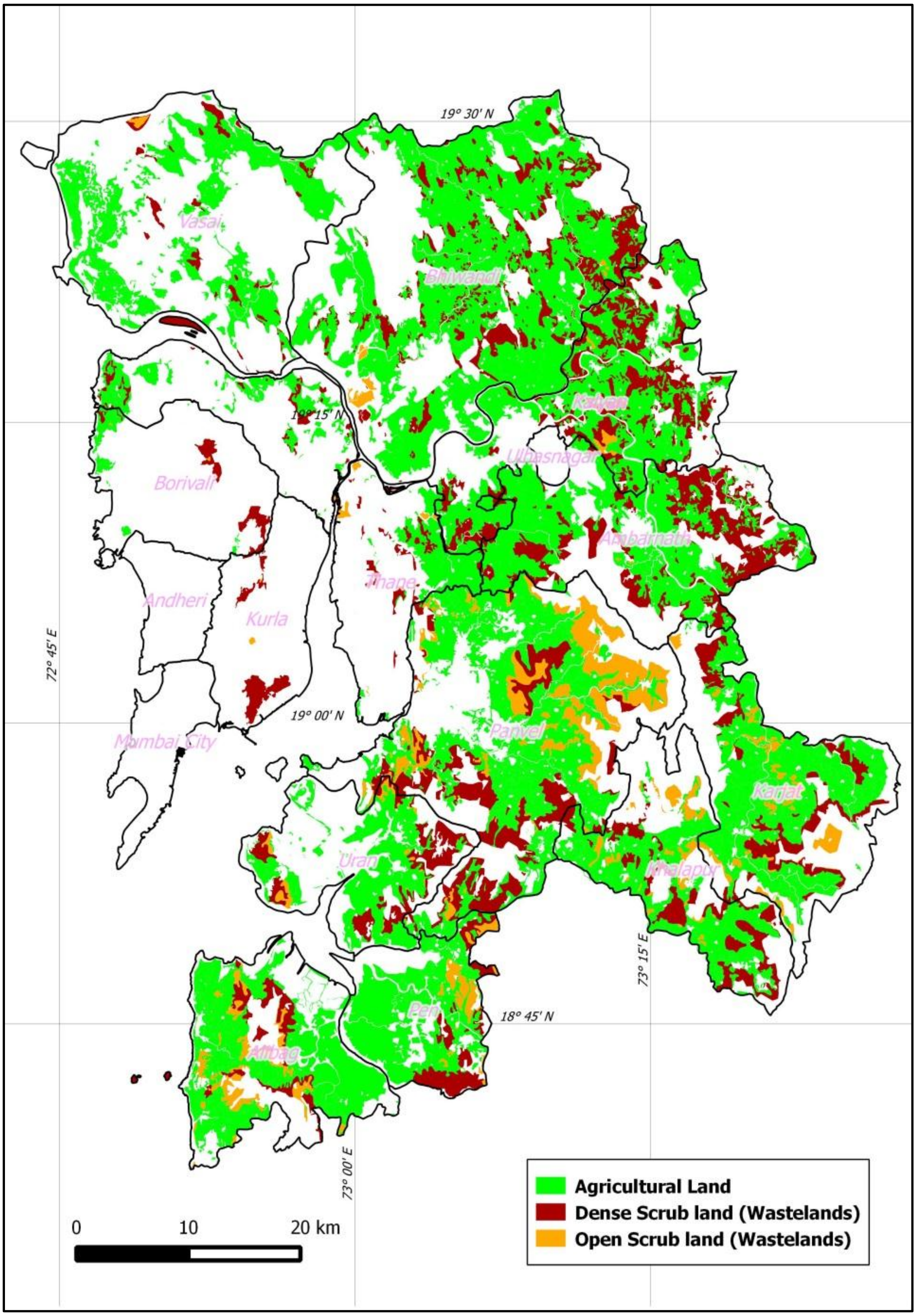


Figure No. 5-4: Agricultural land use pattern in MMR

Data Source: MRSAC, GoM



Map No. 5-4: Spatial distribution of agricultural land use in MMR

Data Source: As per attributes provided by MRSAC, GoM, 2006

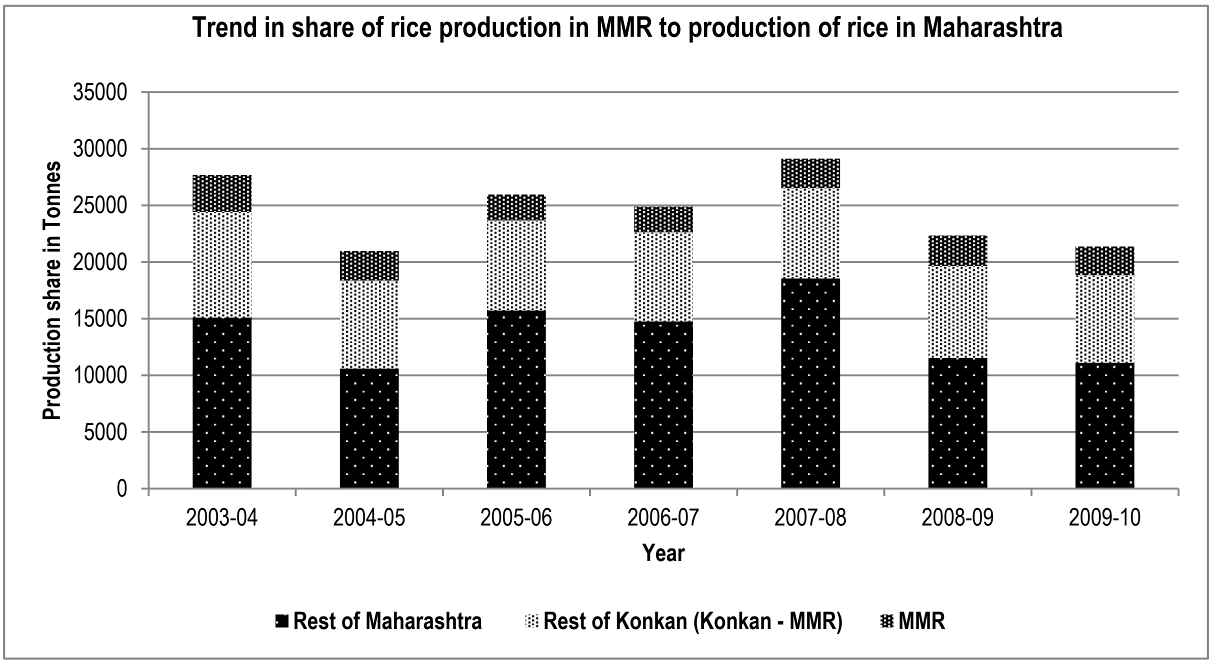


Figure No. 5-5: Trend in share of rice production in MMR to production of rice in Maharashtra

Data Source: Agricultural department, GoM

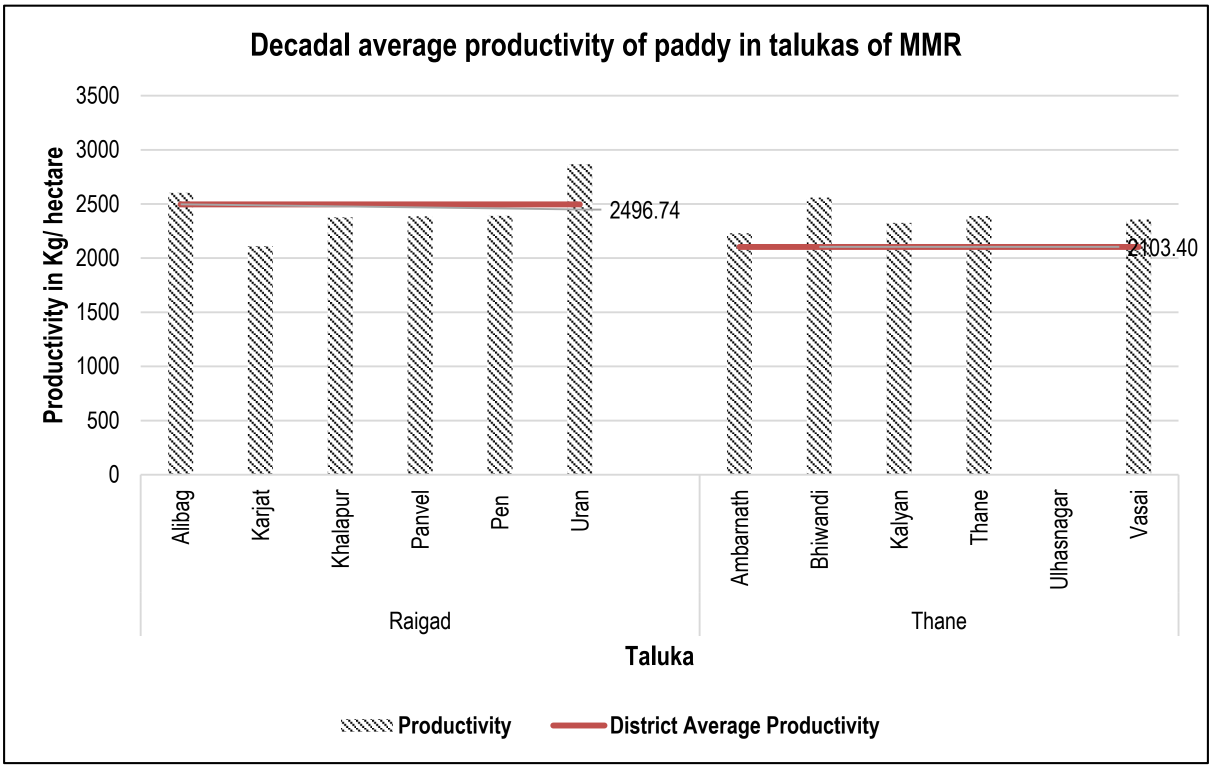


Figure No. 5-6: Decadal average productivity of paddy in talukas of MMR

Data Source: Agriculture Department, GoM

It has also been observed that, in Maharashtra, the productivity of rice in summer season is more than productivity in kharif season. In spite of having such a high productivity of summer rice, production and area under cultivation is very less in MMR region for summer rice. Only two talukas of Raigad namely, Karjat and Khalapur, are undertaking summer rice cultivation. About 8 percent (125.61 Sq.km) of the agricultural land in MMR is used for cultivating at least two crops. Vasai, Alibaug, Karjat and Panvel are the talukas where at least more than 10 sq.km of agricultural land is under cultivation for more than two crops, while Karjat, Bhiwandi, Vasai, Khalapur and Panvel areas have all area under double cropping[97]

It is also interesting to note from Figure No. 5-7, that Horticultural plant cultivation is practiced on a high scale in Thane district especially in Ambernath, Bhiwandi, Kalyan, Thane and Vasai talukas, while Agro-horticultural plantations are abundant in all the talukas of Raigad district in MMR. The spatial coverage of land under various agricultural usages is presented in Map No. 5-5.

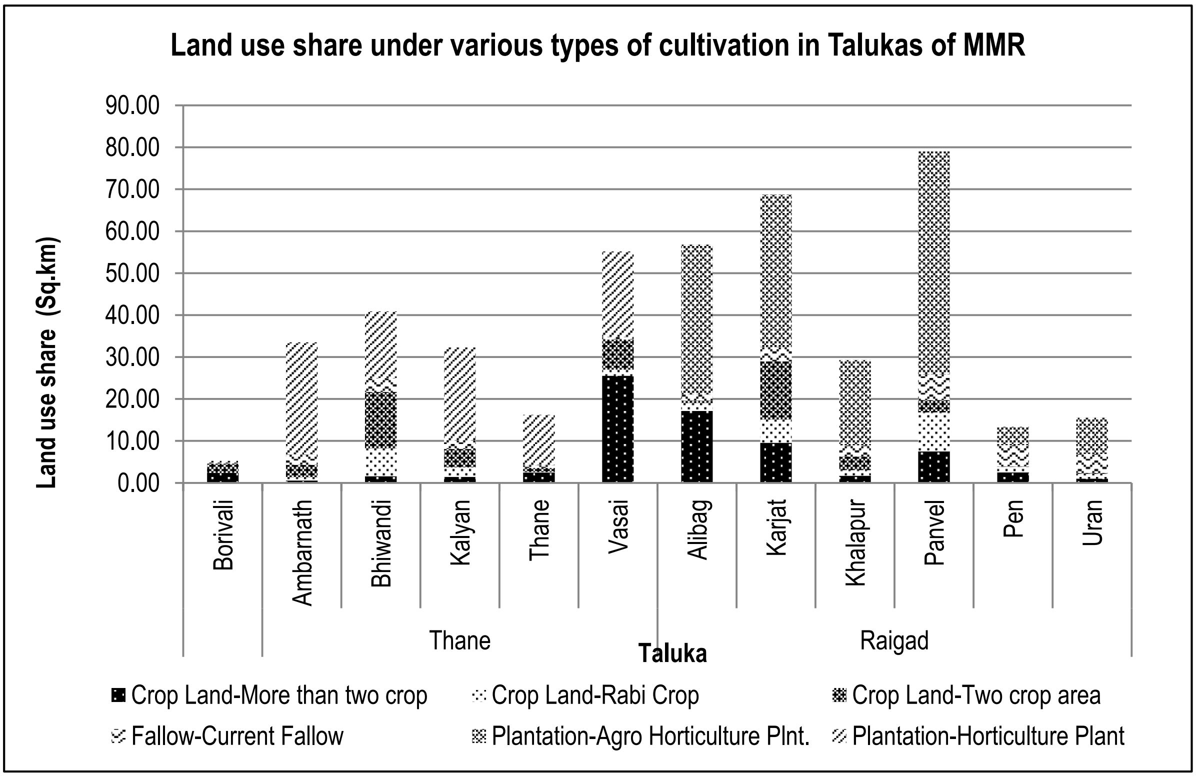
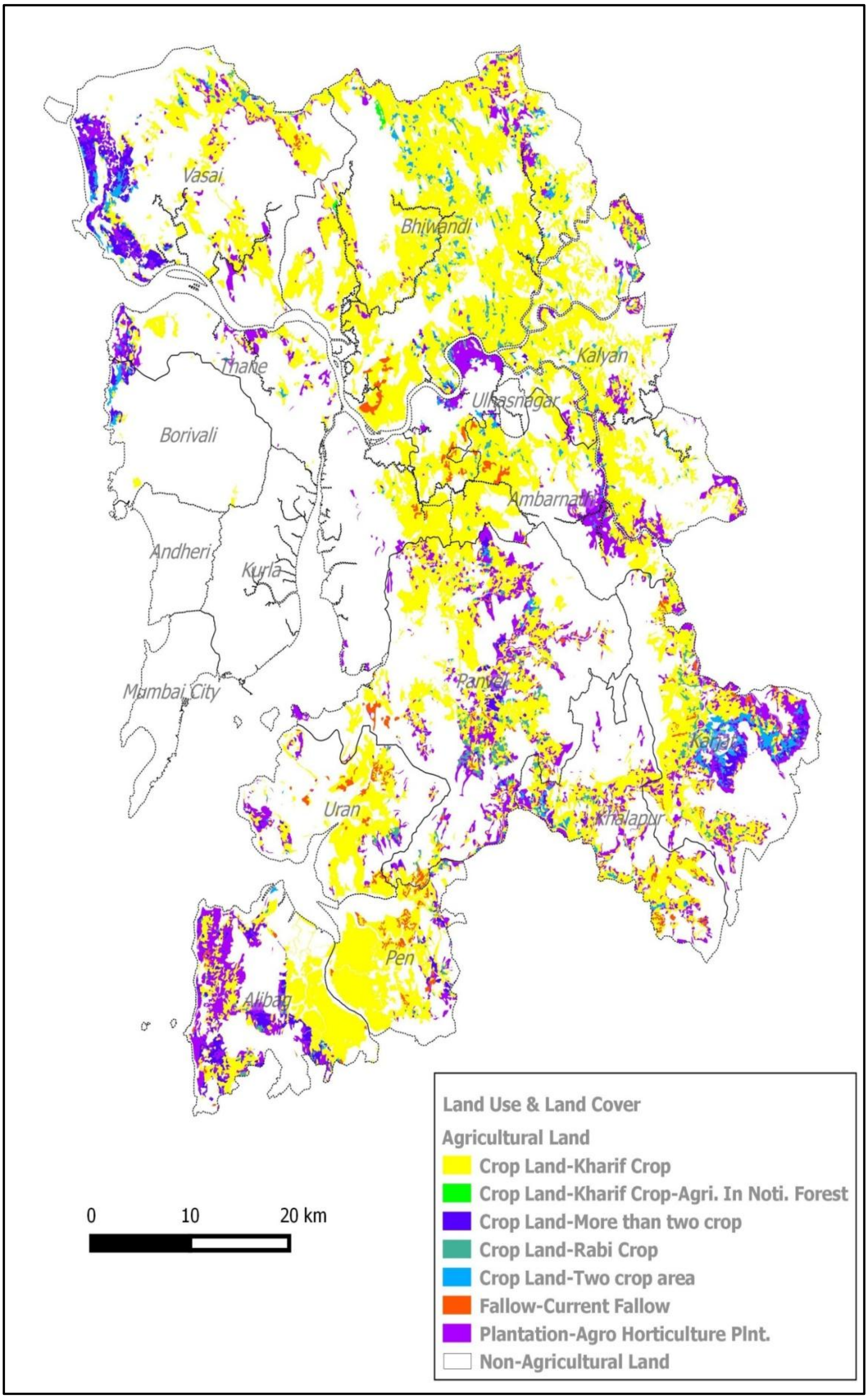


Figure No. 5-7: Land use share under various types of cultivation in Talukas of MMR

Data Source: MRSAC, GoM

[97] More than two crops on agricultural land stands for multiple crops during different seasons. However double cropping means second crop is planted after the first has been harvested during the same season.



Map No. 5-5: Agricultural land use classification in MMR

Source: MRSAC, GoM

5.3.1.2 Pressure on agricultural land

Although agricultural land is a resource of significant importance, it is under tremendous pressure and stress. A major reason for the conversion of agricultural land could be said to be the lack of interest amongst people in agricultural sector and it being regarded as a menial and non-lucrative profession. Also the urban sprawl induces demand for land and infrastructure to accommodate and meet the demands of the population. The pressures on agricultural land in the rapidly developing MMR are discussed in the following sections.

5.3.1.3 Abandoning of Agricultural Practices

Over the past 20 years, the overall share of agricultural land in MMR has decreased by 7 percent with respect to the total area, whereas with respect to agricultural land in MMR the decrease has been of the tune of 18.8 percent (Table No. 5-9). Majority of the agricultural land has changed to waste land or scrub land. As per data from MRSAC the open and dense scrub land coverage in MMR accounts to about 600 sq. km. On spatial analysis (Map No. 5-6) one may note that these wastelands are in close proximity to agricultural lands indicating the inter-conversion from agricultural land to wastelands.

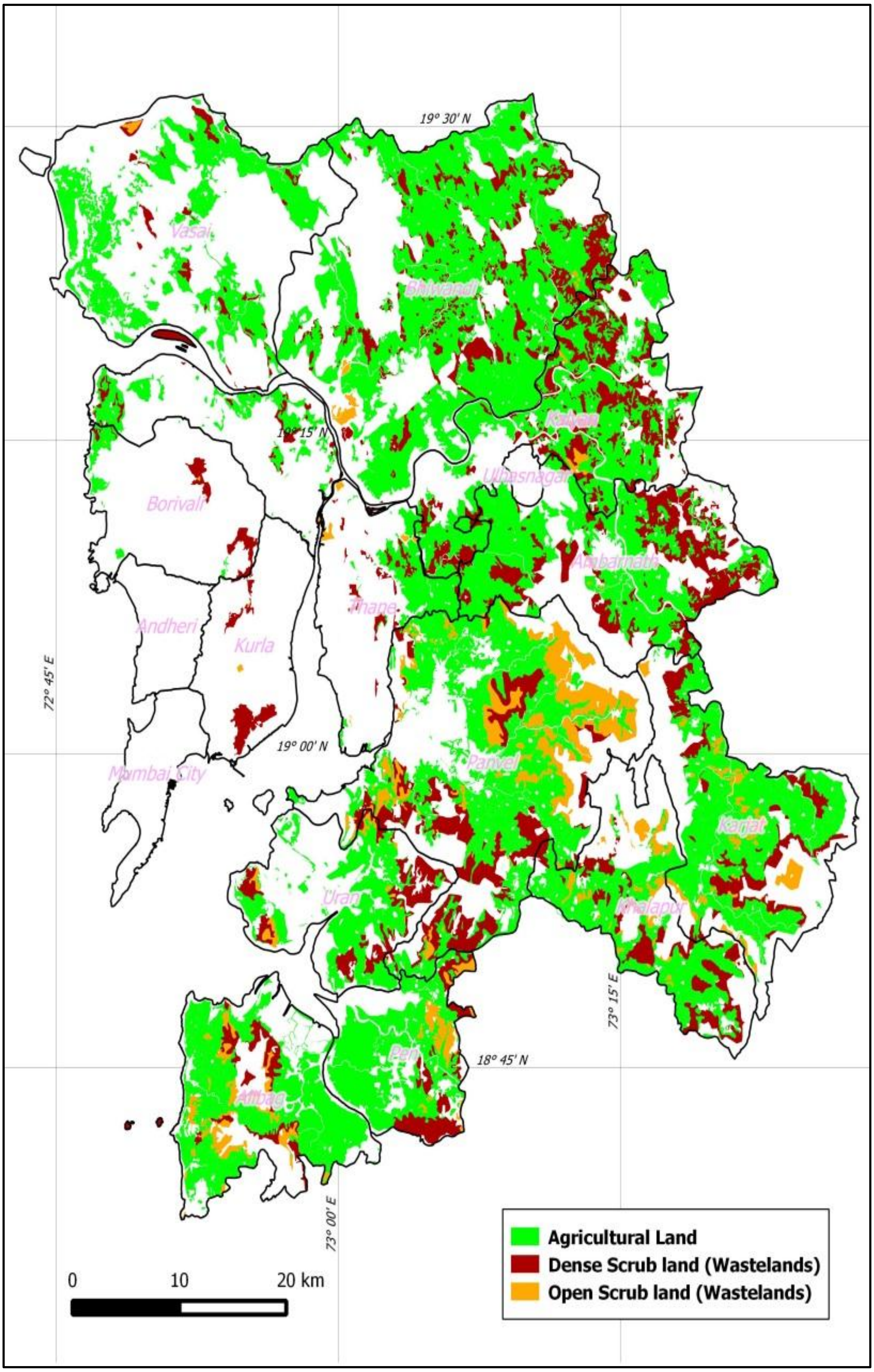
5.3.1.4 Conversion to NA plots

MMR being one of the prime areas and given the crunch of space in and around the region, land as a resource has tremendous value in MMR. Loss of interest as well as lower/negligible benefits from agrarian practices leads to the withdrawal from the profession and given the appreciation the owner receives, it is often noticed that the agricultural land is converted to Non-Agricultural land for economic gains. The conversion of these lands is often used for developing new constructions, buildings, townships, second homes, resorts and so on.

However, this data is not that easy to procure since easy availability of such records is a challenge. The ULBs don't project the correct land records as well as projected change in LULC patterns in their ESR's or on electronic portals. This information is also not available at a single window and various departments in one district are involved in compiling this data.

Recommendation

- A single point window for data compilation and sharing on the permission for conversion to NA plots.
- The data should be updated periodically, every three months, and should be made available online.
- The monitoring of the record keeping mechanism could be further strengthened.



Map No. 5-6: Agricultural and scrub land in MMR

Source: MRSAC, GoM

5.3.1.5 Impact due to loss of agricultural land

Owing to pressures on agricultural land due to urbanization and declining interest in taking up agriculture as an occupation, there has been a loss of agricultural land in MMR. Land under paddy cultivation which is the main crop of MMR is also under tremendous stress. In the past 10 years, more than 3780 hectares of agricultural land under paddy has been lost in MMR (Figure No. 5-8). The highest change in agricultural land under paddy has been recorded in the highly urbanised areas of Thane, Vasai, Kalyan and Ambernath. Moreover the highest percentage change in paddy land has been registered in the recent five years (2008-13). Although the blocks of Raigad have not registered drastic loss of land under paddy, there is still loss of around 2 percent on an average in these blocks.

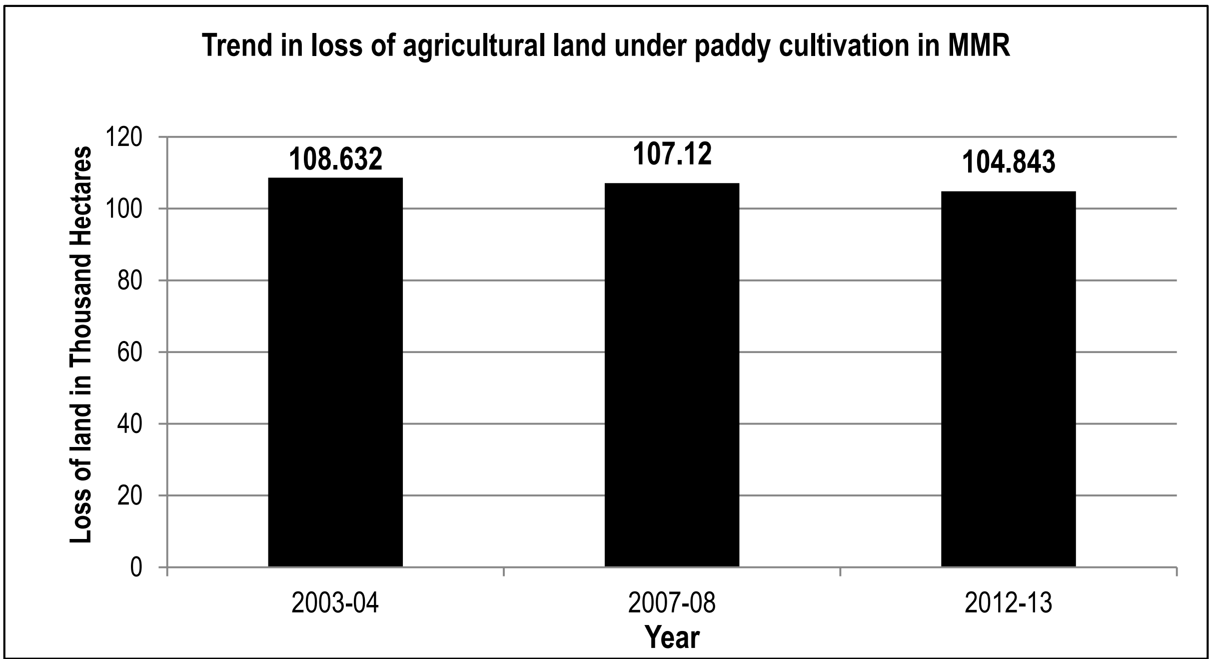


Figure No. 5-8: Trend in loss of agricultural land under paddy cultivation of MMR

Source: Data from MRSAC, GoM

Loss of agricultural land directly impacts the production of crops. Owing to loss of more than 3700 hectares of land under paddy cultivation there has been a loss in production of paddy in MMR. If this land conversion/loss had been avoided over the years and it was still being used for rice production, it would have augmented the rice production to an estimated 8400 tons in the year 2011-12. Since the land was unavailable in the year 2011-12, MMR which had an average productivity of 2239 kg/hectare in the same year, it is estimated to have had a loss of more than 8,400 tons of paddy (Table No. 5-10).

As per TERI's interaction with the locals from the paddy cultivating areas of Uran and Khalapur, it was recorded that the marginal farmers, with small land holdings depend upon this rice cultivation for their staple food. Cultivating paddy on the small holdings helps them cultivate food for a year ensuring them food security. Hence more than the calculated economic losses, it has also impacted the critical issue of food security for the locals. Since all the talukas of Thane have had a major loss for land under paddy (Figure No. 5-9), the development in other talukas of Raigad may impact the marginal farmers of those talukas.

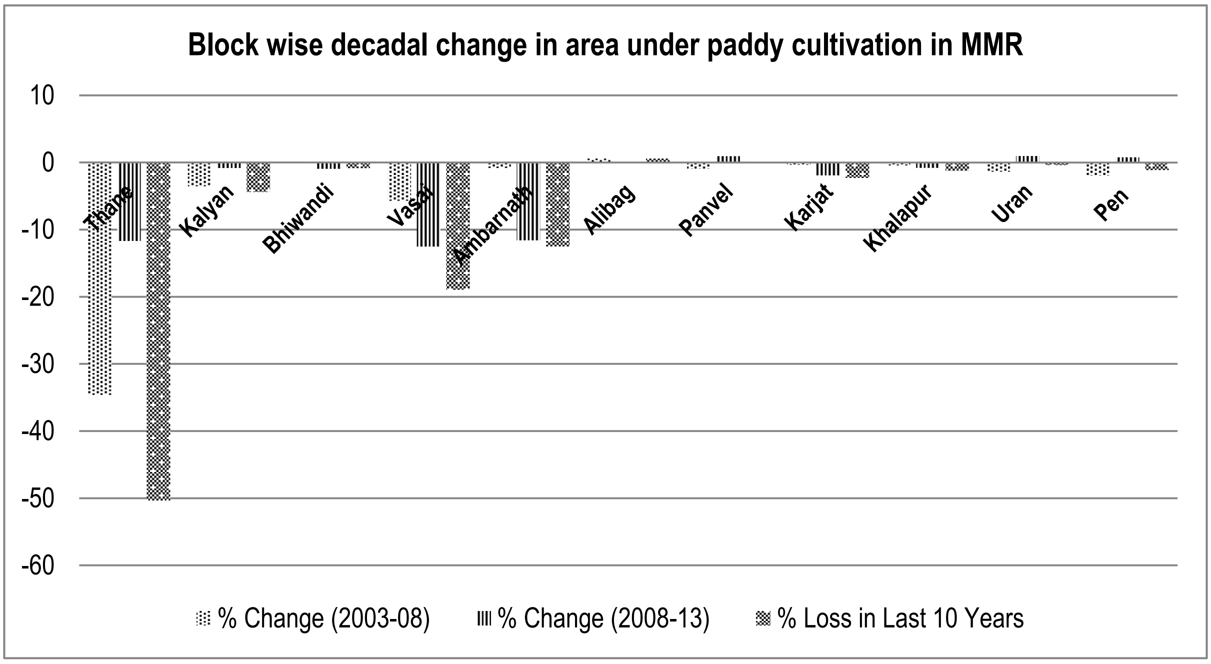


Figure No. 5-9: Block wise decadal change in area under paddy cultivation in MMR

Source: Agriculture department, GoM

Table No. 5-10: Losses due to loss of land under paddy cultivation

Heads	Value
Land Loss in Hectares *(in last 10 years)*	3789
Avg. Productivity for talukas in MMR (*Kg/hectare)*	2239
Loss in production in *(Kg)*	8483571
Loss in production *(tons)*	8483.571
Loss in revenue *(INR) (in year 2011-12 @24 thousand/ton)*	20,36,05,704 (~20 crores)

Source: Calculations based on data sets from MRSAC and Agricultural Department GoM

5.3.1.6 Recommendations

1. To retain the agricultural land in MMR under paddy cultivation and the land under double cropping areas.
2. To reserve dedicated land/ area as food zones/ Food corridors along the peri-urban areas for food corridors. Promote cultivation of basic food vegetables, milk production, food processing zones and poultry within the region.
3. To form a sustainable policy to prevent conversion of agricultural land in to non-agricultural land for development purposes

Significance:

- Agricultural areas along the periphery of the region shall help to meet the basic food demands of the developing region. This shall help in maintaining the eco balance, biodiversity and food security and act as a self-sustaining method for the region.
- It shall help generate employment for local youth
- Given the fact that the region is very accessible to ports (air and sea) the food processing units set up nearby could add to the foreign exchange reducing the losses
- Use of agricultural land would add to the open space as well as the soft land thus helping reduce the heat island impact as elaborated in section Climate variability and MMR of this report. Increase in soft land shall also help in recharging of the ground water.
- Presence of food corridors in the region shall also help in reducing the carbon footprint due to transportation of the food from long distances to meet the demand of a mega region like MMR.

Background

According to FAO[98], population pressure, urbanization, climate change, water scarcity, food consumption patterns and food price volatility are all areas of concern with great impact on food and nutrition security. Due to negligence over the dietary requirements of a person and continual degradation of the agricultural land for one or the other reason is leading to a threat called "food and nutrition security". Agriculture has the potential to improve nutrition in a sustainable way; however for making agriculture 'nutritionally meaningful' it is necessary to sustain the agriculture land.

A tremendous increase in the population, owing to inter and intra state migration, of up to 3.40 crores has been estimated in the next 2 decades which is nearly double the current population of MMR (Table No. 5-4) As per the projected population, the demand for these food items will also double in the next few decades. These basic food items are mainly brought into MMR from the nearby region in order to fulfil the ever increasing demand. The consumption of fuels due to transportation of these resources adds to the carbon footprint of the region. The annual fuel requirement for bringing in food products in MMR (Table No. 5-13), for even for basic food supplements like vegetables, milk and eggs[99] to meet the minimum dietary requirements[100], is typically from areas 200 & 500 Km away, is very high (Table No. 5-12).

[98] FAO 2012, *The State of Food Insecurity in the World*, Food And Agriculture Organization Of The United Nations
[99] http://timesofindia.indiatimes.com/business/india-business/Broiler-meat-egg-demand-to-grow-on-rising-purchasing-power/articleshow/20170278.cms
[100] Food and Nutrition Board, Institute of Medicine, National Academies

Table No. 5-11: Present food statistics for MMR area

Food item	Annual consumption per capita	Total food consumption per year
Eggs	55 Eggs	13 crore Eggs
Vegetables	77 Kg	18 crore Kg
Milk*	71 Kg	17 crore Kg

*Note: * Although milk is measured in liters we have considered it in terms of kg for maintaining the uniformity using standard conversion factors*

Table No. 5-12: Total fuel requirement to bring in basic perishable food items to MMR.

Capacity of truck per item	Fuel required (liters) for a single journey of a truck in km		Total number of trips	Total fuel requirement for a one way journey (Lakh liters)	
	200 Km	500 Km		200 Km	500 Km
13,000 eggs (Small truck)	13	32	97872	13	31
15,525 kg of Milk	40	100	107143	42	107
10, 000 kg of vegetables	40	100	178127	71	178

Table No. 5-13: Total CO_2 emitted during transportation of necessary perishable food items.

Food items	Total fuel requirement Mt (metric tonnes)		Emission factor for diesel	Emission of Co_2 (tonnes)	
	200 Km	500 Km		200 Km	500 Km
Eggs	1539	3790	3.19	4000	12000
Milk	5186	12964	3.19	16000	41000
Vegetables	8621	21553	3.19	27000	68000

The "National Land Utilization Policy," framework for land use planning and management by the Department of Land Resources, Ministry of rural Development, Government of India, focuses on land demand for development of India on one hand and the social, cultural and environmental aspects on the other hand. As land is a State subject, it falls under the legislative and administrative competence of the States. Rapid economic development and consequent urbanisation; growth in the housing sector; improved national highways bringing urbanisation closer to rural hinterland; demand for land for large infrastructure projects in urban hinterland all of these factors have contributed to expansion of urban boundaries[101].

In July 2014, the state of Maharashtra cabinet simplified the process of conversion of agricultural land for urbanisation and other non-agricultural purposes. As per this decision, the agricultural sector within MMR which covers 35 % of the land under cultivation of single or double crops would have a major threat of conversion into land use pattern. Thus, it will have a negative impact on agricultural production and livelihood. If the trend for land use pattern is assessed, the conversion of land into built up area is an irreversible process. Agricultural land and open spaces offer variety of environmental benefits, it sustains different ecosystems, which would be completely lost if the entre agricultural area is used for urbanization.

Moreover, agricultural land does not only mean ploughing, sowing and reaping of crops or produce, but also grazing for cattle, breeding of livestock, poultry farming, manure storage and so on are also come under land used for agricultural purposes. The conversion practise will result in shrinking of land which is not used for cultivation.

Thus, through a strong policy framework, the land us and land cover pattern of MMRDA should be appropriately managed.

[101] http://jnnurm.nic.in/wp-content/uploads/2011/01/Optional_Primer_primer.AGRICULTURAL.pdf

5.3.2 Urban Sprawl and infrastructure

Urban population in MMR accounts for about 92 percent of the total MMR population and the built up area accounts for around 14 percent of the total area. This indicates that the density of population is highly concentrated in about 620 sq.km of built up area. The built up area in MMR has increased by 2 percent (57.74 Sq.Km) in the past 20 years.

As seen in Map No. 5-7, majority of the urban development (built up) has been close to the wetlands (mangroves, coastal area) of the MMR. Taken together the areas of Mumbai, Navi Mumbai, Vasai, Uran, Panvel which have the major share of built up area in MMR. The only inland urban built up area in MMR is seen in the areas of Ulhasnagar, Ambernath and Kalyan, which could be directly attributed to two reasons, presence of industrial belts in those regions as well as direct connectivity to south Mumbai through suburban rail network.

Although the built land may seem to have increased by 2 percent, it is striking to note that the population has increased manifolds (197% in 4 decades) indicating tremendous increase in population density. Also the footprint of built up may seem less but given the fact that there are high rise buildings in the region, the region is expanding vertically. For example in the city of Navi Mumbai (NMMC limits) total land area has remained same, 108.5 Sq. Km, however vertical growth has provided more usable floor space in the city. The usable floor space in NMMC limits has been increased by almost 1.1 Sq.Km. in three years, between 2007 and 2010. The increase in usable floor space in NMMC is depicted in Table No. 5-14.

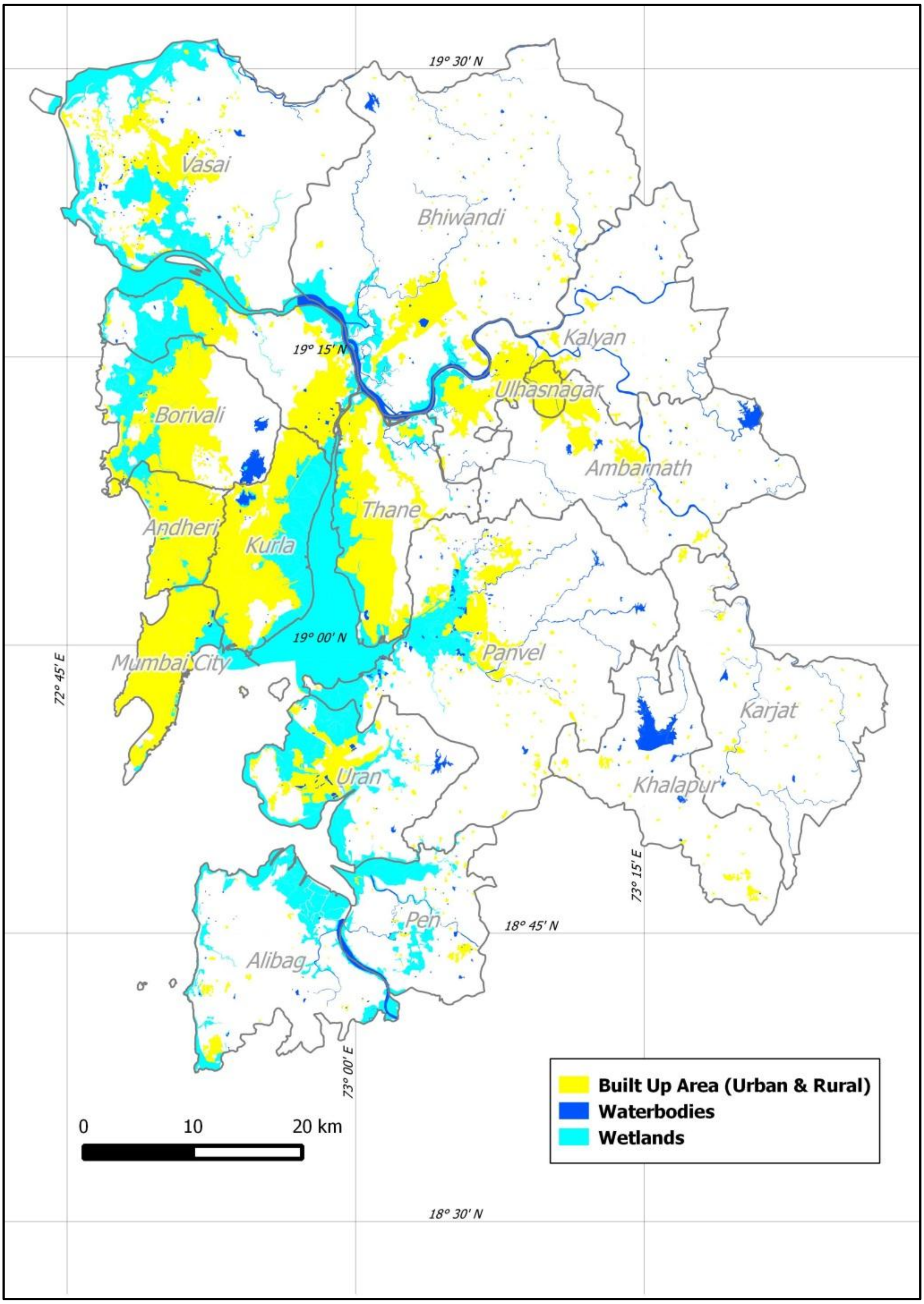
Vertical growth invites a lot of resource demand in form of energy for usage of water and elevators. Also since the density would increase, it would lead to crunch in space for roads, vehicles, parking space, open space and so on. It further adds to the complication of waste disposal for sewage, and sold waste since high population density would lead to generation of huge quantity of waste. Since technologies are not available to treat such huge quantum of waste this could further add to the burden on other resources including land itself.

Table No. 5-14: Increase in usable floor space in Navi Mumbai (NMMC)

		2007-08	2008-09	2009-10
Floor Space (Sq. Km.)	Residential	3.374	3.970	4.326
	Commercial	0.827	0.973	1.060
	Total	4.201	4.943	5.386

Source: Property tax collection in NMMC[102]

[102] NMMC 2010-11, Annual Budget Statement Navi Mumbai Municipal Corporation, Annexure A.5, Income from Property Tax collection and *Process or rate fixing for property tax collection by NMMC*



Map No. 5-7: Built up area in MMR

Data Source: As per attributes provided by MRSAC, GoM, 2006

Various infrastructural projects are also proposed in the MMR, including the Navi Mumbai Airport, the Mumbai Trans Harbour Link (MTHL), the western coastal road connecting Nariman Point to Kandivali and so on. These all projects have been proposed on sensitive lands especially the wetlands (mangroves, swamps) and are bound to have severe impact on the ecosystem.

As per the EIA (Environmental Impact Assessment) report of the proposed Navi Mumbai Airport (2110 Hectares[103]), the construction of the airport is bound to have severe impact on the ecosystem as a whole since more than 54%[104] of the project area is covered by natural cover like mangroves, mud flats, hills, creek and river while 35% land under the project site is open area. The EIA has proposed a plan which would have the following major impacts

- Changing land use and land cover pattern for urban development
- Cutting of hills in the area which are in the vicinity of the proposed airport [105]
- Re-settlement of 7 villages falling in the airport zone and having population of 15000 spread in 3113 households.
- A portion of Gadhi River and Ulwe River flowing through the airport site would need to be trained and diverted along the boundary of airport.
- More than 50% of the airport area falls in the shallow mud, a flood prone area, abutting the creek and the entire land is required to be developed to a safe level.
- Three sensitive sites viz. Elephanta caves, Karnala Birds Sanctuary and Matheran Eco-Sensitive Zones fall within the radius of 20 kms from the airport reference point.

Recommendations:

- Permissions for the development along the coast should be strictly avoided
- The other inland areas of the region like Bhiwandi and Kalyan may be considered for planned development
- An alternate site for the new airport should be considered
- The FSI (Floor Space Index) for the region should not be increased or be liberal or be incentivised

[103] EIA study of Navi Mumbai Airport, Executive Summary, Land Status and Settlement, pps-20
[104] EIA study of Navi Mumbai Airport, Executive Summary, Land use pattern, pps-21
[105] http://cidconmia.com/website/nmia-2/project-activities/pre-development/hill-cutting-navi-mumbai-international-airport/

5.3.3 Quarrying activities

Stone quarry operations in MMR have resulted in extensive alteration of the landscape in the region. Quarrying results in conditions favourable for accelerated erosion because the topsoil environment required for stabilizing the vegetation is eliminated. It induces not only loss of soil but also deforests the area. Once quarry resources are exhausted it causes the region to look barren and degraded. It also impacts the biodiversity of the region and is known to be a major cause for increased RSPM levels. As per State of Environment Report published by MPCB (Maharashtra Pollution Control Board) and Indira Gandhi Institute of Development Research in 2007, the state government has already identified restoration of degraded land due to quarrying activities as a major challenge. This is true especially for Navi Mumbai area, where NMMC is facing tremendous challenges in restoring quarry degraded sites A detailed physical survey and mapping for the stone quarry settlements of Navi Mumbai area has been carried out by Architecture of Rapid Change and Scarce resources [106].Many areas in the MMR are affected by quarry operations of which some are being carried out in ecologically sensitive regions. As on January 2014, there are about 200 operators in MMR who have been provided with lease to undertake stone quarrying and stone crushing activities. The total active sites under quarrying add to a total of 4.5 sq. km area within MMR, which are undertaken in the talukas of Thane, Bhivandi, Panvel and Kalyan (Table No. 5-15).

The Parsik hill range spread around 7 kilometres in length is well within the city limits of Thane and Navi Mumbai. Around 9 percent of the hill has been lost to quarrying activities which has impacted a major part of the 15 sq.km of reserved forest. At the given rate of excavation it is estimated that around 30 percent of the hill shall be destroyed before its lease gets over in the year 2017[107]. Out of the total land under active quarry sites, more than 50 per cent land is owned by private owners followed by CIDCO which has given around 10 lakh Sq.M of land on lease for quarrying activities (Figure No. 5-1).

Table No. 5-15: Taluka wise stone tally of quarry operators and area under lease for quarry in MMR

Taluka	Number of Lessee/Operator	Total Area for land under lease (Sq.M)
Alibag	5	111720
Ambernath	9	431200
Bhivandi	52	1132865.22
Kalyan	16	628200
Karjat	4	175330
Khalapur	5	147810
Panvel	20	401200
Pen	1	31900
Thane	86	1076736.47
Uran	8	131100
Vasai	13	286934.3
Total	**219**	**4554995.99**

Data Source: District Collect orates of Thane[108] and Raigad, 2014.

[106] http://www.academia.edu/3443723/Navi_Mumbai_Stone_Quarry_Settlements_by_ARCSR
[107] Annapurna Shaw (2004). *The Making of Navi Mumbai*. Orient Blackswan. p. 119.
[108] http://www.thane.nic.in/pdf/sand_mining/khanipatta%20list.pdf

The lease for quarry sites is typically given in the range of 5 to 20 years. Hence although Kalyan region has many quarry sites the lease for major operators shall be over by the year 2015. Thane, Ambernath and Bhiwandi are the talukas where the quarrying activity shall continue for another three to four years.

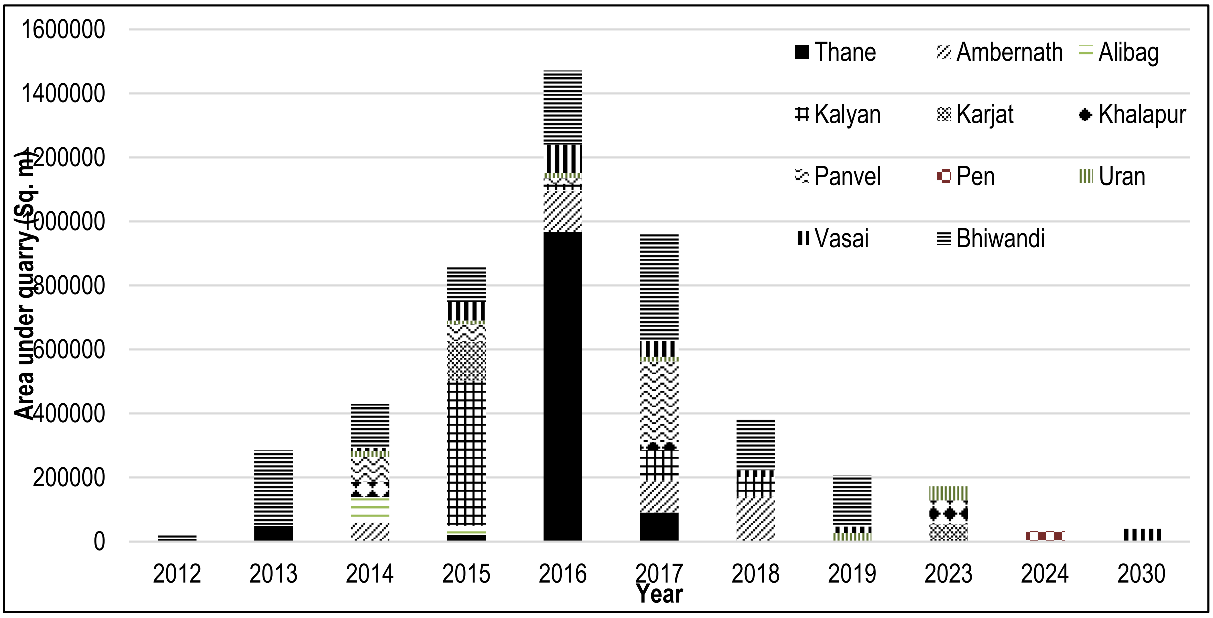


Figure No. 5-10: Taluka wise area under quarry site before lease expiry

Source: District Collect orates of Thane and Raigad, 2014

Specific Recommendation

- In the year 2016, the lease for more than 100 operators shall expire, hence while drafting the regional plan MMRDA should consider appropriate allocation. Stone quarry should be completely stopped.
- During the already issued licenced quarries best practices should be followed, and stricter vigilance is necessary.
- Periodic EIA should be carried out

5.3.3.1 Response Against Quarrying Activities

1. Specific Development Control Regulations for Mumbai Metropolitan Region, 1999[109] have been prepared which specify the guidelines for permitting quarries in MMR.
2. NMMC has planned to assess the feasibility of using abandoned quarries for rainwater harvesting; planting trees for restoration of land under abandoned quarries and implement better handling operational facilities with pollution control measures in quarries in operations[110].
3. MPCB has developed specific guidelines for source wise pollution control measures to be followed for stone quarries[111].

[109] http://www.mumbaidp24seven.in/reference/15_DCR_for_Mumbai_Metropolitan_Region_1999.pdf
[110] http://www.moef.nic.in/soer/state/SoE%20report%20of%20Maharashtra.pdf
[111] http://mpcb.gov.in/ereports/pdf/GUIDELINES%20FOR%20STONE%20QUARRYING.pdf

5.3.4 Salt pans in MMR

Saltpans are defined as a small, undrained, shallow depression in which water accumulates, evaporates, and deposits salt[112]. The MMR coast has been ideal for the manufacture of salt; indeed, salt works have been in existence here for as long as people can remember. However, since 1850's the saltpans began to be acquired for various public purposes, and inch by inch, they ceased to be used to produce salt[113].

Mumbai's saltpans are spread over 13 pockets of salt pans across the eastern suburbs of Ghatkopar, Chembur, Wadala, Kanjurmarg, Bhandup, Mandale, Turbhe, Nahur and Mulund, and the western suburbs of Dahisar, Mira Road, Bhayander, Malvani and Vihar. Navi Mumbai city, is also been developed on a land which was once a sanctuary for salt pans and the area was resided by salt pan workers, before the city was developed[114]. Mira-Bhayander area on the east coast of MMR is presently the major hub for salt pans and production with more than 49 salt pan owners[115]. Although most of these lands are privately owned, since 1960 the Central Salt Department in Jaipur has taken the view that salt work lands belong to the central government, and that the salt manufacturers only have right of use to the land to produce salt under the terms of the licence. The salt pans in MMR fall under the Bhayander and Bhandup circles of the Deputy Salt Commissioner of Mumbai Region (Picture No. 5-5).

Picture No. 5-6: Salt workers working at the saltpans in Mulund (2012)

Source: TERI

112 http://www.thefreedictionary.com/Salt+pans
113 http://infochangeindia.org/agenda/coastal-communities/saltpan-city.html
114 http://www.cidco.maharashtra.gov.in/NM_Introduction.aspx
115 http://www.afternoondc.in/city-news/bhayandar-salt-pan-owners-face-eviction/article_88784

5.3.4.1 Status salt production in districts of MMR

Area under salt production

As on 2013-14 the total area under salt pans in Maharashtra accounted to about 20,131 acres, with a major share of these salt pans being in the districts of MMR. Out of the total area under salt pans only about 68% of the land is utilised for salt production. The land used for salt production is categorized into 4 categories based on its ownership and area. Category I – includes the salt pans exceeding more than 100 acres, Category II – includes the salt pans ranging in the area of 10-100 acres, Category III – includes salt pans used by co-operative societies while the Category IV includes all the salt pans under 10 acres of area which are not under Co-operative societies.

As seen in Figure No. 5-11, the major area of salt cultivation is under Category I in Maharashtra and the year 2013-14 it accounted to about 12,540 acres of which mere 8319 acres (66.34%) was used for salt production. Over the years the operators categorised under Category –II have also, on an average, utilised mere 70% of the land while in the last year (2013-14) only about 60% of the Category –II salt pans were used. Salt pans under Category –III and Category –IV are the most efficiently used production sites. As per the annual report issued by Salt Department, Government of India[116] the number of operation units in Category-I, Category –II, Category-III and Category-IV was about 47, 112, 26 and 5 respectively.

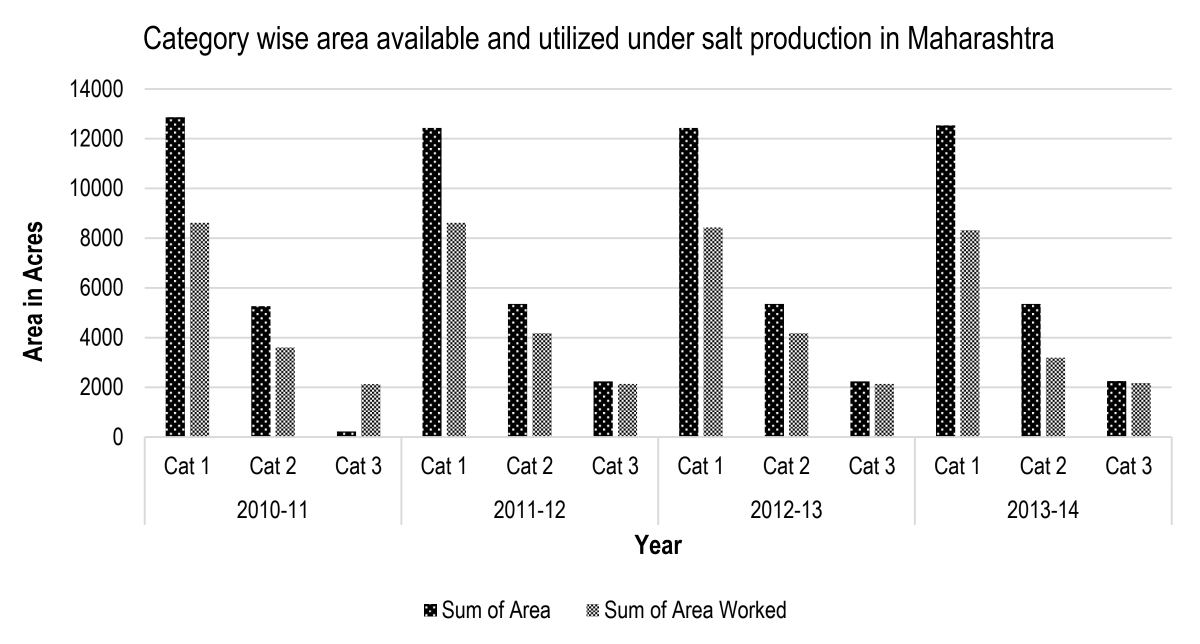


Figure No. 5-11: Category wise area available and utilized under salt production in Maharashtra

Source: Salt Department, Ministry of Commerce and Industry, Government of India[117]

[116] Salt Department *Annual Report 2013-14*, Ministry of Commerce and Industry, Department of Industrial policy and Promotion Government of India,

[117] Annexure 6.3 of the respective Annual Report of 2010-11, 2011-12, 2012-13, 2013-14 of Salt Department GoI (hyperlink: http://www.saltcomindia.gov.in/)

Salt production in MMR

All the four coastal districts of Maharashtra are engaged in salt production; however the salt pans in Thane district have the largest share in terms of salt production in Maharashtra with more than 80% share in the total production. While Mumbai Suburban district is the second highest producer of salt in the state. Over the past five years the salt production from the districts of MMR has consistently accounted to more than 98% of the annual salt production of the state (Figure No. 5-12). In the year 2013-14 the total salt production from the districts of MMR was about 2.52 lakh MT (Metric Tons), with Thane and Mumbai Suburban districts.

In terms of production, it can be clearly seen from Figure No. 5-13 that the salt production in 2013-14 has declined steadily over the years as compared to 2008-09. The total production in 2008-09 was about 187 thousand MT and declined to about 145.5 thousand MT in 2013-14, indicating a decrease of more than 22% in the total salt production from the state of Maharashtra. This decrease in production of salt is majorly attributed to drastic decline in production from Category-I and Category-II (Figure No. 5-13).

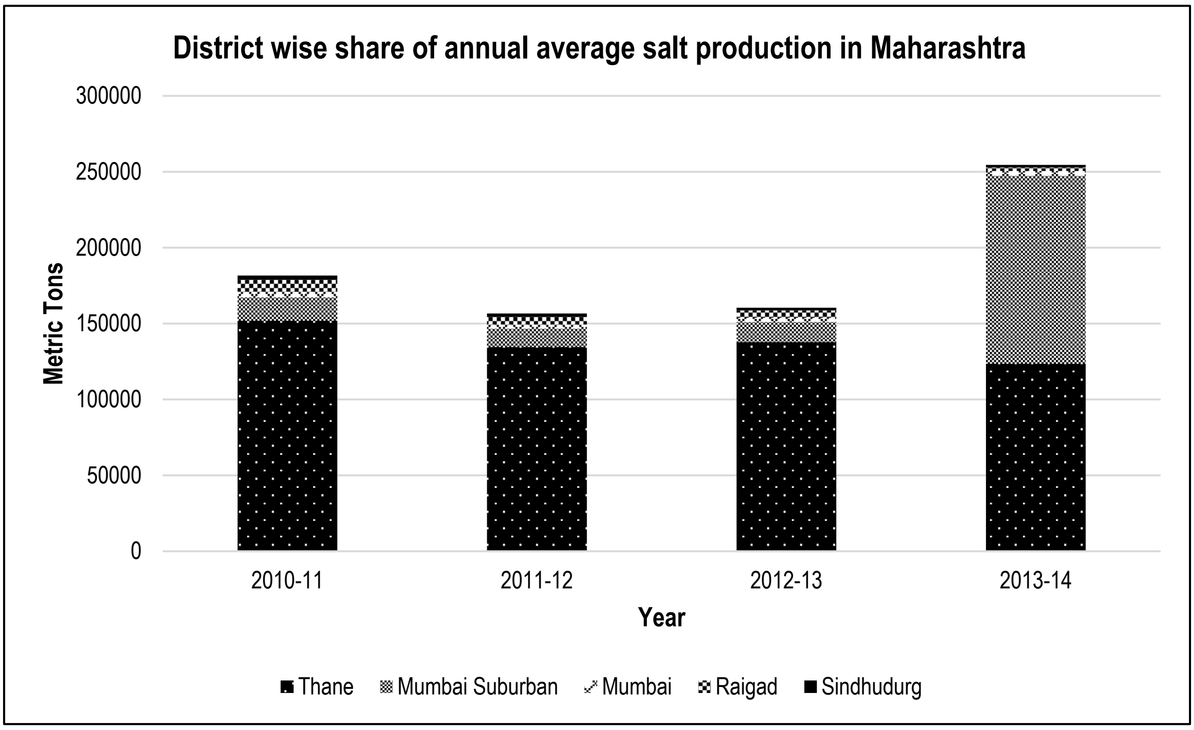


Figure No. 5-12: District wise share of annual average salt production in Maharashtra

Source: Salt Department, Ministry of Commerce and Industry, Government of India[118]

[118] Annexure 6.2 of the respective Annual Report of 2010-11, 2011-12, 2012-13, 2013-14 of Salt Department GoI (hyperlink: http://www.saltcomindia.gov.in/)

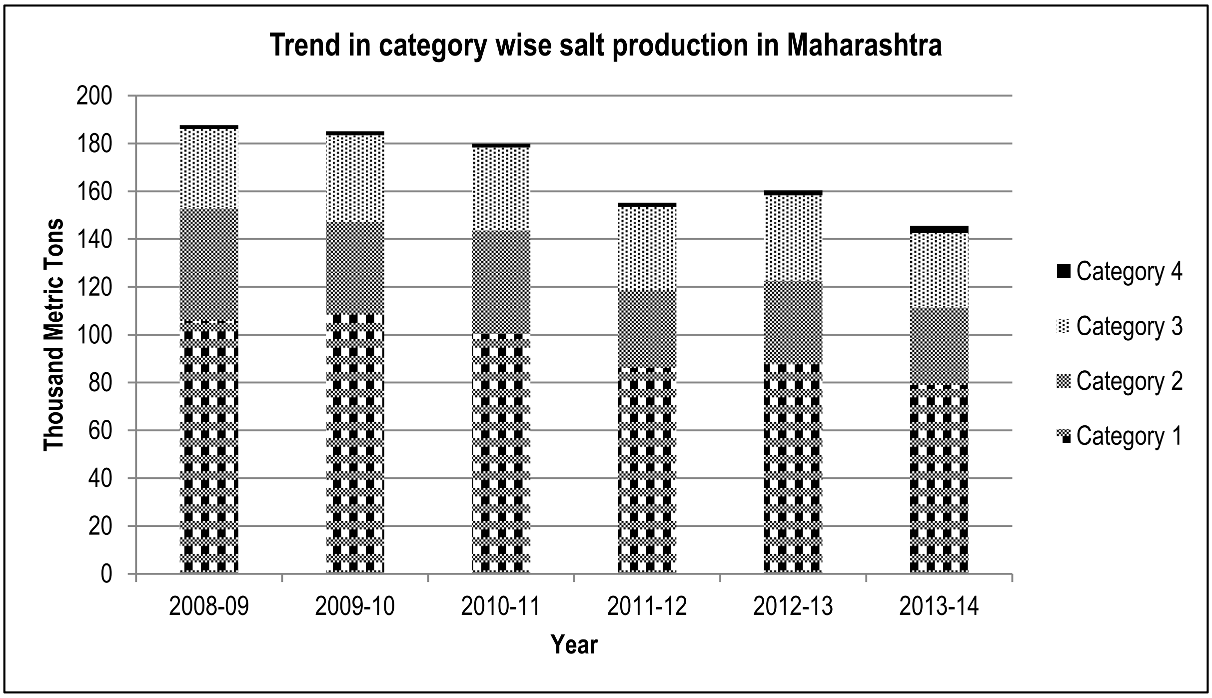


Figure No. 5-13: Trend in category wise salt production in Maharashtra

Source: Annual Report 2010-11 and 2013-14 Salt Department, GoI[119]

Specific Recommendation

- Since the districts of MMR contribute a major share to the states salt production, the saltpan should be treated as conserved entities. As of now, the salt pans lands of Mumbai and Mumbai Suburban are excluded from the internal policy guidelines for salt pan land transfer, released by Department of Industrial Policy and Promotion, Ministry of Commerce and Industry, Government of India. TERI recommends to include these lands in the policy.
- Although the salt pans fall under the strict CRZ (Coastal Regulatory Zone) –I, zones there has been plans and discussions to open up some of these lands for development[1] the conversion of land will directly affect the salt production of the state as well as the salt workers who solely depend upon this occupation for their livelihood[1].
- Moreover, saltpans is an important wetland area which acts as a buffer zone. Hence given the possibilities of natural calamities, tsunami, flooding and sea level rise, saltpans should be strictly protected.

[119] Annexure 6.7 of the respective Annual Reports of 2010-11, and 2013-14 of Salt Department GoI (hyperlink: http://www.saltcomindia.gov.in/)

5.4 Solid Waste

Consumption of resources leaves behind waste in various forms. Consumerism, urbanization and changing lifestyle has increased the per capita waste generation manifolds. Irresponsible disposal of plastic (poly-ethylene), penetration of use-and-throw concepts, excessive use of packaging materials, clothes, glass, plastic, styro-foam, food waste and so on are the major constituents of municipal solid waste. It is estimated that around 1.3 billion tons/year of municipal solid waste is generated in the world and expected to be double by 2025[120]. Given the huge quantum of waste generated by anthropogenic activities, its management and disposal becomes one of the major challenges for urban local bodies, even in the developed countries. Apart from, Municipal Solid Waste (MSW), biomedical waste, hazardous waste and E-waste are also a major global concern.

Although being a developing country, India is amongst the top ten MSW generators in the world and hence under the National Mission for Sustainable Habitat, one of the eight missions under NAPCC (National Action Plan on Climate Change), Government of India has already recognised to evolve the standards in respect of municipal solid waste management sector. As per a survey conducted by Ministry of Urban Development[121], Government of India, it has been documented that solid waste management systems adopted in Indian cities/towns are highly inefficient, out-dated and lack public participation. It further recognises that overall apathy is observed in the collection, transportation and disposal mechanism of municipal waste.

Considering the spatial expansion and population of MMR, solid waste management is a complicated task for the waste managers of the region, which are mostly the municipal or local bodies. Since majority of the waste is disposed in open dumping grounds, land availability for such an application is also a major hindrance. Landfill sites and open dumping sites severely affect the air quality nearby, impact the ground water quality and also the leachate seeps into the creeks and water bodies. Degradation of the waste at dumping sites is known to release land fill gas, which majorly is composed of methane (CH_4), a GHG (Greenhouse gas). Since, methane is 21 times more potent that carbon-di-oxide as a GHG and also a highly flammable gas, it poses local as well as global impacts. This scenario coupled with other issues like irresponsible disposal by citizens, non-segregation of waste, lack of appropriate technology and technical know-how further aggravates the repercussions of the whole issue.

Given the fact that MMR is highly industrialized, urbanised and densely populated this section presents the status of waste; its generation and management, in MMR.

[120] http://www.worldwatch.org/global-municipal-solid-waste-continues-grow
[121] http://urbanindia.nic.in/programme/uwss/nmsh/mswm.pdf

5.4.1 Municipal Solid Waste

5.4.1.1 Generation of Waste

As on March 2014, it is estimated that about 13,000 MT/day of MSW is generated in MMR, the highest than any other metropolis in the country. The rate of generating MSW is increasing rapidly. Within a span of just 3 years (2008-09 and 2011-12), MSW generated in MMR has increased by almost 1000 MT/day (**Error! Reference source not found.**)

Collection, transportation and disposal of MSW, is under the purview of the respective ULB's. However in some areas of Navi Mumbai, it's SPA (Special Planning Authority), CIDCO (City and Industrial Development Corporation of Maharashtra Ltd), provides the urban service of waste collection and disposal. As per the statistics, the majority of the waste generation is from 8 municipal corporations which are responsible for around 98% of the waste generated in MMR.

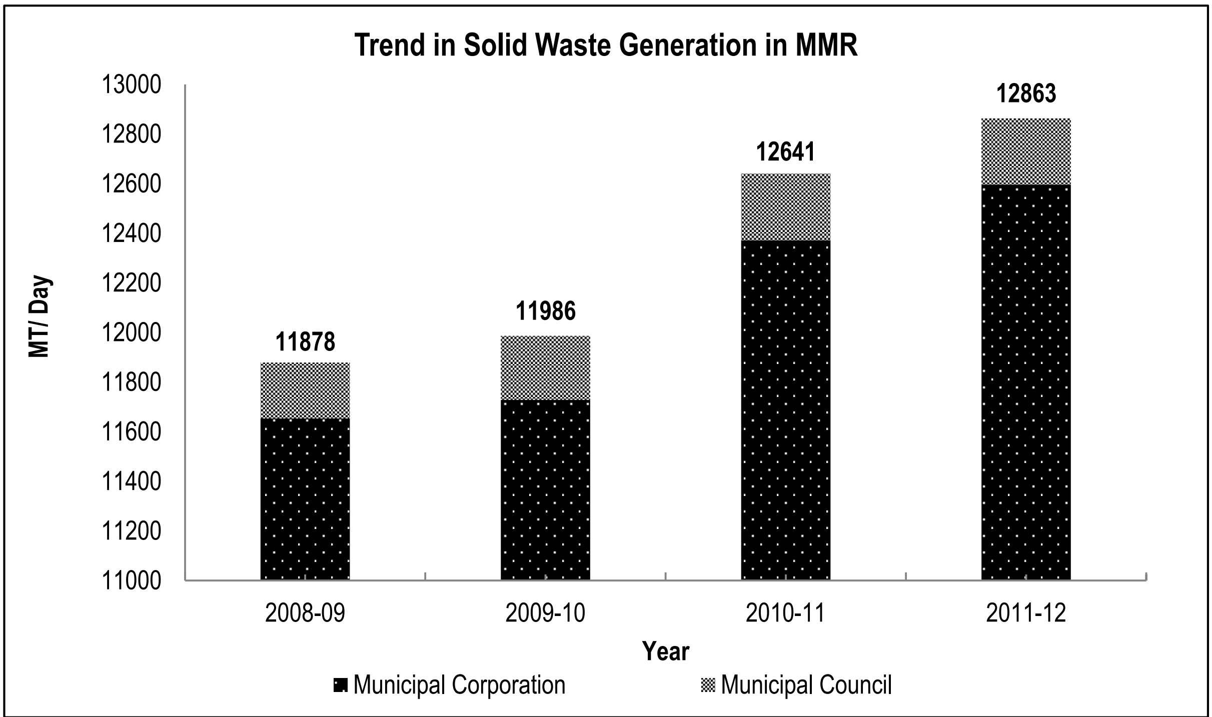


Figure No. 5-14: Trend in Solid Waste Generation in MMR (2008-09 to 2011-12)

Specific Recommendation:

Rural areas of MMR, especially gram panchayat (GP) areas, do not have a proper channel for waste collection and disposal. As of now waste in these GP areas are disposed of in an un-regulated manner near the towns in MMR. Since these areas are fast evolving but still currently have manageable waste being generated, facilities for appropriate management need to be promoted. It is strongly recommended to consider a policy level intervention for the same.

Source: Environment Status Reports of Municipal Corporations except Ulhasnagar Municipal Corporation[122], National Solid Waste Association of India[123], Performance Assessment System[124]

[122] City Sanitation plan 2012 of Ulhasnagar Municipal Corporation

Among the 8 corporations, it is quite obvious that MCGM being the biggest and densely populated municipal area would generate the highest MSW. As per statistics, Greater Mumbai generates more than 70 percent (**Error! Reference source not found.**) of the total olid waste generated in MMR. The other larger corporations like Thane, Navi Mumbai, Kalyan-Dombivali, Mira-Bhayandar, generate SWM around 550-650 MT/day while Mira-Bhayandar, Vasai-Virar and Ulhasnagar cities generate 300-400 MT/day of solid waste. Whereas, the B and C class cities like Pen, Uran, Khopili and so on generate less than 65MT/day of solid waste (Figure No. 5-1). Thus a separate and independent action plan and approach needs to be adopted to manage solid waste of various cities.

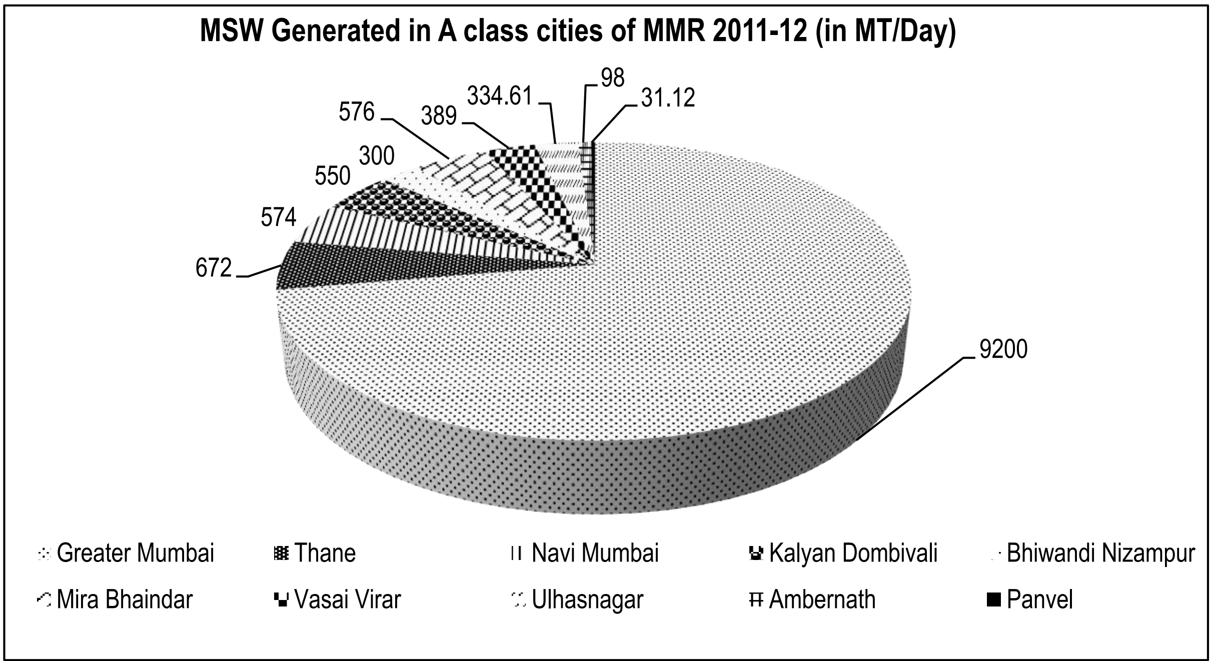


Figure No. 5-15: MSW Generated in various A class cities of MMR 2011-12 (in MT/Day)

Source: Environment Status Reports of Municipal Corporations except Ulhasnagar Municipal Corporation[125], National Solid Waste Association of India[126],

123 Data collected from NSWAI for ENVIS, MoEF, GoI

124 http://www.pas.org.in/web/ceptpas/performance?p_p_id=SLBPerformanceAssessment_WAR_Portal&p_p_lifecycle=1&p_p_state=normal&p_p_mode=view&p_p_col_id=column-1&p_p_col_count=2&actionVal=GetScreen&tabId=4

125 City Sanitation plan 2012 of Ulhasnagar Municipal Corporation

126 Data collected from NSWAI for ENVIS, MoEF, GoI

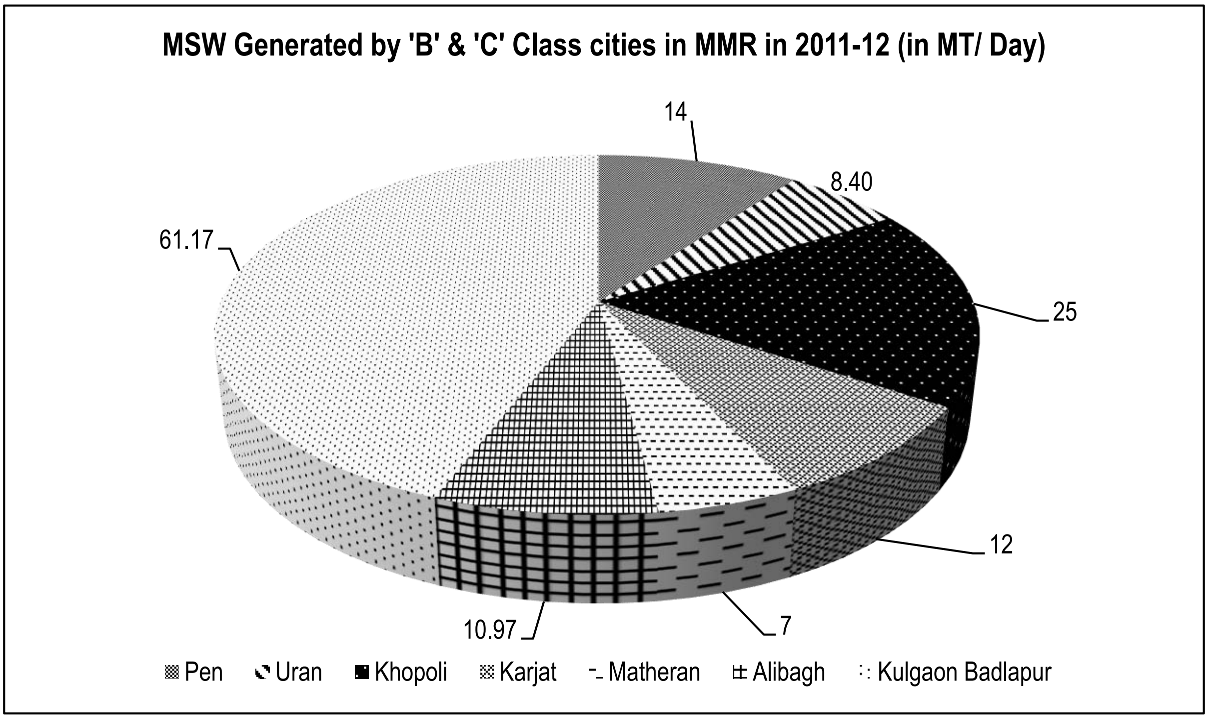


Figure No. 5-16: MSW Generated in various B and C class cities of MMR 2011-12 (in MT/Day)

Source: National Solid Waste Association of India[127], Performance Assessment System[128]

Although, the total waste generated in MCGM region may be the highest, it is important to consider the per capita generation to come up with a strategic plan while prioritizing the action plans for towns in MMR.

One may note from Figure No. 5-16, that Matheran town generates the highest per capita MSW. This is primarily because of the floating population and tourism activities in the town. A biogas plant of 5MT capacity has been installed at Matheran to treat biodegradable waste however dumping of PET bottles and packaging materials still remains unattended and needs immediate attention, given that Matheran has been declared as an Eco-sensitive region. Similarly tourist place like Alibaug, also generates higher per capita solid waste.

It is striking to note that residential areas like Mira-Bhayandar and commercial areas like Ulhasnagar generate higher per-capita solid waste, almost comparable to MCGM region. As seen in Figure No. 5-17, waste collection of Matheran is 2.1 times more than MCGM.

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[127] Data collected from NSWAI for ENVIS, MoEF

[128] http://www.pas.org.in/web/ceptpas/performance?p_p_id=SLBPerformanceAssessment_WAR_Portal&p_p_lifecycle=1&p_p_state=normal&p_p_mode=view&p_p_col_id=column-1&p_p_col_count=2&actionVal=GetScreen&tabId=4

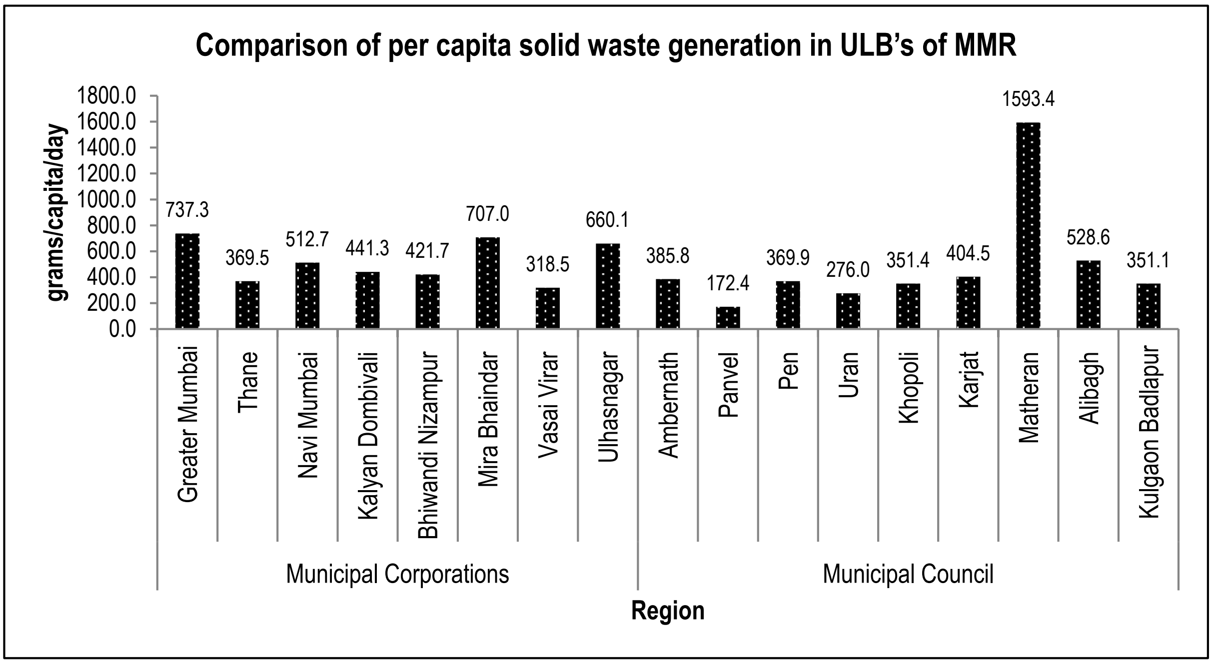


Figure No. 5-17: Comparison of per capita solid waste generation in ULB's of MMR

Data Source: Environment Status Reports of Municipal Corporations) except Ulhasnagar Municipal Corporation[129], National Solid Waste Association of India[130], Performance Assessment System[131] and Census of India 2011 for population data

Specific Recommendation:

Waste profiling studies have not been undertaken by the ULB's except for Navi Mumbai which regularly monitors and maintains data on waste profiling. This shall help in having information on the composition of waste and then developing strategic plan for the same.

MMRDA may allot budget to the ULB's for undertaking these studies since ULB's do not have budget for this types of analysis.

[129] City Sanitation plan 2012 of Ulhasnagar Municipal Corporation
[130] Data collected from NSWAI for ENVIS, MoEF, GoI
[131] http://www.pas.org.in/web/ceptpas/performance?p_p_id=SLBPerformanceAssessment_WAR_Portal&p_p_lifecycle=1&p_p_state=normal&p_p_mode=view&p_p_col_id=column-1&p_p_col_count=2&actionVal=GetScreen&tabId=4

5.4.1.2 Disposal of MSW

Collection, appropriate transportation and scientific/responsible disposal of 13,000 MT of MSW per day are very challenging tasks. As of now open dumping is practiced by almost all the ULB's in MMR at the open dumping grounds identified by each ULB. The major MSW dumping sites in MMR has been presented spatially in Map No. 5-8. As illustrated all the municipal corporations have their disposal sites within their administrative limits which are mostly open dumping sites. In some cases, such as Thane Municipal Corporation, the sites are leased out to some private owner. The details of the dumping sites of various ULBs are provided in Table No. 5-16. No information is available regarding the dumping sites of some of the B and C class municipal councils. For example, TERI's interactions with officials of Alibaug Municipal Council revealed that currently there is a MSW disposal site within the council limits, but it has not been officially allotted for the said purpose. Allotment of land for MSW disposal is under process currently.

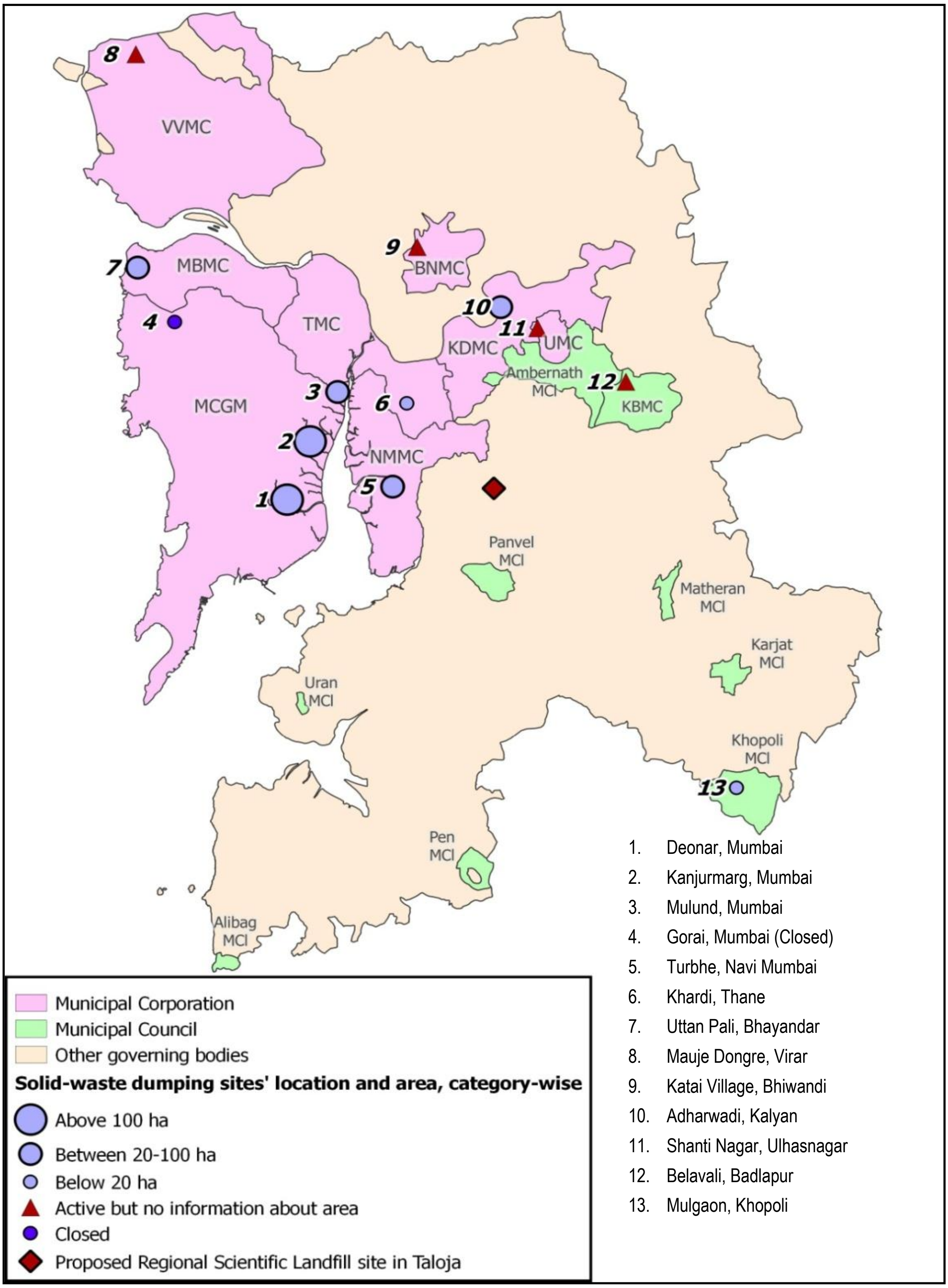
TERI has carried out an assessment of ESRs for all the municipal corporations within MMR. Based on the information from the ESRs, one of the major constraints pertaining to disposal sites is allotment of land, which complies with the norms of MSW Management and Handling Rules, 2000[132] (henceforth called as MSW Rules, 2000). Most of the ULBs face difficulties in identifying appropriate pocket of land for disposal of MSW due to demand of land for other purposes and distance from habitations. According to the rules outlined in MSW Rules, 2000, the disposal site needs to be away from habitation clusters, forests, water bodies, monuments, national parks, wetlands and places of cultural, historical and religious interest. Thus it is a challenging task for the planners to identify land which follows such norms.

5.4.2 Compliance Criteria

In case of certain criteria, it is not clear if the criteria are being complied by the ULBs based on the data provided in their individual ESRs or Performance Assessment System reports of the municipal councils. Hence an exercise was conducted based on the information available from the ESRs of the ULBs and other secondary sources available, to identify the gaps and analyse the level of compliance of the criteria listed out in the MSW Rules, 2000 by the ULBs

In addition to this criteria, the MSW Rules, 2000 outlines a list of other criteria which needs to be complied during management and handling of MSW. These are broadly classified into Collection, Segregation, Storage, Transportation, Processing and Disposal. Apart from these mentioned criteria, the rules lay down certain specifications for selection of disposal site, facilities required at the site, landfilling, pollution prevention, water quality monitoring, ambient air quality monitoring, plantation at landfill site, closure of landfill site and post care. These specifications are included in the Schedule III of the MSW Rules, 2000. Further, Schedule IV of the rules, propose standards for composting, treated leachates and incineration.

[132] http://www.cpcb.nic.in/divisionsofheadoffice/pcp/management_solidwaste.pdf



Map No. 5-8: Major municipal solid waste dumping sites in MMR

Source: ESR's for site and GIS map developed by TERI based on file shared by MRSAC

Table No. 5-16: Details of Disposal sites in Mumbai Metropolitan Region – Urban Local Body wise

Urban Local Body	Name of site	Total area of the dumping site (in Ha)	Ownership of disposal site	Distance from the city	Capacity of the site (in MT)	Load (Tons/Day)	Life expectancy of the site (yrs.)
Municipal Corporation of Greater Mumbai	Mulund	25	MCGM	within city limits	No information	185764.8	2
	Deonar	132				82800.8	1
	Kanjurmarg	141.77				No information	30+
	Gorai	14.5				No information	closed
Thane Municipal Corporation	Khardi, Mumbra	4.04	On rent	within city limits	No information		
Navi Mumbai Municipal Corporation	Turbhe	26.32	NMMC	within city limits	No information		
Kalyan Dombivali Municipal Corporation	Adharwadi, Kalyan	30	No information	within city limits	Exceeded*	No information	Exceeded*
Mira Bhayandar Municipal Corporation	Uttan Pali, Bhayandar	31		within city limits	No information		20*
Bhiwandi Nizampur Municipal Corporation	Katai Village, Bhiwandi	No information		within city limits	No information		
Vasai Virar Municipal Corporation	Mauje Dongre, Chikhaldongre, Virar	No information		2 km	No information		
Ulhasnagar Municipal Corporation	Shanti Nagar, Ulhasnagar#	No information		within city limits	No information		
Ambernath Municipal Council	Mauje Morivali, Gat No. 73, Ambernath	No information					
Panvel Municipal Council	Chal, Near Taloja MIDC	14	CIDCO	within city limits	365000	65	15.5
Uran Municipal Council	No information	1	No information				
Alibag Municipal Council	No information			within city#	No information		
Kulgaon Badlapur Municipal Council	Belivali Village	No information		within	No information	53	30
Pen Municipal Council	No information			No information	No information		
Karjat Municipal Council	No information				No information		
Khopoli Municipal Council	Mulgaon	3.25	No information	Within limits of the council	No information	25	10
Matheran Municipal Council	No information						

Source: ESR of the ULB and # - National Solid Waste Association India Report

Table No. 5-17: Criteria compliance by the ULBs of the MSW (Management and Handling) Rules, 2000

Compliance criteria	Municipal Corporations								Municipal Councils								
	MCGM[1]	TMC[2]	NMMC[3]	KDMC[4]	MBMC[5]	BNMC[6]	VVCMC[7]	UMC[8]	Ambernath[9]	Panvel[10]	Uran[11]	Alibag[12]	Kulgaon-Badlapur[13]	Pen[14]	Karjat[15]	Khopoli[16]	Matheran[17]
Collection of municipal solid wastes																	
i. Organising house-to-house collection of municipal solid wastes through any of the methods	✓	✓	✓	-	✓	-	✓	-	-	-	✓	✓	✓	✓	-	-	✓
ii. Devising collection of waste from slums and squatter areas or localities including hotels, restaurants, office complexes and commercial areas;	✓	✓	✓		✓		✓	-	-	-	-	✓	✓	✓	-	-	-
iii. Wastes from slaughter houses, meat and fish markets, fruits and vegetable markets, which are biodegradable in nature, shall be managed to make use of such wastes;	-	-	-	-	-	-	✓	-	-	-	-	✓	✓	✓	-	-	-
iv. Bio-medical wastes and industrial wastes shall not be mixed with municipal solid wastes and such wastes shall follow the rules separately specified for the purpose	✓	✓		✓	✓		✓	-	-	-	-	-	-	-	-	-	-
v. Collected waste from residential and other areas shall be transferred to community bin by hand-driven containerised carts or other small vehicles	✓	✓	✓	✓	✓	-	✓	-	-	-	✓	✓	✓	✓	-	-	✓
vi. Horticultural and construction or demolition wastes or debris shall be separately collected and disposed of following proper norms. Similarly, wastes generated at dairies shall be regulated in accordance with the State laws	✓	-	-	-	✓	-	-	-	-	-	-	-	-	-	-	-	-
vii. Waste (garbage, dry leaves) shall not be burnt;	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
viii. Stray animals shall not be allowed to move around waste storage facilities or at any other place in the city or town and shall be managed in accordance with State laws.	-	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Segregation of municipal solid wastes																	
i. In order to encourage the citizens, municipal authority shall organise awareness programmes for segregation of wastes and shall promote recycling or reuse of segregated materials.	-	✓	✓	-	✓	-	✓	-	-	-	-	✓	✓	✓	-	-	✓

Compliance criteria	Municipal Corporations								Municipal Councils								
ii. The municipal authority shall undertake phased programme to ensure community participation in waste segregation. For this purpose, regular meetings at quarterly intervals shall be arranged by the municipal authorities with representatives of local resident welfare associations and non-governmental organizations.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Storage of municipal solid wastes																	
i. Storage facilities shall be created and established by taking into account quantities of waste generation in a given area and the population densities. A storage facility shall be so placed that it is accessible to users	✓	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ii. Storage facilities to be set up by municipal authorities or any other agency shall be so designed that wastes stored are not exposed to open atmosphere and shall be aesthetically acceptable and user-friendly;	-	✓	-	-	✓	-	-	-	-	-	-	-	-	-	-	-	-
iii. Storage facilities or bins shall have easy to operate design for handling, transfer and transportation of waste. Bins for storage of bio-degradable wastes shall be painted green, those for storage of recyclable wastes shall be printed white and those for storage of other wastes shall be printed black	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
iv. Manual handling of waste shall be prohibited. If unavoidable due to constraints, manual handling shall be carried out under proper precaution with due care for safety of workers.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Transportation of municipal solid wastes																	
i. The storage facilities set up by municipal authorities shall be daily attended for clearing of wastes. The bins or containers wherever placed shall be cleaned before they start overflowing;	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ii. Transportation vehicles shall be so designed that multiple handling of wastes, prior to final disposal, is avoided.	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Processing of municipal solid wastes																	

Compliance criteria	Municipal Corporations								Municipal Councils								
i. The biodegradable wastes shall be processed by composting, vermicomposting, anaerobic digestion or any other appropriate biological processing for stabilization of wastes. It shall be ensured that compost or any other end product shall comply with standards as specified in Schedule-IV of MSW Rules 2000	✓	✓	✓	✓	✓	-	✓	-	-	-	-	✓	✓	✓	-	-	✓
ii. Mixed waste containing recoverable resources shall follow the route of recycling. Incineration with or without energy recovery including palletisation can also be used for processing wastes in specific cases.	✓	✓	✓	✓	✓	-	-	-	-	-	-	✓	-	✓	-	-	✓
Disposal of Municipal Solid Waste																	
Land filling shall be restricted to non-biodegradable, inert waste and other waste that are not suitable either for recycling or for biological processing. Land filling shall also be carried out for residues of waste processing facilities as well as pre-processing rejects from waste processing facilities. Land filling of mixed waste shall be avoided unless the same is found unsuitable for waste processing. Under unavoidable circumstances or till installation of alternate facilities, land-filling shall be done following proper norms. Landfill sites shall meet the specifications as given in Schedule III.	-	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-

A detailed assessment of all the ULBs of the region is required to be undertaken to study the level of compliance for the criteria mentioned in MSW Rules, 2000. All the ULBs need to develop better mechanisms and implement them so as to efficiently manage the MSW generated in their respective regions. Inclusive approaches need to be followed in order to have more community participation and mass awareness about best practices in the region.

5.4.3 Response for Solid Waste Management

5.4.3.3 Bio-Medical Waste (BMW)

Biomedical waste is defined as the waste generated during the diagnosis, treatment or immunization of human beings or animals or in research institutes pertaining to testing of biological preparations made from micro-organisms, biochemical reagents used for diagnosis, and immunization of humans or animals.

Random disposal of bio-medical waste may lead to spread of various infections hence appropriate disposal is of critical concern. Biomedical Waste (Management and Handling) Rules (BMW Rules) were promulgated under the Environment (Protection) Act, 1986. In Maharashtra, Maharashtra Pollution Control Board (MPCB) is the apex agency to enforce these rules and monitor and regulate the disposal of BMW in MMR.

Health Care Establishments (HCEs) are the major generators of BMW. All the HCEs need authorization from MPCB for handling and treating of BMW generated by them. The HCEs are categorized into following two categories –

1. Bedded (Hospitals, Nursing Homes with Bed Facility)
2. Non-bedded which are further categorized into –
    a. Treating/ providing service to 1000 and above patients per month
    b. Treating/ providing service to less than 1000 patients per month
    c. Education, research institute, veterinary hospitals etc.

As per statistical record of MPCB, there are about 17, 681 HCE's in MMR which generate about 13 thousand kilograms of biomedical waste which is indicated in Table No. 5-18. In addition to the HCEs categorized as per the agency handling the disposal and treatment of the BMW, a general list of the HCEs having more than 100 beds in MMR region are attached as Annex- 17 to this section.

The process that the BMW undergoes at a common treatment facility usually includes Incineration, Autoclaving, Shredding, Effluent treatment and Washing. In MMR region there are two main common treatment facilities namely, Mumbai Waste Management Ltd. at Taloja, Raigad and SMS Envoclean Ltd at Deonar, Mumbai. Both these facilities are monitored for compliance and the last monitoring was carried out on 31st March 2010. The monitoring results revealed that both these facilities are mostly compliant with the BMW Rules, 1998[133].

Further to collection, the BMW is then transported to the common BMW treatment facility while some of the HCEs have their own treatment facility. The common BMW treatment facility have different equipment which process the BMW to such an extent that it can be further disposed to a landfill site taking appropriate measures. The list of common BMW treatment facilities in MMR region are given below (Table No. 5-4).

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[133] Environmental Management Centre (June 2011). Status of Bio-Medical Waste Management in the state of Maharashtra, 2010

Table No. 5-18: Total number of HCEs and BMW generated in MMR

Type of HCEs	Mumbai		Navi Mumbai		Thane		Kalyan		Raigad	
	NoH	BMW Gen	NoH	BMW Gen	NoH	BMW Gen	NoH	BMW Gen	NoH	BMW Gen
Bedded	1417	5929	191	229	235	702	558	836	404	1297
Non-bedded	13408	4160	564	312	797	148	443	74	665	189
Total	**14825**	**10089**	**755**	**541**	**1032**	**850**	**1001**	**910**	**1069**	**1486**

Source: Status of Biomedical Waste Management in the State of Maharashtra 2010, MPCB[134]

Note: NoH = Number of Health Care Establishments; BMW Gen = Biomedical Waste Generated

Table No. 5-19: Agency wise region coverage and BMW collection in MMR

Sr No	Name of Agency	Region catered	Total Nos. of HCEs	Total Nos. of Beds	Load (Kg/day)	Incinerator capacity (Kg/hr.)
1	M/s PRS Enterprises	Kalyan, Dombivali, Ambernath, Badlapur, Ulhasnagar, Shahapur	1001	7480	884.7	90
2	M/s. Envirovigil	Thane, Mirabhayander, Vasai,Virar Nalasopara, Alibag, Pen, Karjat, Murud, Janjira Khopoli, Pali	1335	4802	2903.6	50
3	M/s. SMS Enviroclean Pvt. Ltd	Municipal Corporation of Greater Mumbai	8121	41488	10401	700
4	M/s. Evergreen Environment	Uran, Panvel, Kharghar, Kalamboli, Kamothe, Panvel & Rasayani	68	275	45	0
5	M/s. Mumbai waste management Ltd Taloja	Navi Mumbai Panvel	1387	8348	1486	150

Source: Status of Biomedical Waste Management in the State of Maharashtra 2010, MPCB[135]

[134] MPCB 2011, *Status of Biomedical Waste Management in the State of Maharashtra 2010*, Table No 5,6 &7, pps. 15-19
[135] MPCB 2011, *Status of Biomedical Waste Management in the State of Maharashtra 2010*, Table No 14, pps. 32-34

5.4.3.4 Hazardous Waste (HW)

In MMR, the hazardous waste is managed by MPCB. Accordingly, they have segregated into 5 regional offices in the western region of Maharashtra namely Mumbai, Navi Mumbai, Thane, Raigad, Kalyan. All the collection, treatment and processing is sourced and based on this 5 regions. Currently facilities are available for incineration, recycling and landfilling the hazardous waste. Moreover, there are two waste treatment centres in the region, one at Taloja and other at TTC. Based on the data sourced from the MPCB, the HW generated in the region for the last four years is as given below in Figure No. 5-18. From the figure it is evident that all the regions generated less incinerable waste as compared to recyclable and landfilling types. Over these years, there is an overall increasing trend in terms of the hazardous waste generated. Out of the five, Kalyan and Mumbai generate the highest amount of recyclable waste.

As mentioned earlier, treatment is undertaken at two facilities in Taloja and TTC centres. The waste treatment scenario of these regions is illustrated in the graph below Figure No. 5-19. As the graph indicates, higher amount of HW is treated at Taloja than TTC. In terms of direct disposal in Sanitary Landfill Facility (SLF), both the centres show an increasing trend. Similarly, direct and treated disposal in SLF is preferred over incineration. This could be because of few incinerating centres available in the region.

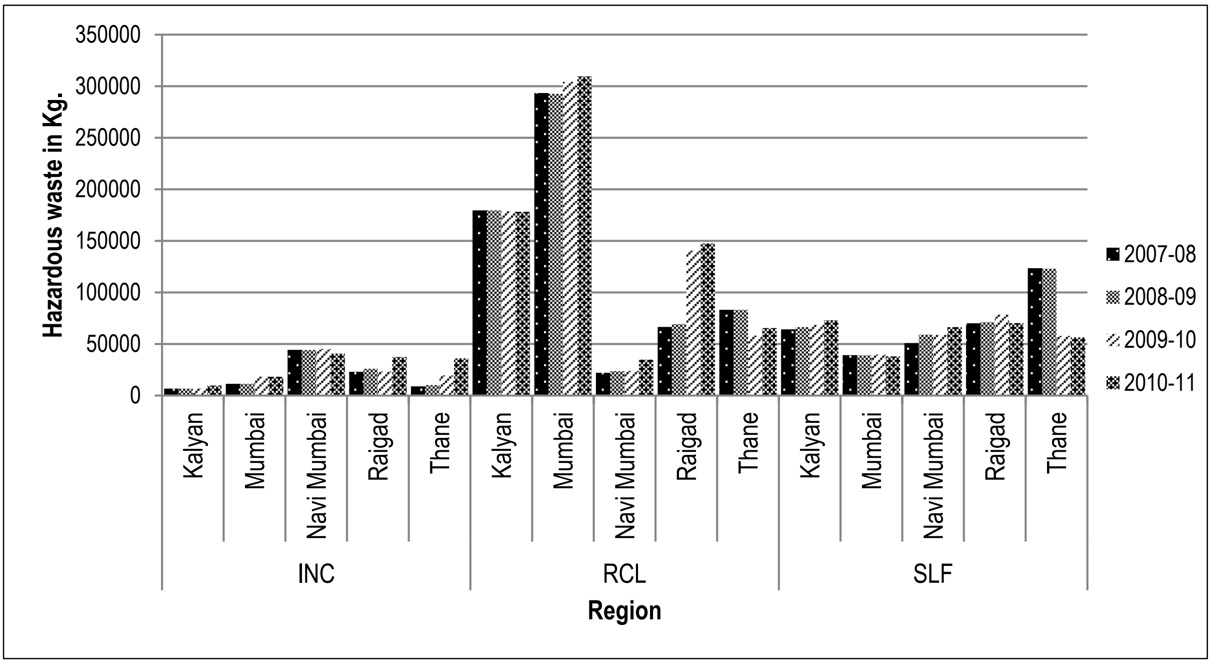


Figure No. 5-18: Hazardous Waste generated in and around MMR region.

Source: Annual Reports of MPCB for the respective years[136]

[136] http://mpcb.gov.in/ereports/annual_report_mpcb.php

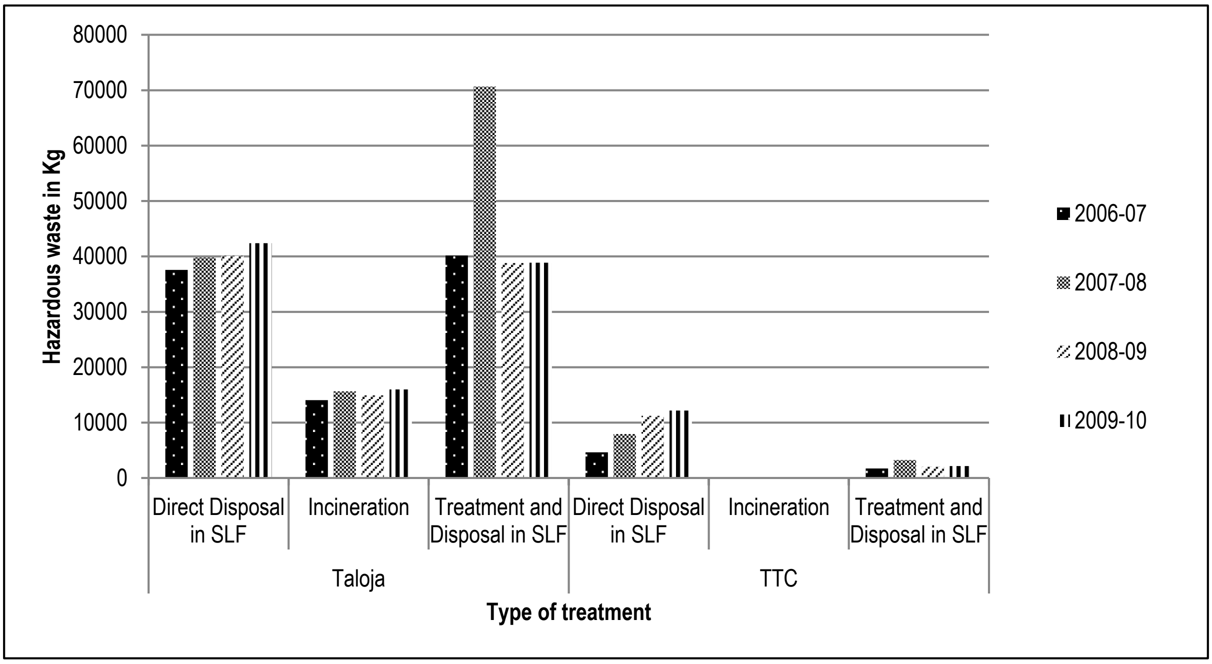


Figure No. 5-19: Hazardous Waste Disposal at Taloja and TTC Centers in MMR

Source: Annual Reports of MPCB for the respective years[137]

5.4.3.5 Electronic Waste (E-waste)

According to a survey carried out MPCB in 2007, MMR region is the highest e-waste generating region in the country[138]. In India, currently, there is no Extended Producer Responsibility (EPR) regulation which can ensure the take back of e-waste by the producer. The E-waste (Management and Handling) Rules, 2011 came into existence from May 2012. In MMR too, there is no large scale organized e-waste recycling facility. Considering this, MPCB carried out a techno-feasibility study in July, 2009 and recommended to set-up a centralized e-waste disposal facility for which MMRDA would be a nodal agency. MPCB has carried out survey to determine the e-waste generated in the state. The quantity generated in Maharashtra, Greater Mumbai and Navi Mumbai is indicated in Table No. 5-20.

MPCB has authorized centres for collection, dismantling and recycling of e-waste. MPCB carried out a survey in 2007 to assess the e-waste recycling system, the risks associated with e-waste recycling, evaluation of capabilities of existing stakeholders and infrastructure for reuse, recycle and disposal of e-waste[139]. The geographical distribution of the organized and unorganized e-waste recycling sectors in Mumbai is as given in Map No. 5-9 and that of Navi Mumbai in Map No. 5-10. Besides this, the specific areas are listed in Table No. 5-21.

[137] http://mpcb.gov.in/ereports/annual_report_mpcb.php
[138] https://mmrda.maharashtra.gov.in/e-waste-processing-disposal-facility#
[139] http://www.mpcb.gov.in/images/pdf/ewastereport1.pdf

Table No. 5-20: E-waste generation in Maharashtra, Greater Mumbai and Navi Mumbai in 2007

Region	Quantity generated in tonnes
Maharashtra	20,270.6
Greater Mumbai	11,017.06
Navi Mumbai	646.48

Source: Times of India, 2009[140]

Further, the report by MPCB[141] also indicated the transportation routes of organized and unorganized e-waste recycling centres in Mumbai and Navi Mumbai which is indicated below in Map No. 5-11. Apart from this, the MPCB authorizes dealers and companies to collect, dismantle and recycle e-waste. The centres are checked for authorization annually. Currently, there are twelve centres authorized and registered to dismantle e-waste generated in MMR region which are as listed below[142]. The number of dismantlers has remained the same since 2013[143]. Apart from this, there are ten MPCB authorized collection centres in the region as of 31 March 2014[144] and their details are given below Table No. 5-22.

Table No. 5-21: List of organized and unorganized e-waste recycling center locations in Mumbai and Navi Mumbai[145]

Sector	Name of the area
Organized sector locations	Malad, Andheri and Powai, Airoli knowledge park, Airoli; Millenium business park, Mhape; International infotech park, Vashi; International technology centre, CBD Belapur and International IT hardware park, Dronagiri.
Unorganized sector locations	Sakinaka, Safed pul, Wire lane and teen number khadi in Andheri; Kutubmandal, Masrani lane and Wire lane in Kurla; Dharavi slum area in Mahim; Sonapur; Don taki in Kamathipura; Lamington road, Proctor road, Tara temple road, S.V. road and Chor bazaar in Lamington road, Mankhurd.

Source: MPCB, 2007[146]

140 http://articles.timesofindia.indiatimes.com/2009-11-11/pune/28074435_1_e-waste-weee-maharashtra-pollution-control-board

141 Maharashtra Pollution Control Board, 2007. *Report on Assessment of Electronic- Waste in Mumbai Pune Area.*

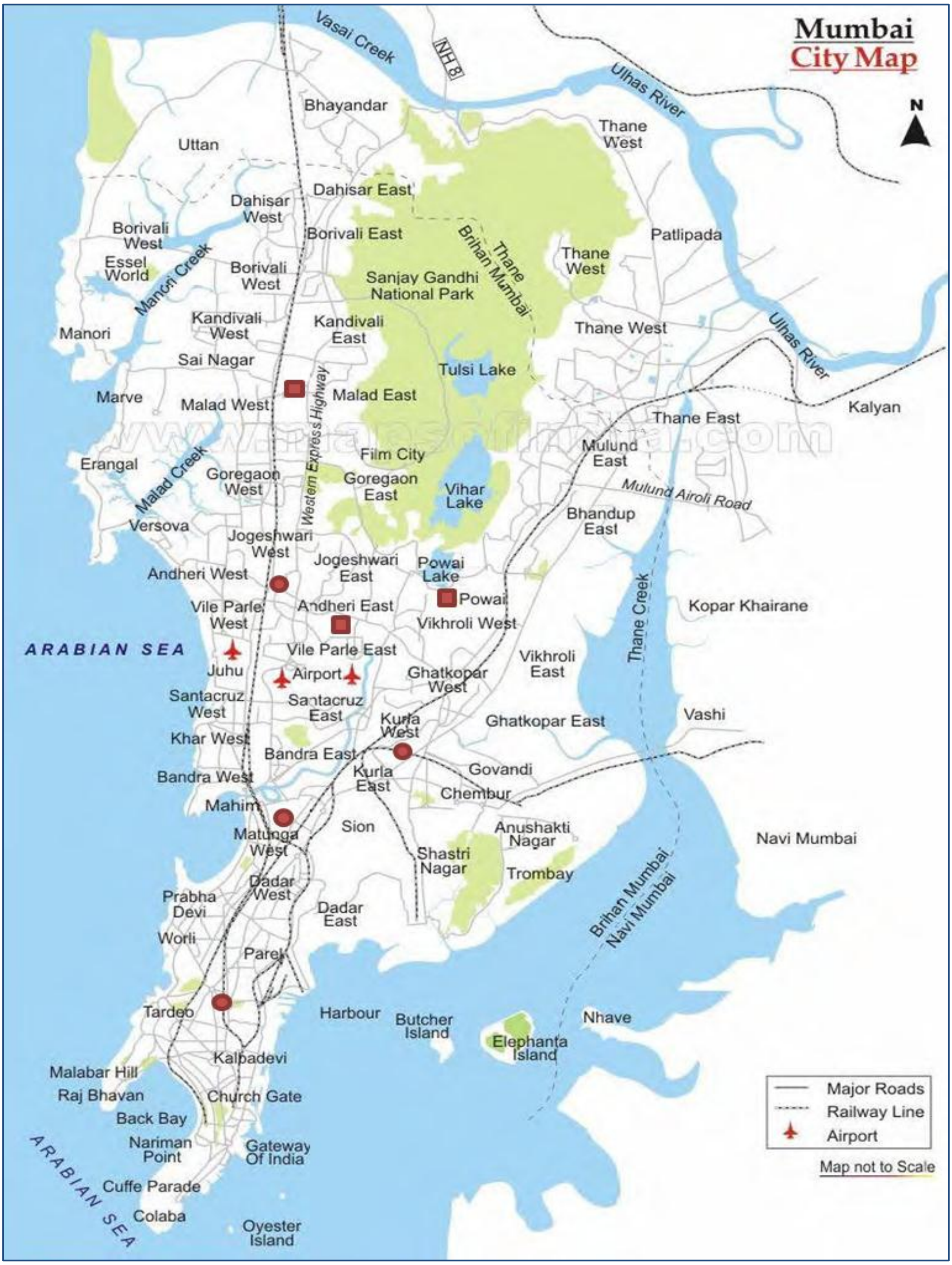
142 http://www.mpcb.gov.in/ewaste/pdf/Lis%20registredE-wasteDismantlers30thApril2014.pdf

143 MPCB authorized and registered E-waste dismantlers Details as on 30/06/2013. Published by MPCB on their website and retrieved on November 22, 2013

144 http://www.mpcb.gov.in/ewaste/pdf/List_authorisedE-wasteCollectionCenters31032014.pdf

145 These are indicated in the Picture No. 1.

146 Maharashtra Pollution Control Board, 2007. *Report on Assessment of Electronic- Waste in Mumbai Pune Area.*

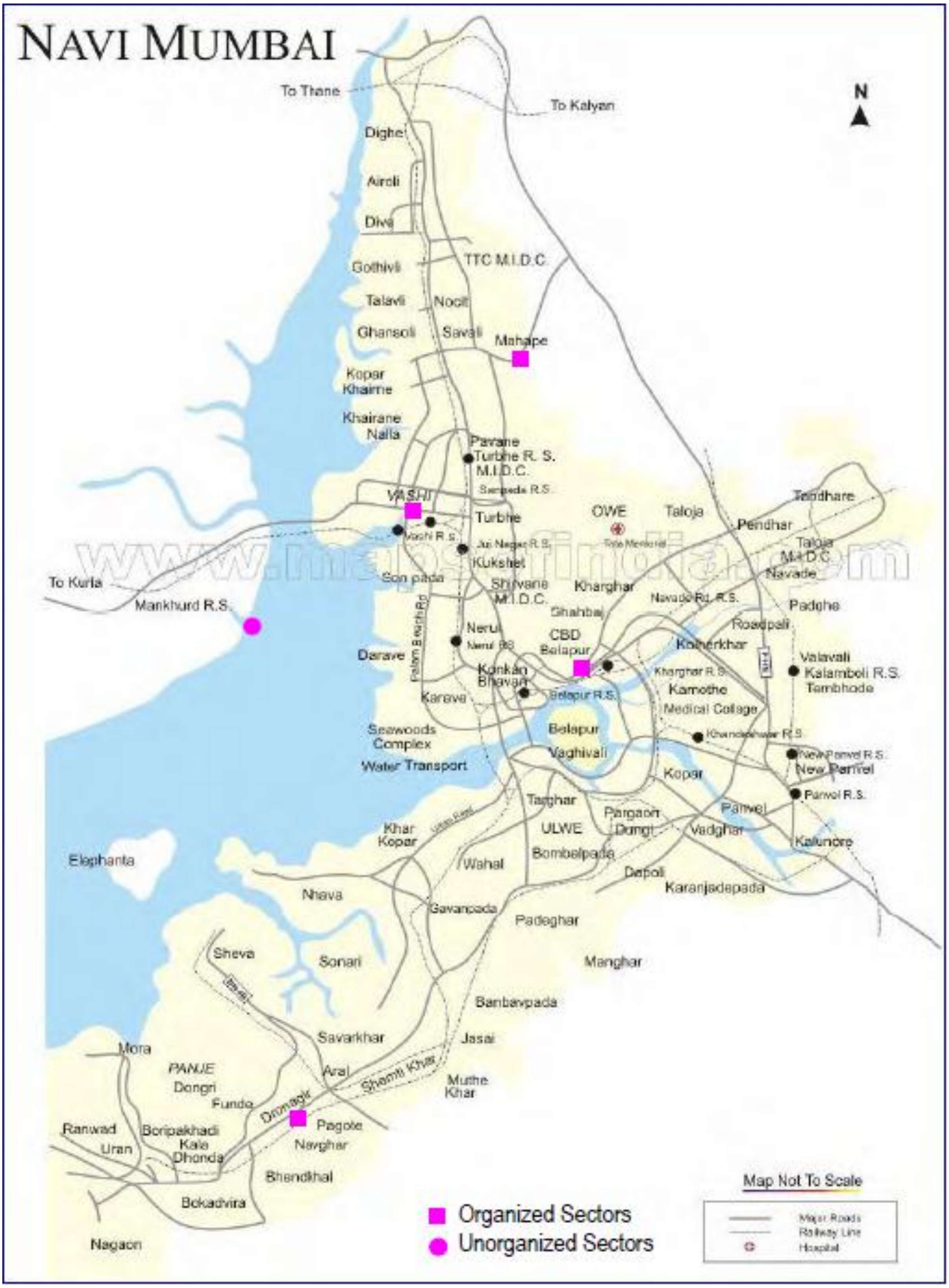


Map No. 5-9: Geographical distribution of organized & unorganized e-waste recycling sectors in Mumbai

Data Source: Report on Assessment of Electronic Waste in Mumbai and Pune, MPCB, 2007

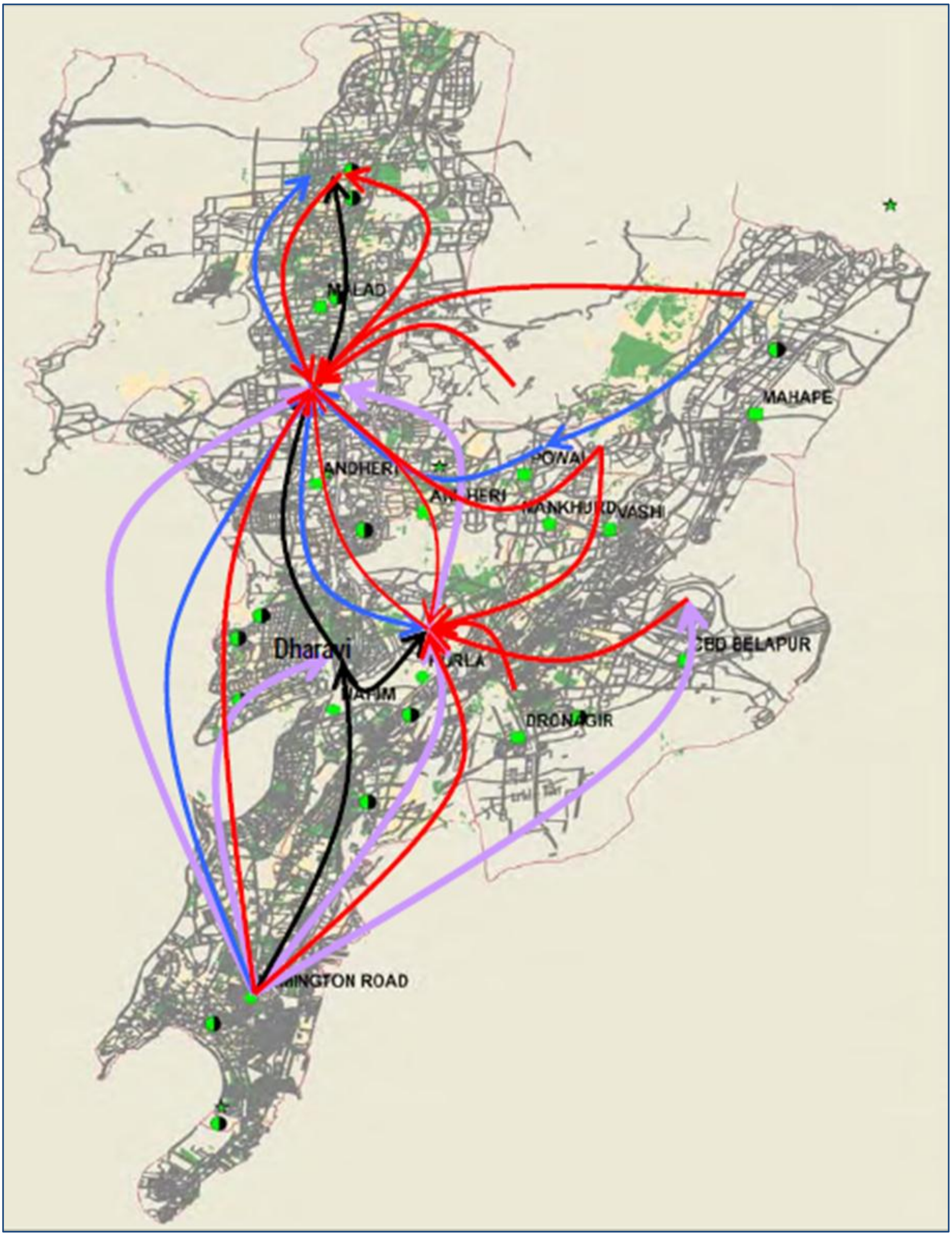
■ **Organized** sector location

● **Unorganized** sector locations



Map No. 5-10: Geographical distribution of organized & unorganized e-waste recycling sectors in Navi Mumbai

Data Source: Report on Assessment of Electronic Waste in Mumbai and Pune, MPCB, 2007



Map No. 5-11: Transportation of organized & unorganized e-waste at the recycling centres in Mumbai and Navi Mumbai

Data Source: Report on Assessment of Electronic Waste in Mumbai and Pune, MPCB, 2007

Table No. 5-22: List of MPCB authorized e-waste dismantlers in MMR as of 30 April, 2014

Sr. No.	Name of the Industry	Capacity for procurement of raw material in metric tonnes per annum
1	**M/s. Earth Sense Recycle Pvt Ltd,** A-7 , Gala no: 1,2&3, Ground Floor, Prerna Complex, Anjur Phata, Vill: Val, Tal: Bhiwandi Dist: Thane	360
2	**M/s. Eco Friend Industries**, A-205, TTC Industrial Area, Pawane Village, Thane Belapur Road, Navi Mumbai – 400 710.	1000
3	**M/s. Just Dispose Recycling Pvt Ltd,** A-103,104,110,119,Arvind Industrial Estate, Navghar , Tal: Vasai, Dist: Thane	500
4	**M/s Shabbir Traders,** Plot No. 999 (7), Kiravali Narayan Kutir Udyog Mandal, Village Adivali, Tal. Panvel, Dist. Raigad	500
5	**M/s. Green World Recycling,** Vill: Val, Pritesh Complex, Buliding no; B-12,Gala No: 7,8 Anjur Phata,village: Val Tal: Bhiwandi, Dist: Thane	1000
6	**M/s. Clean Tech** B/8, Gala No. 3, Parasnath Indl. Estate, Anjur Phata Road, Village Val, Tal.-Bhiwandi, Dist.-Thane	2000
7	**M/s. Z-Tronics Infratel Pvt Ltd,** Survey no: 103, Gala no: 538, 539, Village : Pimpari, Post Dahisar, Tal & Dist: Thane	4000
8	**M/s. Kesariyaji Recyclers,** Bldg. No: B-3, Gala no: 13, Pritesh Complex, Vill : Val Tal: Bhwiandi Dist : Thane	600
9	**M/s. Green Valley E-Waste Management Pvt Ltd,** Pritesh Complex, Bldg. No: A-7, Gala no: 7, Anjurphata , Dapoda Road, Val: vill: Val, Tal: Bhiwandi Dist: Thane	240
10	**M/s. Indian Scrap Traders,** Ghusia Market, Gala no: 661, Vill: Pimpari, Post: Dahisar Dist: Thane.	240
11	**M/s. Go-Green Recycling ,** Plot no: 32, Sec 1[a], Service Industrial Area , Koparkhairne, Navi Mumbai	240
12	**M/s. Hari International** Shree Parasnath Complex, Unit no: 6, Bldg no: D-4, Anjur Phata, Dapoda Road, Vill: Val, Tal: Bhiwandi Dist: Thane.	240

Source: MPCB, 2014[147]

[147] http://www.mpcb.gov.in/ewaste/pdf/List_authorisedE-wasteCollectionCenters31032014.pdf

Table No. 5-23: List of MPCB authorized e-waste collection centres in MMR region

1. M/s. E-Parisaraa Pvt. Ltd., Unit no: 18, in the Building no: E/6, "Bhumi World" Mouje Pimplas, Tal: Bhiwandi, Dist: Thane	**2. M/s. Khan Traders** G – 10, C-Wing, Sarvodaya CHS Ltd., Gautam Nagar, MIDC Andheri, (E) Mumbai – 400093.
3. M/s. Evergreen RecyleKaro (P) Ltd, Mali House , Beside Sarva Mangal Society , Nahur Bhandup (E), Mumbai – 400042	**4. M/s. Carrier Media India Pvt Ltd,** Unit no: 24, Gr Floor,, Nav Nandan, Industrial Premises Coop Society Ltd, Near Mulund Telephone Exchange, Off LBS Marg, Mulund Mumbai- 400080
5. M/s. Attero Recycling Pvt Ltd ; C/o. Sequel Logistics Pvt Ltd, Arihant Commercial Complex, Shed no: 19, Gala no: 7, Kopar village , Bhiwandi , Dist: Thane	**6. M/s. Carrier Media India Pvt Ltd,** ICWC Complex Bldg no: 205 - 210, Opp Gajanan Petrol Pump , Dapode Road, Mankoli Naka, Bhiwandi
7. M/s. Ashok Steel Traders Plot no: B/05, S.no: 24, 1A, Village: Waliv, Tal: Vasai, Dist: Thane.	**8. M/s. MIRC Electronic Ltd** V, Sheetal Industrial Estate , Navghar, Vasai (E), Tal: Vasai , Dist: Thane.
9. M/s. V. Chiranjiv & Co. Plot no: 829, Road no: 8, Kalmboli Steel Complex, Kalamboli , Navi Mumbai	**10. M/s. Z-tronics Infratel Pvt Ltd,** At Sr. no. 103, Gala no:538, 539 at Pimpari, Tal: Thane , Dist: Thane
11. M/s. Symcom Communication Hissa no: 2, situated at opp. Gausia Market, Mumbai Pune Road , Dahisar Mori, Pimpari Gaon, Dist: Thane - 400612	

Source: MPCB, 2014[148]

[148] http://www.mpcb.gov.in/ewaste/pdf/List_authorisedE-wasteCollectionCenters31032014.pdf

5.4.3.6 Other Initiatives

1. MCGM initiated the program Advanced Locality Management (ALM) for 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. It is a partnership between MCGM & Citizens for sustainable environment friendly waste management program for the neighborhoods' buildings[149].
2. Slum Adoption Program was implemented by MCGM with an intention to financially support slum communities to form garbage committees that would then hire workers to clean their areas while Refuse Paper Plastic and Wood Fuel-RPPWF (Refuse Paper Plastic and Wood Fuel) is a result of in depth result of ecologically sustainable waste management strategies and technologies that culminate in clean, carbon neutral sources of energy [150].
3. Initiatives have been taken by ENVIS ICPE (Indian Centre for Plastics in the Environment) on Plastics Recycling & Waste Management in select Mumbai Wards and Eco-Sensitive Hill Station – Matheran. In Mumbai effective segregation of waste was undertaken through awareness among the citizens while in Matheran plastic recycling unit was initiated by M/s Bisleri to ensure recycling and disposal of PET bottles[151].
4. MMRDA has taken the initiative of developing Regional Solid Waste Management facilities for the Urban Local Bodies. MMRDA has setup the Regional Solid Waste Management Facility at Taloja on a Public Private Partnership model and has engaged reputed private entities with experience in management of municipal solid waste through viable and sustainable technologies[152].
5. Greater Mumbai Cleanliness and Sanitation Byelaws 2006[153] have been developed especially for MCGM in which fines are imposed for non-segregation of hazardous waste, garden waste, bio medical waste and bio degradable waste.
6. The Environmental Improvement Society (EIS) set up in 1997, provides funds for innovative projects in solid-waste management that help improve the quality of life in the MMR. Some activities of the MMR – Environment Improvement Society are as follows:
    - Creating a critical awareness and promoting best practices on solid waste management in selected areas in the western and central suburbs in Greater Mumbai.
7. With the launch of "Swacch Bharat Abhïyan" by Shri. Narendra Modi, Prime Minister, India; many private and governmental agencies, film stars, citizens and stakeholders from various other backgrounds within MMR have taken up pledge for making the initiative a grand success. Cleanliness drives are being conducted throughout the region which would ultimate help to tackle the issue of solid waste.

[149] http://www.mcgm.gov.in/irj/portal/anonymous/qlvarprg
[150] http://research.ijcaonline.org/icgct/number3/icgct1327.pdf
[151] http://www.icpeenvis.nic.in/index2.aspx?slid=62&sublinkid=138&langid=1&mid=1
[152] http://italiaindia.com/index.php?/business-opportunities/category/january-2011
[153] http://www.mcgm.gov.in/irj/portal/anonymous/qlblaw

5.4.4 Conclusion

Solid waste management and disposal is one of the sectors which need urgent attention both at the regional level and ULB level. If land as a resource needs to be preserved, solid waste management needs to be tackled immediately, especially considering the amount of waste generated and its disposal or treatment efficiency. Few of the key issues of the sector are –

1. Scarcity of land for disposal of solid waste
2. Adequate infrastructure to manage the large amount of waste generated.
3. Efficient technology and practices of treating and disposing the waste
4. In case of bio-medical waste, lack in coverage of the HCEs present in the region
5. For E-waste, lack in linkage between producers and collection centres/ dismantlers/ recyclers

Scarcity of land is one issue that needs urgent attention. Due to this, the waste is disposed in open leading to severe health issues to the residents in the surrounding regions. The solid waste managers also face difficulty in identifying appropriate pocket of land to dispose waste, which complies with the specifications of the MSW Rules. This issue has been highlighted in the ESRs of the ULBs, where several pockets of land were rejected and re-identified due to non-compliance of MSW Rules. Apart from this, the air pollution caused by the transportation and incineration of solid waste, occupational hazards arising from direct handling of waste by the waste and rag pickers need to be assessed.

To address these problems, the ULBs need to streamline the solid waste management system from generation, collection, treatment/ processing and disposal. The overall management of municipal solid waste as well as other types of waste needs to be improvised. This can be achieved if the ULBs comply with the different rules outlined for different types of waste management and handling.

Environmental Status Report of Mumbai Metropolitan Region

Section

6. Annexes

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Annex 1. Review of ESRs of ULBs in MMR

In Maharashtra, the preparation of a technical ESR is regarded as a significant tool in decision making in the context of urban development. As per the BPMC (Bombay Provincial Municipal Corporations) Act 1949, Section 67 (A), it is mandatory for all the A class ULBs (Urban Local Bodies) in Maharashtra to submit an annual ESR to the Hon'ble General Body. MoUD (Ministry of Urban Development), is the nodal agency that mandates the creation of ESRs[1].

The ESR indicates the status of environmental management in the city and identifies areas where further interventions for improvement are required. The budget allocation of municipal bodies is largely dependent on the status reflected in the ESR. This technical compilation comprehensively documents the changes in the environment, the initiatives taken to address these concerns, and an estimate of the budgetary allocations and expenses for the infrastructural facilities in the city. There are a total of 26 municipal corporations[2] in the state which have to abide by the law and need to compile an annual ESR before July 31 every year.

MPCB (Maharashtra Pollution Control Board) documents that inspite of continuous efforts taken by central and state government approximately 60% of the municipalities comply with the requirement of documenting ESR's[3]. Owing to the fact that there is lack of consistent data and uniformity in documenting the ESR's across cities, MPCB in consultation with the Department of Environment, GoM in June 2009, released guidelines that suggest the ESRs to be prepared as per the DPSIR (Driving forces - Pressures - Status - Impacts - Response) framework for significant parameters (resources) in the context of the city's environment. Also an indicator based framework has been developed which incorporates quantitative approach to allow an objective comparison between cities on their environmental performance as well as to evaluate the trends.

In this background, and while compiling the ESR of MMR we have made a review of the ESR's documented by various A class cities in MMR. Except for Ulhasnagar Municipal Corporation all the A class cities in MMR document an annual ESR. Bhiwandi- Nizamur Municipal Corporation publishes the ESR once in two years.

Given that MPCB recommends specific guidelines for publishing an ESR, a matrix has been developed to compare the various ESR's and develop a data gap matrix to identify the data which is not available/presented in ESR of the respective ULB.

[1] http://mpcb.gov.in/images/pdf/Evaluation_of_ESRs.pdf
[2] http://en.wikipedia.org/wiki/Local_government_in_Maharashtra
[3] http://mpcb.gov.in/images/pdf/Evaluation_of_ESRs.pdf

ESR review Matrix as per MPCB guidelines

MPCB recommends documenting certain indicators to maintain uniformity across ULBs while compiling an ESR. The guidelines were released in the year 2009 and the ULB's are expected to document the enlisted indicators. But still there are data gaps and the following matrix depicts the data which one may find in the ESR of the respective ULB.

The following matrix strictly presents the gap in data representation in the ESR of that ULB, it does not necessarily mean that the ULB may not possess such an information.

SN	Section	Indicators	MCGM[4]	TMC[5]	NMMC[6]	KDMC[7]	MBMC[8]	BNMC[9]	VVMC[10]	AMC[11]	PMC[12]
1	Demographic growth	Population growth rate									
		% of slum population to total population		D	D						
2	Economic growth	Work participation ratio									
		% of people below poverty lines									

[4] Municipal Corporation of Greater Mumbai
[5] Thane Municipal Corporation
[6] Navi Mumbai Municipal Corporation
[7] Kalyan-Dombivali Municipal Corporation
[8] Mira-Bhayandar Municipal Corporation
[9] Bhiwandi-Nizampur Municipal Corporation
[10] Vasai-Virar Municipal Corporation
[11] Ambernath Municipal Corporation
[12] Panvel Municipal Council

SN	Section	Indicators	MCGM[4]	TMC[5]	NMMC[6]	KDMC[7]	MBMC[8]	BNMC[9]	VVMC[10]	AMC[11]	PMC[12]
		Ratio of municipal revenue to municipal expenditure									
3	Industrial Growth	No. of polluting industries									
4	Spatial growth	Population density		D		D			D		D
		% of slum are to city area									
5	Land use	% of green area to the total city area			D						
		Green area per person				D					
6	Air	Ambient air quality									
		Noise Quality									
7	Water Quality	Lakes								River	
		Coastal									
		Supply			wells						
		End use									
		Other		Sewage	Wells	Nallah			Nallah		Nallah
8	Energy	Per capita energy consumption		D		D					

SN	Section	Indicators	MCGM[4]	TMC[5]	NMMC[6]	KDMC[7]	MBMC[8]	BNMC[9]	VVMC[10]	AMC[11]	PMC[12]
		Share of renewable energy									
		Annual fuel consumption		Petrol & Diesel							
9	Human	Mortality rate							D		
		Infant mortality rate							D		
10	Water supply	Net LPCD				D			D		D
		% of households connected by service connection			D						
		Unaccounted for water									
		Duration of water supply			D						
		Staff per 1000 connections									
11	Sewerage & Sanitation	Tot sewage generated									
		% of pop catered to by underground sewer network			D						
		Staff per 1000 connections									

SN	Section	Indicators	MCGM[4]	TMC[5]	NMMC[6]	KDMC[7]	MBMC[8]	BNMC[9]	VVMC[10]	AMC[11]	PMC[12]
12	Solid Waste Mgmt	Tot SW generated									
		Life of landfill site									
		% of waste disposed into landfill site to tot waste generated			D						
		% of waste collected to tot waste									
		Availability of bio medical waste treatment									
13	Transport	Road area as % of ward area			D						
		% of pop travelling by public transport			D						

Note

	No mention of that parameter/indicator in the ESR
	Indicator/Parameter presented in the ESR
D	The parameter/indicator could be derived from the information in the ESR

Data Sources for saturating the Matrix

In an attempt to saturate the matrix and procure data sets as desired by the MPCB guidelines we have approached various agencies and data sources to seek the information on the data gaps identified while reviewing of the ESR's. Presented below is a matrix for the same.

The data gaps have been saturated by approaching various government agencies, and with personal interaction with the respective ULB.

The key for the matrix is provided below.

	Available in ESR
D	Derived from different sources or ESR
O	Municipal Website / reports
P	PAS - Performance Assessment System
C	Census of India
M	Maharashtra Pollution Control Board
E	Maharashtra State Electricity Distribution Co Ltd
I	Personal Interaction
S	City Sanitation Plan

SN	Section	Indicators	MCGM[13]	TMC[14]	NMMC[15]	KDMC[16]	MBMC[17]	BNMC[18]	VVMC[19]	UMC[20]	AMC[21]	PMC[22]
1	**Demographic growth**	Pop growth rate								C		C
		% of slum pop to total pop		D	D				I	I		I
2	**Economic growth**	Work participation ratio		C	C	C	C		C	C	C	C
		% of ppl blw poverty lines	O	I	I	I	I	I	I	I	I	I
		Ratio of municipal revenue to municipal expenditure	O	I	I	I	I	I	I	I	I	
3	**Industrial Growth**	No. of polluting industries		M	M	M		M	M	M	M	M

[13] Municipal Corporation of Greater Mumbai
[14] Thane Municipal Corporation
[15] Navi Mumbai Municipal Corporation
[16] Kalyan-Dombivali Municipal Corporation
[17] Mira-Bhayandar Municipal Corporation
[18] Bhiwandi-Nizampur Municipal Corporation
[19] Vasai-Virar Municipal Corporation
[20] Ulhasnagar Municipal Corporation
[21] Ambernath Municipal Council
[22] Panvel Municipal Council

SN	Section	Indicators	MCGM[13]	TMC[14]	NMMC[15]	KDMC[16]	MBMC[17]	BNMC[18]	VVMC[19]	UMC[20]	AMC[21]	PMC[22]
4	Spatial growth	Pop den		D		D			D	D	D	D
		% of slum area to city area	I	I	I	I	I	I	I	I	I	I
5	Land use	% of green area to the tot city area	D		D				D	I		D
		Green area per person	D		D	D		D	D	I	D	D
6	Air	Ambient air quality								M	M	
		Noise Q								M	M	
7	Water Quality	Lakes										
		Coastal										
		Supply				P				P	P	
		End use										

SN	Section	Indicators	MCGM[13]	TMC[14]	NMMC[15]	KDMC[16]	MBMC[17]	BNMC[18]	VVMC[19]	UMC[20]	AMC[21]	PMC[22]
		Other (Sewage/wells/Nallah)	I									
8	Energy	Per capita energy consumption		D	E	D	E	E	E	E	E	E
		Share of renewable energy										
		Annual fuel consumption										
9	Human	Mortality rate	O	I	I	I	I	I	D	I	I	I
		Infant mortality rate	O	I	I	I	I	I	D	I	I	I
10	Water supply	Net LPCD			P	D			D	P		D
		% of households connected by service connection	P		D			P	P	P	P	I
		Unaccounted for water	I	P	P			P	P	P	P	I
		Duration of water supply	P	P	D	P		P	P	P	P	I

SN	Section	Indicators	MCGM[13]	TMC[14]	NMMC[15]	KDMC[16]	MBMC[17]	BNMC[18]	VVMC[19]	UMC[20]	AMC[21]	PMC[22]
		Staff per 1000 connections	P	P	P	P	P	P	P	P	P	I
11	**Sewerage & Sanitation**	Tot sewage generated	O	S				S	S	S	S	S
		% of pop catered to by underground sewer network	P	P	D	P			S	S	P	S
		Staff per 1000 connections	P	P	P		P	P	P	P	P	I
12	**Solid Waste Management**	Tot SW generated								P		
		Life of landfill site		I	I	I			I	I	I	
		% of waste disposed into landfill site to tot waste generated			D	I		I	I	I	I	
		% of waste collected to tot waste	P	P	P			P		P	P	
		Availability of bio medical waste treatment	M					M		M		

SN	Section	Indicators	MCGM[13]	TMC[14]	NMMC[15]	KDMC[16]	MBMC[17]	BNMC[18]	VVMC[19]	UMC[20]	AMC[21]	PMC[22]
13	Transport	Road area as % of ward area			D	D		D	D	D	D	D
		% of pop travelling by public transport			D	I	I	I	I	I	I	I

Annex 2. Water quality standards for best designated usages

Category of Fresh Water	A - I	A-II	A-III	A-IV
Best Usage	**Unfiltered Public water supply after approved disinfection**	**Public water supply with approved treatment equal to coagulation, sedimen-tation & disinfection.**	**Not fit for human consumption, Fish & Wildlife Propagation.**	**Fit for Agriculture, Industrial cooling & process water.**
Chemical Qualities : Maximum allowable concentration				
Toxic Substances				
Arsenic (As)	0.3 mg/l	0.3 mg/l	1.0 mg/l	0.1 mg/l
Cadmium (Cd)	0.01 mg/l	0.01 mg/l	-	-
Chromium (Cr^{+6})	0.05 mg/l	0.05 mg/l	0.05 mg/l	0.2 mg/l
Cyanide (CN)	0.05 mg/l	0.1 mg/l	0.05 mg/l	0.2 mg/l
Lead (Pb)	0.1 mg/l	0.1 mg/l	-	0.1 mg/l
Boron (B)	-	-	-	2.0 mg/l
Mercury (Hg)	0.001 mg/l	0.001 mg/l	0.001 mg/l	-
Gross alpha activity	3 PCI/l	10-9 uc/ml	3 PCI/l	3 PCI/l
Gross Beta activity	30 PCI/l	10-8 uc/m	30 PCI/l	30 PCI/l
Substances affecting health				
Fluoride (F)	1.5 mg/l	1.5 mg/l	-	1.0 mg/l
Nitrates (NO3)	45 mg/l	45 mg/l	-	-
Substances affecting the potability of water				
pH	6.5 to 8.5	6.0 to 8.5	6.5 to 9.0	6.5 to 9.0
T.D.S.	-	T.D.S.	T.D.S.	-.
Total Solids	1500 mg/l.	1500 mg/l.	-.	-
Total Suspended Solids	25 mg/l	-	-	-
Total Hardness (Caco3)	50 mg/l	-	-	-
Total Residual Chlorine	-	-	-	-

Category of Fresh Water	A - I	A-II	A-III	A-IV
Electrical conduct at 25° C	-	-	1000 x 10-6 mhos	3000 x 10-6 mhos
Free Carbon Di Oxide	-	-	12 mg/l	-
Free Ammonical Nitrogen	-	-	1.2 mg/l	-
Oil & Grease	-	-	0.1 mg/l	-
Pesticides	-	-	0.02 mg/l	-
Biotic Index	-	-	6.0 mg/l	-
Total ammonical nitrogen	1.5 mg/l	1.5 mg/l	-	50 mg/l
Chlorides (Cl)	600 mg/l	600 mg/l	-	600 mg/l
Sulphates	400 mg/l	400 mg/l	-	1000 mg/l
Copper (Cu)	1.5 mg/l	1.5 mg/l	-	-
Manganese (Mn)	0.5 mg/l	3.0 mg/l	-	-
Iron (Fe)	1.0 mg/l	5.0 mg/l	-	-
Sodium	-	-	-	-
Zinc (Zn)	15.0 mg/l	1.5 mg/l	5.0 mg/l	5.0 mg/l
Phenolic Compounds	0.002 mg/l	0.002 mg/l	0.05 mg/l	-
Alkyl Benzene sulphates	1.0 mg/l	1.0 mg/l	-	-
Mineral Oil	0.3 mg/l	0.3 mg/l	-	-
Ammonia	1.5 mg/l	1.5 mg/l	-	-
B.O.D. (5 days 20 ° C)	2.0 mg/l(Monthly average of atleast 10 samples)	5.0 mg/l(Monthly average of atleast 10 samples)	10 mg/l	30 mg/l
C.O.D.	-	-	-	150 mg/l
D.O.	Not less than 5 mg/l(Monthly average of 100 samples)	4.0 mg/l	Not less than 3 mg/l	Not less than 2 mg/l
Bacteriological Standards : (MPN/100)	Coliform Bact. 250	Not greater than 5000		

Source: http://mpcb.gov.in/envtdata/waterquality41.php

Annex 3. Water quality standards for coastal waters

In a coastal segment marine water is subjected to several types of uses. Depending of the types of uses and activities, water quality criteria have been specified to determine its suitability for a particular purpose. Among the various types of uses there is one use that demands highest level of water quality/purity and that is termed a "designed best use" in that stretch of the coastal segment.

Based on this, primary water quality criteria have been specified for following five designated best uses:

Table No. 1: Water quality standards for coastal waters

Class	Designated best use
SW-I	Salt pans, Shell fishing, Mariculture and ecologically sensitive zone.
SW-II	Bathing, Contact Water Sports and Commercial fishing.
SW-III	Industrial cooling, Recreation (non contact) and Aesthetics.
SW-IV	Harbour.
SW-V	Navigation and Controlled Waste Disposal.

Source: http://mpcb.gov.in/images/pdf/CoastalwaterStandards.pdf

The standards along with rationale/remarks for various parameters, for different designated best uses, is tabulated below.

Table No. 2: SW-I Waters (For Salt pans, Shell fishing, Mariculture and Ecologically Sensitive Zone)

S.	Parameter	Standards	Rationale/Remarks
1.	pH range	6.5-8.5	General broad range, conducive for propogation of aquatic lives, is given. Value largely dependant upon soil water interaction.
2.	Dissolved Oxygen	5.0 mg/l or 60 percent saturation value, whichever is higher.	Not less than 3.5 mg/l at any time of the year for protection of aquatic lives.

S.	Parameter	Standards	Rationale/Remarks
3.	Colour and Odour	No noticeable colour or offensive odour.	Specially caused by chemical compounds like creosols, phenols, naptha, pyridine, benzene, toluene etc. causing visible colouration of salt crystal and tainting of fish flesh.
4.	Floating Matters	Nothing obnoxious or detrimental for use purpose.	Surfactants should not exceed an upper limit of 1.0 mg/l and the concentration not to cause any visible foam.
5.	Suspended Solids	None from sewage or industrial waste origin	Settleable innert matters not in such concentration that would impair any usages specially assigned to this class.
6.	Oil and Grease (including Petroleum Products)	0.1 mg/l	Concentration should not exceed 0.1 mg/l as because it has effect on fish egs and larvae.

Source: http://mpcb.gov.in/images/pdf/CoastalwaterStandards.pdf

Note :

SW-1 is desirable to be safe and relatively free from hazardous chemicals like pesticides, heavy metals and radionuclide concentrations. Their combined (synergestic or antagonistic) effects on health and aquatic lives are not yet clearly known. These chemicals undergo bio accumulation, magnification and transfer to human and other animals through food chain. In areas where fisheries, salt pans are the governing considerations, and presence of such chemicals apprehended/reported, bioassay test should be performed following appropriate methods for the purpose of setting case specific limits.

Table No. 3: Primary Water Quality Criteria For Class SW-II Waters (For Bathing, Contact Water Sports and Commercial Fishing)

S.N	Parameter	Standards	Rationale/Remarks
1.	pH range	6.5-8.5	Range does not cause skin or eye irritation and is also conducive for propagation of aquatic life.
2.	Dissolved Oxygen	4.0 mg/l or 50 percent saturation value, which ever is higher.	Not less than 3.5 mg/l at any time of the year for protection of aquatic lives
3.	Colour and Odour	No noticeable colour or offensive odour.	Specially caused by chemical compounds like creosols, phenols, naptha, pyridine, benzene, toluene etc. causing visible colouration of salt crystal and tainting of fish flesh.
4.	Floating Matters	Nothing obnoxious or detrimental for use purpose.	None in concentration that would impair usages specially assigned to this class.
5.	Turbidity	30 NTU (Nephelo Tur- bidity Unit)	Measured at 0.9 depth.
6.	Fecal Coliform	100/100 ml (MPN)	The average value not exceeding 200/100 ml. in 20 percent of samples in the year and in 3 consecutive samples in monsoon months.
7	Biochemical Oxygen Demand (BOD) (3 days at 27^{o} C) 27°C)	3 mg/l	Restricted for bathing (aesthetic quality of water). Also prescribed by IS:2296 1974.

Table No. 4: Primary Water Quality Criteria for Class SW-III Waters [For Industrial cooling, Recreation (non-contact) and Aesthetics]

S.	Parameter	Standards	Rationale/Remarks
1.	pH range	6.5-8.5	The range is conducive for propagation of aquatic species and restoring natural system.
2.	Dissolved Oxygen	3.0 mg/l or 40 percent saturation value, which ever is higher.	To protect aquatic lives
3.	Colour and Odour	No noticeable colour or offensive odour.	None in concentration that would impair usages specially assigned to this class.
4.	Floating Matters	Nothing obnoxious or detrimental for use purpose.	None in concentration that would impair usages specially assigned to this class.
5.	Fecal Coliform	500/100 ml (MPN)	Not exceeding 1000/100 ml in 20 percent of samples in the year and in 3 consecutive samples in monsoon months.
6.	Turbidity	30 NTU (Nephelo Tur- bidity Unit)	Reasonably clear water for Recreation, Aesthetic appreciation and Industrial cooling purposes.
7.	Dissolved Iron	0.5 mg/l or less	It is desirable to have the (as Fe) collective concentration of dissolved Fe and Mn less or equal to 0.5 mg/l to avoid scaling effect.
8.	Dissolved Manganese (as Mn)	0.5 mg/l or less	

Note: Standard included exclusively for Industrial Cooling purpose. Other parametersare same.

Table No. 5: Primary Water Quality Criteria for Class SW-IV Waters (For Harbour Waters)

S.	Parameter	Standards	Rationale/Remarks
1.	pH range	6.5-9.0	To minimize corrosive and scaling effect.
2.	Dissolved Oxygen	3.0 mg/l or 40 percent saturation value, which ever is higher.	Considering bio-degradation of oil and inhibition to is oxygen production through photosynthesis.
3.	Colour and Odour	No noticeable colour or offensive odour.	None from reactive chemicals which may corrode paints/metallic surfaces.
4.	Floating Matters Oil, grease and scum (including Petroleum products)	10 mg/l	Floating matter should be free from excessive living organisms, which may clog or coat operative parts of marine vessels/equipment.
5.	Fecal Coliform	500/100 ml (MPN)	Not exceeding 1000/100 ml in 20 percent of samples in the year and in 3 consecutive samples in monsoon months.
6.	Biochemical Oxygen Demand (3 days at 27°C)	5 mg/l	To maintain water relatively free from pollution caused by sewage and other decomposable wastes.
7.	Biochemical Oxygen Demand (BOD) (3 days at 27°C) 27°C)	3 mg/l	Restricted for bathing (aesthetic quality of water). Also prescribed by IS:2296 1974.

Table No. 6: Primary Water Quality Criteria for Class SW-V Waters (For Navigation and Controlled Waste Disposal)

S.	Parameter	Standards	Rationale/Remarks
1.	pH range	6.5-9.0	As specified by New England Interstate Water Pollution Control Commission.
2.	Dissolved Oxygen	3.0 mg/l or 40 percent saturation value, whichever is higher.	To protect aquatic lives.
3.	Colour and Odour	None is such concentration that would impair any usages specifically assigned to this class..	As specified by New England Interstate Water Pollution Control Commission.
4.	Sludge deposits, Solid refuse floating oil, grease & scum.	None except for such small solids, amount that may result from discharge of appropriately treated sewage and/or individual waste effluents.sewage and/or individual waste	As in(1) above
5.	Fecal Coliform	500/100 ml (MPN)	Not exceeding 1000/100 ml in 20 percent of samples in the year and in 3 consecutive samples in monsoon months.

Source: EPA, 1986 [GSR 7, dated Dec. 22, 1998

Annex 4. Water bodies in Greater Mumbai

Sr. No.	Name / Location of Water Body	Area (acres)	Ownership
Very large sized water bodies			
1	Vihar Lake, Sanjay Gandhi National Park	1195.7	MCGM
2	Powai Lake	445.91	MCGM
3	Tulsi Lake, Sanjay Gandhi National Park	264.34	MCGM
4	Lake- Pawan Hans, Juhu	52.97	Govt. Agency
5	Chandivali Lake, Chandivali	8.67	MCGM
6	Bandra Talao, Gopalan Chowk, Bandra West	7.43	MCGM
Large sized water bodies			
7	Water body near Eastern Express Highway, Bhandup East	5.72	Not known
8	Water body Near Sewri-Chembur Road	5.58	MCGM
9	BARC 2	5.39	Govt. Agency
10	Goregaon Boating Club, Aarey Milk Colony	5.3	MCGM
11	Gaondevi Lotus Lake, Malad West	4.85	MCGM
12	Seepz Lake, Andheri East	4.49	Private Party
13	Vyaravali Tekdi, Seepz, Andheri East	4.44	MCGM
14	NITIE (National Institute of Training in Industrial Engineering) Lake, Powai	4.42	Educational Institute
15	Juhu Aerodrome, Juhu Park	4.36	Govt. Agency
16	Water Reservoir, Malad Hill	4.28	MCGM
17	Pond, Tata Colony-Central Avenue, Trombay	4.27	Govt. Agency
18	Water body Near Mahul Road	4.25	Not known
19	Kulav Talao, Gorai	4.13	MCGM
20	Juhu Aerodrome 2, Juhu Park	3.92	Govt. Agency
21	Bhavans College Lake, Andheri West	3.07	Educational Institute
Medium sized water bodies			
22	Ganesh Visarjan Talao, Eastern Express Highway, Mulund-East	2.95	MCGM
23	Ganesh Visarjan Talao, Kurla West	2.93	MCGM
24	Rani Jhansi Talao, Link Road, Borivali	2.74	MCGM
25	Madh Talao, Near Madh jetty	2.71	MCGM
26	Aarey Milk Colony 4	2.65	Govt. Agency
27	Pond in Anushakti Nagar	2.45	Govt. Agency
28	Pond, Central Avenue, Trombay	2.36	Govt. Agency
29	Royal Palms	2.27	Not known
30	Charkop Talao/Dingeshwar Talao, Kandivali West	2.24	Trust
31	Jalashay Tekdi, Seepz, Andheri East	2.23	MCGM
32	Bhandupeshwar Kund, Bhandup East	1.95	MCGM
33	Film City	1.84	Not known
34	Banganga, Walkeshwar	1.83	MCGM
35	Talao opp. Marol Fire Brigade, Airport Road, Andheri	1.75	MCGM
36	Talao near RCF Gate No. 2 - Chembur	1.75	Govt. Agency
37	Pond, India United Mill No. 1, Near Currey Road Railway Station	1.64	Govt. Agency

38	Maritime Training Institute, Chandivali	1.64	Educational Institute
39	Trombay Koliwada	1.64	Govt. Agency
40	Vanala Talao / Tokri Talao, Madh	1.56	MCGM
41	Turbhe Jalashay, Wadavali	1.54	MCGM
42	Talao Near Gorai Church	1.54	MCGM
43	FF Center, Chandivali	1.47	Educational Institute
44	Vairali Talao, Uttan Road	1.44	Not known
45	Veer Savarkar Talao, Borivali West	1.4	MCGM
46	Bandar Pakhadi Talao, Kandivali West	1.39	MCGM
47	Teen Talao / Charai Talao, Chembur	1.38	MCGM
48	Pond, Kamala Mill, Parel	1.35	Govt. Agency
49	Talao near Nau-Sena Baug, Aksa	1.3	Defense
50	Ashish Talao, Chembur	1.26	MCGM
51	Sumalai Talao, Manori	1.26	MCGM
52	Madh	1.2	Govt. Agency
53	Harbadevi Mandir Talao, Next to Killeshwar Mahadeo Mandir, Madh	1.17	MCGM
54	Sion Talao, Sion-Chunabhatti	1.14	MCGM
55	Chheda Nagar	1.14	Not known
56	Kandarpada Talao	1.09	Not known
57	Kharodi Lake-1, Malad West	1.05	MCGM
58	Hiradevi Talao, Erangal	1.01	Not known
Small sized water bodies			
59	Ganga Bawdi, Madh	0.92	MCGM
60	Shivaji Talao, Bhandup West	0.9	MCGM
61	Gaon Talao, Manori	0.87	MCGM
62	Malwani Talao, Near Malwani Church, Malad West	0.86	MCGM
63	Shephali Talao, Uttan - 2	0.83	Not known
64	Ganesh Ghat Jogging Track, Near V.P.M. College, Mulund	0.83	MCGM
65	Tata Mill, Near Parel Railway Station	0.78	Govt. Agency
66	Karjadevi Talao, Manori, Malad West	0.77	MCGM
67	Pond, Gold Mohur Mill, Dadasaheb Phalke Road, Dadar	0.71	Govt. Agency
68	Talao near Lokhandwala Complex	0.71	MCGM
69	Bhujale Talao / Somwar Bazar Talao, Link Road, Malad West	0.71	MCGM
70	Pond, Century Textile Mill, Parel	0.68	Govt. Agency
71	Maharashtra Nature Park Lake, Dharavi	0.67	MCGM
72	Uttan - 8	0.65	Not known
73	Uttan - 9	0.63	Not known
74	Talao near Movie Star Cinema, Goregaon West	0.61	MCGM
75	Talao opposite Sai Dham Nagar,Charkop, Kandivali West	0.61	MCGM
76	Pond-MTNL Complex, Parel	0.6	Govt. Agency
77	Pond, Piramal Mill, Lower Parel	0.59	Govt. Agency
78	Pond, India United Mill No. 2, 3- Near Chinchpokli Railway Station	0.58	Govt. Agency
79	Aarey Milk Colony 2	0.57	Govt. Agency

80	Kharodi Lake-3, Malad West	0.57	MCGM
81	Pond, Kohinoor Mill, Dr.Ambedkar Road, Dadar	0.54	Govt. Agency
82	Pond, India United Mill No.6, Veer Sawarkar Marg, Prabhadevi	0.52	Govt. Agency
83	Talao near Fertiliser Township, Chembur	0.51	Govt. Agency
84	Uttan - 3	0.51	Not known
85	Lake, University of Mumbai Campus, Santacruz East	0.5	Govt. Agency
86	Karnatak Sangh Talao, Chembur	0.49	MCGM
87	Lokmanya Tilak Talao, Jogeshwari- Vikhroli Link Road	0.48	MCGM
88	Eksar Talao, Borivali West	0.46	MCGM
89	Sarvodaya Hospital & Research Centre, Malad West	0.41	Private Party
90	Lake near Irla junction, Andheri West	0.39	Private Party
91	Uttan - 5	0.37	Not known
92	Pond, India United Mill No. 5	0.35	Govt. Agency
93	Mumbai University 2	0.35	Govt. Agency
94	Talao, Barve Nagar (Reservoir)	0.35	MCGM
95	S.N. Maharaj Chowk, Juhu	0.34	Govt. Agency
96	Uttan - 4	0.34	Not known
97	Kharodi Lake-2, Malad West	0.33	MCGM
98	Pond, Madhusudan Mill, Lower Parel	0.31	Govt. Agency
99	Uttan - 6	0.3	Not known
100	Khardala Talao, Manori	0.29	MCGM
101	Jam Mills, Near Currey Road Railway Station	0.27	Govt. Agency
102	Ali Talao, Road No. 3, Malvani	0.27	Not known
103	Pond, Prakash Cotton Mill, Parel	0.26	Govt. Agency
104	Mahindra & Mahindra	0.23	Private Party
105	Vajira Mandir Talao, Borivali (West)	0.23	Trust
106	Bhati Talao, Madh	0.2	MCGM
107	Pond- New City Mill, Chinchpokli	0.1	MCGM

Source: Study of Lakes on Mumbai, 2009, WWF-India

Annex 5. Usage pattern of water bodies in Mumbai

Sr. No.	Name / Location of Water Body	Religious Activity	Washing	Fire fighting	Fishing	Recreatio nal	Boating	Defecation	Not Known
1	Banganga, Walkeshwar	+	+	-	+	-	-	-	-
2	Pond- New City Mill, Chinchpokli	-	-	+	-	-	-	-	-
3	Pond, India United Mill No. 5	-	-	+	-	-	-	-	-
4	Pond, India United Mill No. 2, 3- Near Chinchpokli Railway Station	-	-	+	-	-	-	-	-
5	Pond, India United Mill No. 1, Near Currey Road Railway Station	-	-	+	-	-	-	-	-
6	Jam Mills, Near Currey Road Railway Station	-	-	+	-	-	-	-	-
7	Tata Mill, Near Parel Railway Station	-	-	+	-	-	-	-	-
8	Pond, Gold Mohur Mill, Dadasaheb Phalke Road, Dadar	-	-	+	-	-	-	-	-
9	Pond-MTNL Complex, Parel	-	-	+	-	-	-	-	-
10	Pond, Kohinoor Mill, Dr.Ambedkar Road, Dadar	-	-	+	-	-	-	-	-
11	Sion Talao, Sion-Chunabhatti	+	+	-	-	-	-	-	-
12	Water body Near Sewri-Chembur Road	-	-	-	-	-	-	+	-
13	Pond, Century Textile Mill, Parel	-	-	+	-	-	-	-	-
14	Pond, Kamala Mill, Parel	-	-	+	-	-	-	-	-
15	Pond, Prakash Cotton Mill, Parel	-	-	+	-	-	-	-	-
16	Pond, Madhusudan Mill, Lower Parel	-	-	+	-	-	-	-	-
17	Pond, Piramal Mill, Lower Parel	-	-	+	-	-	-	-	-
18	Pond, India United Mill No.6, Veer Sawarkar Marg, Prabhadevi	-	-	+	-	-	-	-	-
19	Maharashtra Nature Park Lake, Dharavi	-	-	-	-	-	-	-	-

Sr. No.	Name / Location of Water Body	Religious Activity	Washing	Fire fighting	Fishing	Recreatio nal	Boating	Defecation	Not Known
20	Lake, University of Mumbai Campus, Santacruz East	-	-	-	-	-	-	-	-
21	Mumbai University 2	-	-	-	-	Not known	-	-	-
22	Bandra Talao, Gopalan Chowk, Bandra West	-	-	-	-	+	-	-	-
23	Talao opp. Marol Fire Brigade, Airport Road, Andheri	-	-	-	-	-	-	-	-
24	Lokmanya Tilak Talao, Jogeshwari- Vikhroli Link Road	+	-	-	-	+	-	-	-
25	Seepz Lake, Andheri East	-	-	-	-	-	-	-	-
26	Vyaravali Tekdi, Seepz, Andheri East	NA	NA	NA	NA	NA	NA	NA	-
27	Jalashay Tekdi, Seepz, Andheri East	NA	NA	NA	NA	NA	NA	NA	-
28	Talao near Lokhandwala Complex	-	-	-	-	+	-	-	-
29	Lake- Pawan Hans, Juhu	-	-	-	-	-	-	-	-
30	Lake near Irla junction, Andheri West	-	-	-	-	+	+	-	-
31	Bhavans College Lake, Andheri West	-	-	-	-	+	-	-	-
32	Harbadevi Mandir Talao, Next to Killeshwar Mahadeo Mandir, Madh	+	+	-	-	-	-	-	-
33	Ganga Bawdi, Madh	-	-	-	-	-	-	-	+
34	Juhu Aerodrome, Juhu Park	-	-	-	-	-	-	-	+
35	Juhu Aerodrome 2, Juhu Park	-	-	-	-	-	-	-	+
36	S.N. Maharaj Chowk, Juhu	-	-	-	-	-	-	-	+
37	Ganesh Visarjan Talao, Kurla West	+	-	-	-	-	-	-	-
38	Maritime Training Institute, Chandivali	-	-	-	-	-	-	-	+
39	FF Center, Chandivali	-	-	-	-	-	-	-	+
40	Chandivali Lake, Chandivali	-	-	-	-	+	-	-	-
41	Turbhe Jalashay, Wadavali	-	-	-	-	-	-	-	-
42	Pond in Anushakti Nagar	-	-	-	-	-	-	-	-

Sr. No.	Name / Location of Water Body	Religious Activity	Washing	Fire fighting	Fishing	Recreatio nal	Boating	Defecation	Not Known
43	Pond, Central Avenue, Trombay	-	-	-	-	-	-	-	-
44	Pond, Tata Colony-Central Avenue, Trombay	-	-	-	-	-	-	-	+
45	Talao near Fertiliser Township, Chembur	-	-	-	-	-	-	-	+
46	Ashish Talao, Chembur	-	-	-	-	-	-	-	+
47	BARC 2	Not known	Not known	Not known	Not known	Not known	Not known	Not known	+
48	Trombay Koliwada	Not known	Not known	Not known	Not known	Not known	Not known	Not known	+
49	Teen Talao / Charai Talao, Chembur	+	-	-	-	+	-	-	-
50	Karnatak Sangh Talao, Chembur	+	-	-	-	+	-	-	-
51	Talao near RCF Gate No. 2 - Chembur	-	-	-	-	-	-	-	+
52	Chheda Nagar	+	+	-	-	-	-	-	-
53	Water body Near Mahul Road	-	-	-	-	-	-	-	-
54	Talao, Barve Nagar (Reservoir)	NA	NA	NA	NA	NA	NA	NA	-
55	Goregaon Boating Club, Aarey Milk Colony	-	-	-	-	+	+	-	-
56	Talao near Movie Star Cinema, Goregaon West	-	-	-	-	-	-	+	-
57	Aarey Milk Colony 2	-	+	-	-	+	-	-	-
58	Aarey Milk Colony 4	+	-	+	-	+	+	-	-
59	Film City	-	-	-	-	-	-	-	+
60	Royal Palms	-	-	-	-	+	-	-	-
61	Bhujale Talao / Somwar Bazar Talao, Link Road, Malad West	-	-	-	-	+	-	-	-
62	Gaondevi Lotus Lake, Malad West	-	-	-	-	+	-	-	-
63	Karjadevi Talao, Ma-ri, Malad West	-	+	-	-	-	-	+	-
64	Vanala Talao / Tokri Talao, Madh	-	+	-	+	-	-	-	-
65	Madh Talao, Near Madh jetty	-	+	-	-	-	-	-	-

Sr. No.	Name / Location of Water Body	Religious Activity	Washing	Fire fighting	Fishing	Recreatio nal	Boating	Defecation	Not Known
66	Bhati Talao, Madh	-	-	-	+	-	-	-	-
67	Talao near Nau-Sena Baug, Aksa	-	-	-	-	-	-	-	-
68	Kharodi Lake No 1, Malad West	-	+	-	-	-	-	+	-
69	Kharodi Lake No 2, Malad West	-	+	-	-	-	-	+	-
70	Kharodi Lake No.3, Malad West	-	+	-	-	-	-	+	-
71	Water Reservoir, Malad Hill	-	-	-	-	-	-	-	-
72	Sarvodaya Hospital & Research Centre, Malad West	-	-	-	-	-	-	-	-
73	Malwani Talao, Near Malwani Church, Malad West	-	-	-	-	-	-	-	-
74	Sumalai Talao, Manori	-	-	-	-	-	-	+	-
75	Gaon Talao, Manori	-	-	-	+	-	-	-	-
76	Khardala Talao, Ma-ri	-	+	-	-	-	-	-	-
77	Ali Talao, Road No. 3, Malvani	-	-	-	-	-	-	+	-
78	Hiradevi Talao, Erangal	+	-	-	-	-	-	-	-
79	Madh	-	+	-	-	-	-	-	-
80	Bandar Pakhadi Talao, Kandivali West	+	+	-	-	-	-	-	-
81	Charkop Talao/Dingeshwar Talao, Kandivali West	+	+	-	-	-	-	-	-
82	Mahindra & Mahindra	Not known	Not known	Not known	Not known	Not known	Not known	Not known	+
83	Talao opposite Sai Dham Nagar,Charkop, Kandivali West	-	-	-	-	-	-	+	-
84	Vajira Mandir Talao, Borivali (West)	+	-	-	-	-	-	-	-
85	Rani Jhansi Talao, Link Road, Borivali	-	-	-	-	+	-	-	-
86	Veer Savarkar Talao, Borivali West	-	-	-	-	+	-	-	-
87	Eksar Talao, Borivali West	+	-	-	-	-	-	-	-
88	Talao Near Gorai Church	-	+	-	-	-	-	-	-

Sr. No.	Name / Location of Water Body	Religious Activity	Washing	Fire fighting	Fishing	Recreatio nal	Boating	Defecation	Not Known
89	Kulav Talao, Gorai	-	-	-	-	-	-	-	-
90	Vairali Talao, Uttan Road	-	-	-	-	-	-	-	-
91	Shephali Talao, Uttan - 2	-	+	-	-	-	-	-	-
92	Uttan - 3	-	-	-	-	-	-	-	-
93	Uttan - 4	Not known	Not known	Not known	Not known	Not known	Not known	Not known	+
94	Uttan - 5	-	-	-	-	-	-	-	-
95	Uttan - 6	-	+	-	-	-	-	-	-
96	Uttan - 8	-	-	-	-	-	-	-	-
97	Uttan - 9	-	+	-	-	-	-	-	-
98	Kandarpada Talao	+	-	-	-	+	+	-	-
99	Shivaji Talao, Bhandup	+	-	-	-	-	-	-	-
100	Bhandupeshwar Kund, Bhandup East	+	-	-	+	+	+	-	-
101	Powai Lake	-	-	-	-	+	-	-	-
102	NITIE (National Institute of Training in Industrial Engineering) Lake, Powai	-	-	-	+	-	-	-	-
103	Water body near Eastern Express Highway, Bhandup East	-	-	-	-	-	-	-	-
104	Ganesh Ghat Jogging Track, Near V.P.M. College, Mulund	-	-	-	-	+	-	-	-
105	Ganesh Visarjan Talao, Eastern Express Highway, Mulund-East	+	-	-	-	+	-	-	-
106	Vihar Lake, Sanjay Gandhi National Park	-	-	-	-	-	-	-	-
107	Tulsi Lake, SGNP	-	-	-	-	-	-	-	-

\+ Present - Absent NA: Not available due to resitricted entry

Source: Study of Lakes on Mumbai, 2009, WWF-India

Annex 6. Visual status of the water bodies of Mumbai

Sr. No.	Name/ Location of WaterBody	Growth of aquatic weeds	Eutrophication	Algal bloom	Heavy growth of water lilies	Saline water ingress
1	Banganga, Walkeshwar	-	+	+	-	-
2	Pond-New City Mill, Chinchpokli	Not known	Not known	Not known	Not known	Not known
3	Pond,IndiaUnitedMill No. 5	-	-	-	-	-
4	Pond,IndiaUnitedMill No. 2, 3- Near Chinchpokli Railway Station	Not known	-	+	Not known	Not known
5	Pond,IndiaUnitedMill No. 1, Near CurreyRoad Railway Station	+	+	+	-	-
6	Jam Mills,NearCurreyRoad Railway Station	-	+	+	-	-
7	TataMill, NearParel Railway Station	-	+	+	-	-
8	Pond,Gold MohurMill, Dadasaheb Phalke Road,Dadar	+	+	+	-	-
9	Pond-MTNL Complex, Parel	-	+	-	-	-
10	Pond,Kohinoor Mill, Dr.Ambedkar Road,Dadar	Not known	-	+	-	-
11	Sion Talao,Sion-Chunabhatti	-	-	+	-	-
12	WaterbodyNearSewri-Chembur Road	-	-	-	-	-
13	Pond,Century TextileMill, Parel	Not known	Not known	+	Not known	
14	Pond,Kamala Mill, Parel	Not known	Not known	Not known	Not known	Not known
15	Pond,Prakash CottonMill, Parel	Not known	Not known	Not known	Not known	Not known
16	Pond,Madhusudan Mill, LowerParel	-	-	+	-	-
17	Pond,Piramal Mill, LowerParel	-	-	+	Not known	-
18	Pond,IndiaUnitedMill No.6, Veer Sawarkar Marg,Prabhadevi	-	-	+	-	-
19	Maharashtra NaturePark Lake, Dharavi	-	-	+	-	-

Sr. No.	Name/ Location of WaterBody	Growth of aquatic weeds	Eutrophication	Algal bloom	Heavy growth of water lilies	Saline water ingress
20	Lake,University of Mumbai Campus, Santacruz East	+	+	+	-	-
21	Mumbai University 2	Not known	Not known	+	Not known	Not known
22	Bandra Talao,Gopalan Chowk, Bandra West	-	+	-	-	-
23	Talaoopp. Marol Fire Brigade, Airport Road,Andheri	-	+	+	-	-
24	Lokmanya Tilak Talao,Jogeshwari-Vikhroli Link Road	-	-	+	-	-
25	SeepzLake,Andheri East	-	-	+	-	-
26	Vyaravali Tekdi,Seepz, Andheri East	NA	NA	NA	NA	NA
27	Jalashay Tekdi,Seepz, Andheri East	NA	NA	NA	NA	NA
28	Talaonear Lokhandwala Complex	Not known	Not known	Not known	Not known	+
29	Lake-Pawan Hans,Juhu	+	+	+	-	-
30	Lakenear Irla junction, Andheri West	-	-	+	-	-
31	Bhavans College Lake,Andheri West	-	+	+	-	-
32	Harbadevi Mandir Talao,Next to Killeshwar Mahadeo Mandir, Madh	+	+	+	-	-
33	GangaBawdi,Madh	-	+	+	-	-
34	Juhu Aerodrome, Juhu Park	+	+	+	-	-
35	Juhu Aerodrome 2, Juhu Park	+	+	+	-	-
36	S.N. Maharaj Chowk, Juhu	Not known	-	+	-	-
37	Ganesh Visarjan Talao,KurlaWest	-	-	+	-	-
38	Maritime Training Institute, Chandivali	-	-	+	-	-

Sr. No.	Name/ Location of WaterBody	Growth of aquatic weeds	Eutrophication	Algal bloom	Heavy growth of water lilies	Saline water ingress
39	FF Center, Chandivali	-	-	+	-	-
40	Chandivali Lake,Chandivali	-	+	+	-	-
41	Turbhe Jalashay, Wadavali	-	-	+	-	-
42	Pond in Anushakti Nagar	-	-	+	-	-
43	Pond,Central Avenue, Trombay	-	-	+	-	-
44	Pond,TataColony-Central Avenue, Trombay	-	-	+	-	-
45	Talaonear Fertiliser Township, Chembur	-	-	+	-	-
46	AshishTalao,Chembur	-	+	+	-	-
47	BARC2	-	-	+	-	-
48	Trombay Koliwada	-	+	+	-	-
49	Teen Talao/ CharaiTalao,Chembur	-	-	+	-	-
50	Karnatak SanghTalao,Chembur	-	-	+	-	-
51	Talaonear RCF GateNo. 2 - Chembur	-	-	+	-	-
52	Chheda Nagar	-	-	+	-	-
53	WaterbodyNearMahulRoad	Not known	Not known	Not known	-	-
54	Talao,BarveNagar(Reservoir)	NA	NA	NA	NA	NA
55	Goregaon Boating Club,AareyMilk Colony	-	-	-	-	-
56	Talaonear MovieStar Cinema, Goregaon West	+	+	+	-	-
57	AareyMilk Colony 2	-	-	+	-	-
58	AareyMilk Colony 4	-	-	+	-	-

Sr. No.	Name/ Location of WaterBody	Growth of aquatic weeds	Eutrophication	Algal bloom	Heavy growth of water lilies	Saline water ingress
59	Film City	-	-	+	-	-
60	RoyalPalms	-	-	+	-	-
61	Bhujale Talao/ Somwar BazarTalao, Link Road,MaladWest	-	-	+	-	-
62	Gaondevi LotusLake,MaladWest		+	-	+	-
63	Karjadevi Talao,Manori, MaladWest	+	+	+	-	+
64	Vanala Talao/ TokriTalao,Madh	-	-	+	-	-
65	Madh Talao,NearMadh jetty	-	-	+	-	+
66	BhatiTalao,Madh	+	+	+	+	-
67	Talaonear Nau-Sena Baug,Aksa	+	+	+	Not known	-
68	Kharodi Lake-1, MaladWest	-	-	+	-	-
69	Kharodi Lake-2, MaladWest	+	+	+	-	-
70	Kharodi Lake-3, MaladWest	+	+	+	-	-
71	WaterReservoir, MaladHill	NA	NA	NA	NA	NA
72	Sarvodaya Hospital & Research Centre, MaladWest			+	-	-
73	Malwani Talao,NearMalwani Church, MaladWest	+	+	+	-	-
74	Sumalai Talao,Manori	+	+	+	-	-
75	Gaon Talao,Manori	+	+	+	-	-
76	Khardala Talao,Manori	+	+	+	-	+
77	Ali Talao,Road No. 3, Malvani	-	-	+	-	-
78	Hiradevi Talao,Erangal	+	+	+	-	-

Sr. No.	Name/ Location of WaterBody	Growth of aquatic weeds	Eutrophication	Algal bloom	Heavy growth of water lilies	Saline water ingress
79	Madh	-	-	+	-	-
80	Bandar Pakhadi Talao,Kandivali West	-	-	+	-	-
81	Charkop Talao/Dingeshwar Talao, Kandivali West	-	-	+	-	+
82	Mahindra & Mahindra	Not known	Not known	+	Not known	Not known
83	Talaoopposite Sai Dham Nagar,Charkop, Kandivali West	-	-	-	-	-
84	VajiraMandir Talao,Borivali (West)	-	-	+	-	-
85	RaniJhansiTalao, Link Road,Borivali West	-	-		-	-
86	VeerSavarkar Talao, Borivali West	-	-	+	-	-
87	EksarTalao,Borivali West	+	+	+	-	-
88	TalaoNearGoraiChurch			+	-	+
89	KulavTalao,Gorai	+	+	+	-	-
90	VairaliTalao,Uttan Road	+	+	-	+	-
91	Shephali Talao,Uttan - 2	+	-	+	-	-
92	Uttan - 3	-	-	+	-	-
93	Uttan - 4	Not known	Not known	Not known	Not known	Not known
94	Uttan - 5	+	-	+	-	-
95	Uttan - 6	-	-	+	-	-
96	Uttan - 8	-	-	+	-	-
97	Uttan - 9	-	-	+	-	-
98	Kandarpada Talao	-	-	+	-	-
99	ShivajiTalao,Bhandup West	-	+	+	-	-

Sr. No.	Name/ Location of WaterBody	Growth of aquatic weeds	Eutrophication	Algal bloom	Heavy growth of water lilies	Saline water ingress
100	Bhandupeshwar Kund,Bhandup East	-	-	-	-	-
101	PowaiLake	-	-	+	-	-
102	NITIE(National Institute of Training in Industrial Engineering) Lake,Powai	-	-	-	-	-
103	Waterbodynear Eastern Express Highway, Bhandup East	-	-	+	-	-
104	Ganesh GhatJogging Track,Near V.P.M.College, Mulund	-	-	+	-	-
105	Ganesh Visarjan Talao,Eastern Express Highway, Mulund-East	-	-	+	-	-
106	ViharLake,Sanjay GandhiNational Park	-	-	-	-	-
107	TulsiLake,Sanjay Gandhi National Park	-	-	-	-	-

\+ Present - Absent NA: Not available due to resitricted entry

Source: Study of Lakes on Mumbai, 2009, WWF-India

Annex 7. Identified water bodies which need immediate attention

Sr. No.	Name / Location of Water Body	D.P. Classification	Area (Acres)	Size	Ownership	Major threats
1	Banganga, Walkeshwar	Tank	1.83	Medium	MCGM	Em + SW+ Ev
2	Pond- New City Mill, Chinchpokli	Mill Land	0.10	Small	MCGM	Em + En+ Ev
3	Pond, India United Mill No. 5	Mill Land	0.35	Small	Govt. Agency	Em + En+ Ev
4	Pond, India United Mill No. 2, 3- Near Chinchpokli Railway Station	Mill Land	0.58	Small	Govt. Agency	Em + En+ Ev
5	Pond, India United Mill No. 1, Near Currey Road Railway Station	Mill Land	1.64	Medium	Govt. Agency	Em + En+ Ev
6	Jam Mills, Near Currey Road Railway Station	Mill Land	0.27	Small	Govt. Agency	Em + En+ Ev
7	Tata Mill, Near Parel Railway Station	RG	0.78	Small	Govt. Agency	Em + En+ Ev
8	Pond, Gold Mohur Mill, Dadasaheb Phalke Road, Dadar	Mill Land	0.71	Small	Govt. Agency	Em + En+ Ev
9	Pond-MTNL Complex, Parel	RG	0.60	Small	Govt. Agency	Em + En+ Ev
10	Pond, Kohinoor Mill, Dr.Ambedkar Road, Dadar	Tank	0.54	Small	Govt. Agency	D+ Em + SW+ Ev
11	Sion Talao, Sion-Chunabhatti	Tank	1.14	Medium	MCGM	En+ SW
12	Water body Near Sewri-Chembur Road	Water logged low lying area	5.58	Large	MCGM	SW + Ev
13	Pond, Century Textile Mill, Parel	Mill Land	0.68	Small	Govt. Agency	Em + En+ Ev
14	Pond, Prakash Cotton Mill, Parel	Mill Land	0.26	Small	Govt. Agency	D+ Em + En+ Ev

Sr. No.	Name / Location of Water Body	D.P. Classification	Area (Acres)	Size	Ownership	Major threats
15	Pond, Madhusudan Mill, Lower Parel	Mill Land	0.31	Small	Govt. Agency	D+ Em + En+ Ev
16	Pond, Piramal Mill, Lower Parel	Mill Land	0.59	Small	Govt. Agency	D+ Em + En+ Ev
17	Bandra Talao, Gopalan Chowk, Bandra West	RG	7.43	Very Large	MCGM	Em + En+ Ev
18	Lokmanya Tilak Talao, Jogeshwari- Vikhroli Link Road	Tank	0.48	Small	MCGM	Em + En+ Ev
19	Lake- Pawan Hans, Juhu	Park	52.97	Very Large	Govt. Agency	D+ Em + En +SW+ Ev
20	Harbadevi Mandir Talao, Next to Killeshwar Mahadeo Mandir, Madh	NDZ	1.17	Medium	MCGM	Em + En+ Ev
21	Ganga Bawdi, Madh	NDZ	0.92	Small	MCGM	Em + En+ Ev
22	Talao near Fertiliser Township, Chembur	----	0.51	Small	Govt. Agency	D+ Em + En+ Ev
23	Ashish Talao, Chembur	RG	1.26	Medium	MCGM	D+ Em + En+ Ev
24	Trombay Koliwada	----	1.64	Medium	Govt. Agency	D+ Em + En+ Ev
25	Chheda Nagar	----	1.14	Medium	Not known	Em + En+ Ev
26	Talao near Movie Star Cinema, Goregaon West	----	0.61	Small	MCGM	D+ Em + En +SW+ Ev
27	Gaondevi Lotus Lake, Malad West	RG	4.85	Large	MCGM	D+ Em + En+ Ev
28	Vanala Talao / Tokri Talao, Madh	RG	1.56	Medium	MCGM	Em + En+ Ev
29	Kharodi Lake-1, Malad West	----	1.05	Medium	MCGM	Em + En+ SW
30	Kharodi Lake-3, Malad West	----	0.57	Small	MCGM	Em + En +SW+ Ev

Sr. No.	Name / Location of Water Body	D.P. Classification	Area (Acres)	Size	Ownership	Major threats
31	Malwani Talao, Near Malwani Church, Malad West	----	0.86	Small	MCGM	D+ En +SW
32	Ali Talao, Road No. 3, Malvani	R Zone	0.27	Small	Not known	En+ SW + Ev
33	Talao opposite Sai Dham Nagar,Charkop, Kandivali West	----	0.61	Small	MCGM	Em + En +SW+ Ev
34	Eksar Talao, Borivali West	----	0.46	Small	MCGM	D+ Em + En +SW+ Ev
35	Kandarpada Talao	R Zone	1.09	Medium	Not known	Em + En+ Ev
36	Shivaji Talao, Bhandup West	Tank	0.90	Small	MCGM	Em + En +SW+ Ev

D: Deteriorating water quality **Em**: Embankment of edges **En**: Encroachment
SW: Solid waste dumping **Ev**: Evaporation losses due to loss of green cover
Source: Study of Lakes on Mumbai, 2009, WWF-India

Annex 8. Sources and harmful effects on humans by Air pollutants

Sr. No	Name of Pollutant and Description	Molecular formula	Natural Source	Anthropogenic	Effects
1	**Nitrogen dioxide** Oxides of nitrogen are a generic term for a group of highly reactive gases that contain nitrogen and oxygen in varying amounts. NOx are emitted as nitrogen oxide (NO) which is rapidly oxidized to more toxic nitrogen dioxide (NO2) Nitrogen dioxide (NO2) is a reddish-brown toxic gas with a characteristic sharp, biting odor and is a prominent air pollutant.	NOx	1. Lightning 2. Forest Fires 3. Bacterial activity of soil.	1. Combustion of fossil fuel (coal, heavy fuel oil in thermal power plants, office, factories). 2. Paper Industry. 3. Extraction & distribution of fossil fuels. 4. Smelting of metals (sulfide ores to produce copper, lead and zinc). 5. Petroleum refining. 6. Combustion process in diesel, petrol, natural gas driven vehicles.	1. Respiratory illness. 2. Visibility impairment. 3. Aggravate existing heart and lung diseases.

Sr. No	Name of Pollutant and Description	Molecular formula	Natural Source	Anthropogenic	Effects
2	**Respirable Suspended Particulate Matter** (PM10, size ≤ 10µm, coarse fraction PM10 - PM2.5) called thoracic fraction) Particulate matter (PM) is a complex mixture of suspended solid and liquid particle in semi equilibrium with surrounding gases. The major constituents of RSPM are organic and elemental carbon, metals/elements like silicon, magnesium, iron, ions like sulphates, nitrates, ammonium etc. PM10 can settle in the bronchi and lungs and cause health problems	PM 10	1. Coarse particles are produced by the mechanical break-up of larger solid particles. 2. Wind-blown dust such as road dust, fly ash, soot, agricultural processes. 3. Physical processes of crushing, grinding and abrasion of surfaces. photochemically. 4. Produced particles, such as those found in urban haze. 5. Pollen grains, mold spores, and plant and insect parts. 6. Non-combustible materials released when burning fossil fuels.	1. Road traffic emissions particularly from diesel vehicles. 2. Industrial combustion plants some public power generation. 3. Commercial and residential combustion. 4. Non-combustion processes (e.g. quarrying). 5. Agricultural activities.	1. Cardio-pulmonary problems 2. Asthma, bronchitis, and pneumonia in older people 3. Visibility reduction 4. High particulate matter concentrations in the atmosphere can lead to growth stunting or mortality in some plant species

Sr. No	Name of Pollutant and Description	Molecular formula	Natural Source	Anthropogenic	Effects
3	**Particulate Matter** (PM2.5, size ≤ 2.5µm, fine fraction size up to 2.5 µm, respirable fraction). Airborne particles smaller than 2.5 µm called fine particles. Composed mainly of carbonaceous materials (organic and elemental), inorganic compounds (sulfate, nitrate, and ammonium), and trace metal compounds (iron, aluminium, nickel, copper, zinc, and lead). pose the greatest problems, PM2.5, tend to penetrate into the gas exchange regions of the lung, and very small particles (<100 nanometers) may pass through the lungs to affect other organs. The smallest	PM 2.5	1. Fine particles are largely formed from gases arises from originating from volcanoes, dust storms, forest and grassland fires, living vegetation, and sea spray 2. Ultrafine particles are formed by nucleation, which is the initial stage in which gas becomes a particle. These particles can grow up to a size of 1µm either through condensation, when additional gas condensates or, coagulation.	1. Vehicular emission 2. Industrial combustion plants some public power generation. 3. Commercial and residential combustion.	1. Cardiopulmonary disease, 2. Cancer of the trachea, bronchus, and lung,

Sr. No	Name of Pollutant and Description	Molecular formula	Natural Source	Anthropogenic	Effects
	particles, however, less than 100 nm (nanoparticles) can get into the bloodstream and affect the cardiovascular system.				
4	**Carbon Monoxide** It is a colorless, odorless and tasteless gas which is slightly lighter than air. It is highly toxic to humans and animals in higher	CO	1. Produced during normal animal metabolism (by the action of heme oxygenase 1 and 2 on the heme from hemoglobin	1. Exhaust of internal combustion engines, especially of vehicles with petrol engines. 2. Burning of carbon fuels. 3. Organic combustion in waste incineration. 4. Power station processes. 5. Iron smelting. 6. Burning of crop residues.	1. CO enters the bloodstream through lungs and combines with hemoglobin forms carboxyhemoglobin. This condition is known as anoxemia, which inhibits blood's oxygen carrying capacity to organs and tissues. 2. Persons with heart disease are sensitive to CO poisoning and may experience chest pain if they breathe the gas while exercising. 3. Adverse effects on the fetus of a pregnant

Sr. No	Name of Pollutant and Description	Molecular formula	Natural Source	Anthropogenic	Effects
	quantities. Mainly formed by incomplete combustion of carbon containing fuels.		break down and produces carboxyhemoglobin in normal persons) in low quantities and has some normal biological functions (signaling molecule). 2. Volcanic activity. 3. Forest and bushfires.		woman. 4. Infants, elderly persons, and individuals with respiratory diseases are also particularly sensitive. 5. Anti-inflammatories, vasodilators and encouragers of neovascular growth.
5	**Sulphur dioxide** SO2 is the chemical compound produced by volcanoes and in various industrial processes and are also a precursor to particulates in the atmosphere.	SOx	Volcanos (67%)	1. Combustion of fossil fuel (coal, heavy fuel oil in thermal power plants, office, factories). 2. Paper Industry. 3. Extravtion & distribution of fossil fuels. 4. Smelting of metals (sulfide ores to produce copper, lead and zinc). 5. Petroleum refining 6. Combustion process in diesel, petrol, natural gas driven vehicles.	1. Respiratory illness. 2. Visibility impairment. 3. Aggravate existing heart and lung diseases.

Sr. No	Name of Pollutant and Description	Molecular formula	Natural Source	Anthropogenic	Effects
6	**Lead** Lead is a bright silvery soft, dense, ductile, highly malleable, bluish-white metal that has poor electrical conductivity heavy metal and is highly resistant to corrosion.	Pb	Lead occurs naturally in the earth's crust	1. Waste incineration 2. Metal processing 3. Paint Industry 4. Lead solder in food cans, breast milk, drinking water, Cosmetics, ceramic pottery, burning of firewood or kerosene, indigenous remedies, tobacco and tobacco products, contaminated drinking water, toys, industrial effluents, lead acid batteries, ammunition, paints and varnishes, water pipes 5. Automobile exhaust,	1. Pb is rapidly absorbed into the bloodstream and is believed to have adverse effects on the central nervous system, the cardiovascular system, kidneys, and the immune system 2. Causes blood disorders like anemia increase in blood presssure. 3. Potent neurotoxin that accumulates both in soft tissues and the bones. 4. Causes nephropathy, and colic-like abdominal pains. 5. Weakness in fingers, wrists, or ankles. 6. Miscarriage and reduction of fertility in males, delayed puberty in girls 7. Permanently reduce the cognitive capacity of children
7	**Benzene** Benzene is a colorless, sweet smelling liquid. Benzene is generated whenever carbon-rich materials undergo incomplete combustion. Benzene is generated whenever carbon-rich materials undergo incomplete combustion	C_6H_6	1. Volcanoes 2. Forest fires	1. Combustion of fuel (automotive fuel, wood and stationary fossil fuel, other aromatics. 2. Evaporation (fuel storage containers, during refueling. 3. Industrial emission. 4. Coke oven. 5. Perchlorethlyene is emitted from some dry cleaning facilities. 6. Tobacco smoke, wood smoke 7. Glues, paints, furniture wax, and detergents.	1. Hematotoxic, neurotoxic, leukemogenic, carcinogenic effects. 2. Chronic exposure to benzene may cause chromosomal damage, immune suppression, aplastic anemia, myelodysplastic syndrome, leukemia, non-Hodgkins's lymphoma, and cancer of the lung and nasopharynx. 3. Affect the reproductive system, developing fetus and fertility in men, low birth weights, delayed bone formation, and bone marrow damage.

Sr. No	Name of Pollutant and Description	Molecular formula	Natural Source	Anthropogenic	Effects
8	**Ozone** Ozone is a pale blue gas, soluble in water and non-polar solvents with specific sharp odor somewhat resembling chlorine bleach. Ozone is a secondary pollutants formed in the atmosphere by reaction between oxides of nitrogen and volatile organic compounds (VOCs) in the presence of sunlight. Peak O3 levels occur typically during the warmer times of the year.	O3	Ozone is present in the atmosphere in the stratosphere, in a region also known as the ozone layer between about 10 km and 50 km above the surface.	1) Formed by the reaction of sunlight on air containing hydrocarbons and nitrogen oxides emitted by car engines, industrial operations, and chemical solvents to form ozone. 2) Electronic equipment such as photocopiers.	1) 1) Lung function deficits. 2) Respiratory illness. 3) Premature death, asthma, bronchitis, heart attack, and other cardiopulmonary problems. 4) Ground-level ozone and pollution which interferes with photosynthesis and stunts overall growth of some plant species.
9	**1, 3 Butadiene**	C4H6		Petrol and diesel combustion.	Exposure over a long time may lead to Cancer.

Annex 9. Revised NAAQS -2009

रजिस्ट्री सं॰ डी॰ एल॰-33004/99 REGD. NO. D. L.-33004/99

भारत का राजपत्र
The Gazette of India

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राष्ट्रीय परिवेशी वायु गुणवत्ता मानक

केन्द्रीय प्रदूषण नियंत्रण बोर्ड

अधिसूचना

नई दिल्ली, 18 नवम्बर, 2009

सं. बी-29016/20/90/पी.सी.आई.-I.—वायु (प्रदूषण निवारण एवं नियंत्रण) अधिनियम, 1981 (1981 का 14) की धारा 16 की उपधारा (2) (एच) द्वारा प्रदत्त शक्तियों का प्रयोग करते हुए तथा अधिसूचना संख्या का.आ. 384(ई), दिनांक 11 अप्रैल, 1994 और का.आ. 935 (ई) दिनांक 14 अक्टूबर, 1998 के अधिक्रमण में केन्द्रीय प्रदूषण नियंत्रण बोर्ड इसके द्वारा तत्काल प्रभाव से राष्ट्रीय परिवेशी वायु गुणवत्ता मानक अधिसूचित करता है, जो इस प्रकार है-

राष्ट्रीय परिवेशी वायु गुणवत्ता मानक

क्र. सं.	प्रदूषक	समय आधारित औसत	परिवेशी वायु में सान्द्रण		
			औद्योगिक, रिहायशी, ग्रामीण और अन्य क्षेत्र	पारिस्थितिकी य संवेदनशील क्षेत्र (केन्द्र सरकार द्वारा अधिसूचित)	प्रबोधन की पद्धति
(1)	(2)	(3)	(4)	(5)	(6)
1	सल्फर डाई आक्साइड (SO_2), µg/m^3	वार्षिक* 24 घंटे**	50 80	20 80	-उन्नत वेस्ट और गाईक -पराबैंगनी परिदीप्ती
2	नाइट्रोजन डाई आक्साइड (NO_2), µg/m^3	वार्षिक* 24 घंटे**	40 80	30 80	-उपांतरित जैकब और हॉचाइजर (सोडियम-आर्सेनाईट) -रासायनिक संदीप्ति
3	विविक्त पदार्थ (10माइक्रान से कम आकार)या PM_{10}, µg/m^3	वार्षिक* 24 घंटे**	60 100	60 100	-हरात्मक विश्लेषण -टोयम -बीटा तनुकरण पद्धति

4187 GI/2009 (1)

NATIONAL AMBIENT AIR QUALITY STANDARDS
CENTRAL POLLUTION CONTROL BOARD
NOTIFICATION
New Delhi, the 18th November, 2009

No. B-29016/20/90/PCI-I.—In exercise of the powers conferred by Sub-section (2) (h) of section 16 of the Air (Prevention and Control of Pollution) Act, 1981 (Act No.14 of 1981), and in supersession of the Notification No(s). S.O. 384(E), dated 11th April, 1994 and S.O. 935(E), dated 14th October, 1998, the Central Pollution Control Board hereby notify the National Ambient Air Quality Standards with immediate effect, namely:-

NATIONAL AMBIENT AIR QUALITY STANDARDS

S. No.	Pollutant	Time Weighted Average	Concentration in Ambient Air		
			Industrial, Residential, Rural and Other Area	Ecologically Sensitive Area (notified by Central Government)	Methods of Measurement
(1)	(2)	(3)	(4)	(5)	(6)
1	Sulphur Dioxide (SO_2), µg/m³	Annual* 24 hours**	50 80	20 80	- Improved West and Gaeke -Ultraviolet fluorescence
2	Nitrogen Dioxide (NO_2), µg/m³	Annual* 24 hours**	40 80	30 80	- Modified Jacob & Hochheiser (Na-Arsenite) - Chemiluminescence
3	Particulate Matter (size less than 10µm) or PM_{10} µg/m³	Annual* 24 hours**	60 100	60 100	- Gravimetric - TOEM - Beta attenuation
4	Particulate Matter (size less than 2.5µm) or $PM_{2.5}$ µg/m³	Annual* 24 hours**	40 60	40 60	- Gravimetric - TOEM - Beta attenuation
5	Ozone (O_3) µg/m³	8 hours** 1 hour**	100 180	100 180	- UV photometric - Chemilminescence - Chemical Method
6	Lead (Pb) µg/m³	Annual* 24 hours**	0.50 1.0	0.50 1.0	- AAS /ICP method after sampling on EPM 2000 or equivalent filter paper - ED-XRF using Teflon filter
7	Carbon Monoxide (CO) mg/m³	8 hours** 1 hour**	02 04	02 04	- Non Dispersive Infra Red (NDIR) spectroscopy
8	Ammonia (NH_3) µg/m³	Annual* 24 hours**	100 400	100 400	-Chemiluminescence -Indophenol blue method

(ई), दिनांक 14 अक्टूबर, 1998 द्वारा प्रकाशित की गयी थी ।

(1)	(2)	(3)	(4)	(5)	(6)
9	Benzene (C_6H_6) µg/m^3	Annual*	05	05	- Gas chromatography based continuous analyzer - Adsorption and Desorption followed by GC analysis
10	Benzo(a)Pyrene (BaP) - particulate phase only, ng/m^3	Annual*	01	01	- Solvent extraction followed by HPLC/GC analysis
11	Arsenic (As), ng/m^3	Annual*	06	06	- AAS /ICP method after sampling on EPM 2000 or equivalent filter paper
12	Nickel (Ni), ng/m^3	Annual*	20	20	- AAS /ICP method after sampling on EPM 2000 or equivalent filter paper

* Annual arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals.

** 24 hourly or 08 hourly or 01 hourly monitored values, as applicable, shall be complied with 98% of the time in a year. 2% of the time, they may exceed the limits but not on two consecutive days of monitoring.

Note. — Whenever and wherever monitoring results on two consecutive days of monitoring exceed the limits specified above for the respective category, it shall be considered adequate reason to institute regular or continuous monitoring and further investigation.

SANT PRASAD GAUTAM, Chairman
[ADVT-III/4/184/09/Exty.]

Note: The notifications on National Ambient Air Quality Standards were published by the Central Pollution Control Board in the Gazette of India, Extraordinary vide notification No(s). S.O. 384(E), dated 11th April, 1994 and S.O. 935(E), dated 14th October, 1998.

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Annex 10. Compact Disc with Digitized data sets

Annex 11. Details of monitoring stations in MMR under monitoring programs

Sr. No	Program/Type/Station Name	Implementing Agency	Commission Date	Frequency Of Monitoring
	CAAQMS (Continuous Ambient Air Quality Monitoring Station)			
	Residential			Daily
1	Bandra	M/S Chemtrols Engineering Ltd., Mumbai	May, 2007	
2	Navi Mumbai- Airoli	N.M.M.C / M/S Chemtrols Engineering Ltd., Mumbai	December,2008	
3	Navi Mumbai- Vashi	N.M.M.C / M/S Chemtrols Engineering Ltd., Mumbai	October, 2006	
4	Sion	Maharashtra Pollution Control Board (MPCB)	June, 2004	
	NAMP (National Air Monitoring Program)			
	Commercial			2 Days In A Week
5	Navi Mumbai- Airoli Datta Meghe	Karmaveer Bhaurao Patil College, Vashi	April, 2006	
6	Thane- Naupada	Thane Municipal Corporation	July, 2005	
7	Kalbadevi	National Environmental Engineering Research Institute (NEERI)		
	Industrial			
8	Ambernath	Maharashtra Pollution Control Board (MPCB)	December, 2005	
9	Dombivali - Phase II MIDC	Maharashtra Pollution Control Board (MPCB)		
10	Navi Mumbai- Mahape	Karmaveer Bhaurao Patil College, Vashi	April, 2006	
11	Navi Mumbai- Taloja	Karmaveer Bhaurao Patil College, Vashi	April, 2006	
12	Thane- Balkum/Kolshet	Thane Municipal Corporation	July, 2005	
13	Parel	National Environmental Engineering Research Institute (NEERI)		
	Residential			
14	Badlapur	C.H.M.College, Ulhasnagar	June, 2006	
15	Navi Mumbai- Kharghar	Karmaveer Bhaurao Patil College, Vashi	April, 2006	
16	Navi Mumbai- Nerul	D Y Patil College, Nerul		

Sr. No	Program/Type/Station Name	Implementing Agency	Commission Date	Frequency Of Monitoring
17	Panvel	Karmaveer Bhaurao Patil College, Vashi	April, 2006	
18	Thane- Kopri	Thane Municipal Corporation	February, 2006	
19	Ulhasnagar - CHM college	C.H.M.College, Ulhasnagar	June, 2006	
20	Ulhasnagar - Powai Chowk	C.H.M.College, Ulhasnagar	June, 2006	
21	Worli	National Environmental Engineering Research Institute (NEERI)	1990	
	SAMP (State Air Monitoring Program)			
	Commercial			2 Days In A Week
22	Bhiwandi - Prematai Hall	Bhiwandi Municipal Corporation	April, 2011	
23	Kalyan	Bhiwandi Municipal Corporation	April, 2011	
	Industrial			
24	Dombivali - MIDC Office	C.H.M.College, Ulhasnagar	May, 2012	
	Sensitive			
25	Bhiwandi - I. G. M Hospital	Bhiwandi Municipal Corporation	April, 2011	

Source: MPCB, 2013

Continuous Ambient Air Quality Monitoring (CAAQMS) in MMR

Airoli - Navi Mumbai Monitoring Station

Date of Commissioning**: December, 2008**	
Location Details	
Latitude 19.15595	**Longitude:** 72.993167
Address: Fire Brigade Station Compound, Airoli, Navi Mumbai.	
Type: Residential	**Program**: CAAQMS
Frequency of Monitoring: Daily	
Implementing Agency: N.M.M.C / M/S Chemtrols Engineering Ltd., Mumbai	

Table No. 7: Readings recorded at Airoli monitoring station- Navi Mumbai under CAAQMS

Year	**N**	**SO_2**		**NO_X**		**RSPM**	
		Avg. (µg/m³)	***% days of exceedence***	**Avg. (µg/m³)**	***% days of exceedence***	**Avg. (µg/m³)**	***% days of exceedence***
	Standards	***Annual***	***24 hrs***	***Annual***	***24 hrs***	***Annual***	***24 hrs***
		50	*80*	*40*	*80*	*60*	*100*
2008-09	80*	31.3	1.3	111.8	66.3	86.8	20.0
2009-10	335	23.3	4.2	**89.3**	46.9	**120.2**	42.7
2010-11	343	27.3	0.6	**66.6**	29.4	**128.2**	64.4
2011-12	250	13.4	Nil	**75.4**	30.0	**180.8**	80.4
2012-13	297	20.6	1.0	**42.8**	6.1	**108.9**	48.5

Source: MPCB, 2013
N = No. of observations

* Since the station was commissioned in the month of Dec 2008, hence monitoring reading for Airoli station for FY 2008-09 are not distributed equally throughout the year. Therefore annual average were not compared with annual standards

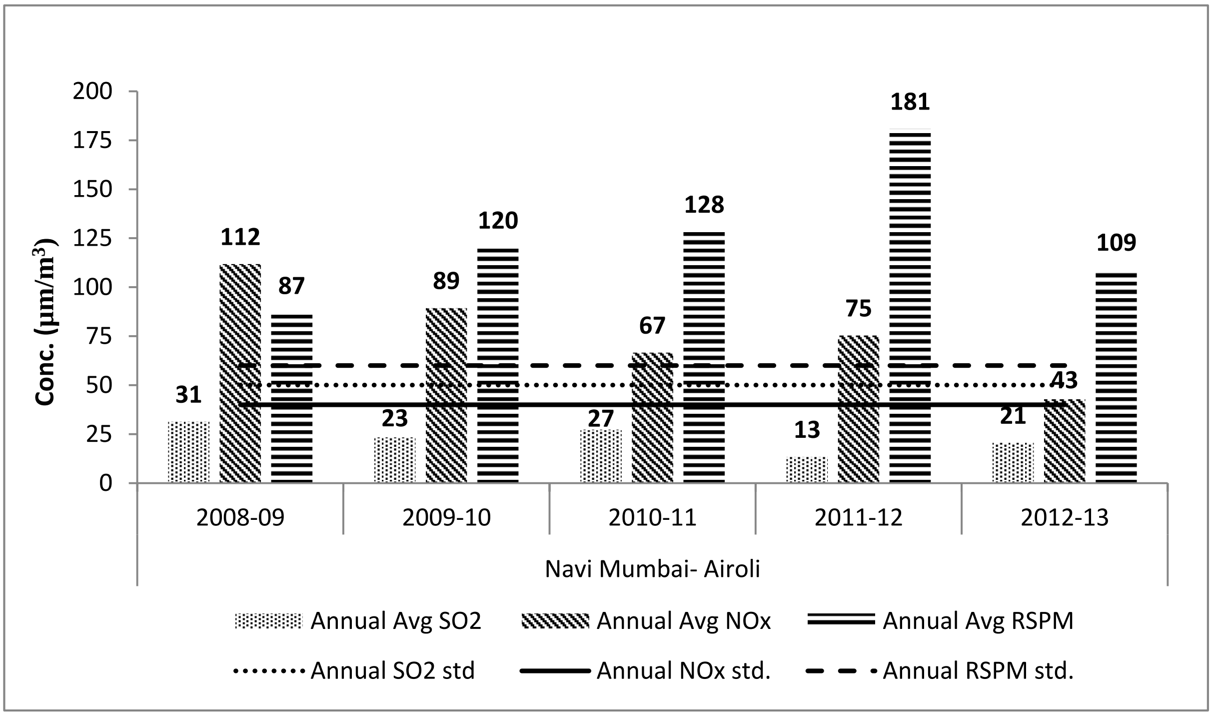


Figure 1: Annual trend in SO_2, NO_X and RSPM levels monitored at Airoli - Navi Mumbai under CAAQMS

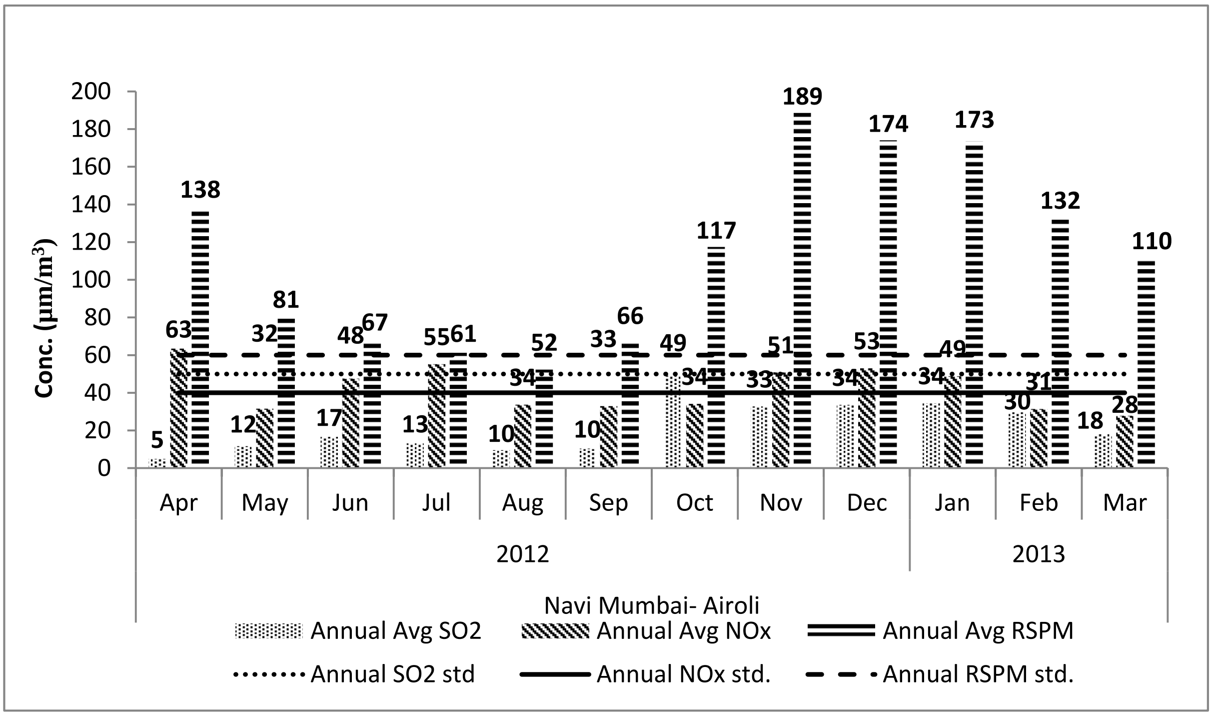


Figure 2: Monthly average readings recorded at Airoli-Navi Mumbai under CAAQMS (2012-13)

Table No. 8: Monthly average readings recorded at Airoli - Navi Mumbai under CAAQMS

FY 2012-13	N	SO_2		NO_X		RSPM	
		Avg. (µg/m³)	*% days of exceedence*	**Avg. (µg/m³)**	*% days of exceedence*	**Avg. (µg/m³)**	*% days of exceedence*
24 hrs. Standards		*80*		*80*		*100*	
Apr	29	4.9	Nil	63.5	37.9	137.7	96.6
May	26	11.7	Nil	31.6	Nil	80.7	19.2
Jun	30	16.6	Nil	47.6	3.3	67.2	6.7
Jul	30	13.1	Nil	55.2	10.0	61.2	Nil
Aug	26	9.5	Nil	33.7	Nil	52.3	Nil
Sep	25	10.4	Nil	32.9	4.0	66.5	28.0
Oct	21	49.2	9.5	34.1	Nil	117.4	71.4
Nov	23	32.7	Nil	50.8	8.7	188.6	100.0
Dec	15	33.6	Nil	53.0	Nil	174.1	100.0
Jan	23	34.4	4.3	48.8	Nil	173.4	69.6
Feb	26	29.6	Nil	31.4	Nil	131.9	76.9
Mar	23	18.0	Nil	27.8	Nil	110.4	56.5

Source: MPCB, 2013
N = No. of observations

Bandra Monitoring Station

Date of Commissioning: **May, 2007**	
Location Details	
Latitude: 19° 063.083	**Longitude**: 72°84.645′
Address: Govt. Polytechnic, Kherwadi, Bandra, Mumbai	
Type: Residential	**Program**: CAAQMS
Frequency of Monitoring: Daily	
Implementing Agency: M/S Chemtrols Engineering Ltd., Mumbai	

Table No. 9: Readings recorded at Bandra monitoring station under CAAQMS

Year	**N**	**SO_2**		**NO_X**		**RSPM**	
		Avg. (µg/m³)	*% days of exceedence*	**Avg. (µg/m³)**	*% days of exceedence*	**Avg. (µg/m³)**	*% days of exceedence*
	Standards	*Annual*	*24 hrs*	*Annual*	*24 hrs*	*Annual*	*24 hrs*
		50	*80*	*40*	*80*	*60*	*100*
2007-08	233	19.2	*Nil*	**59.7**	*21.0*	**157.9**	*61.4*
2008-09	335	19.1	*Nil*	**59.9**	*20.3*	**137.2**	*60.3*
2009-10	339	17.4	*0.3*	**90.4**	*46.0*	**139.9**	*59.3*
2010-11	349	19.1	*0.3*	**48.1**	*9.5*	**116.1**	*52.4*
2011-12	353	20.6	*Nil*	**65.4**	*19.3*	**130.8**	*55.8*
2012-13	355	18.1	*Nil*	**48.0**	*2.0*	**115.9**	*51.0*

Source: MPCB, 2013
N = No. of observations

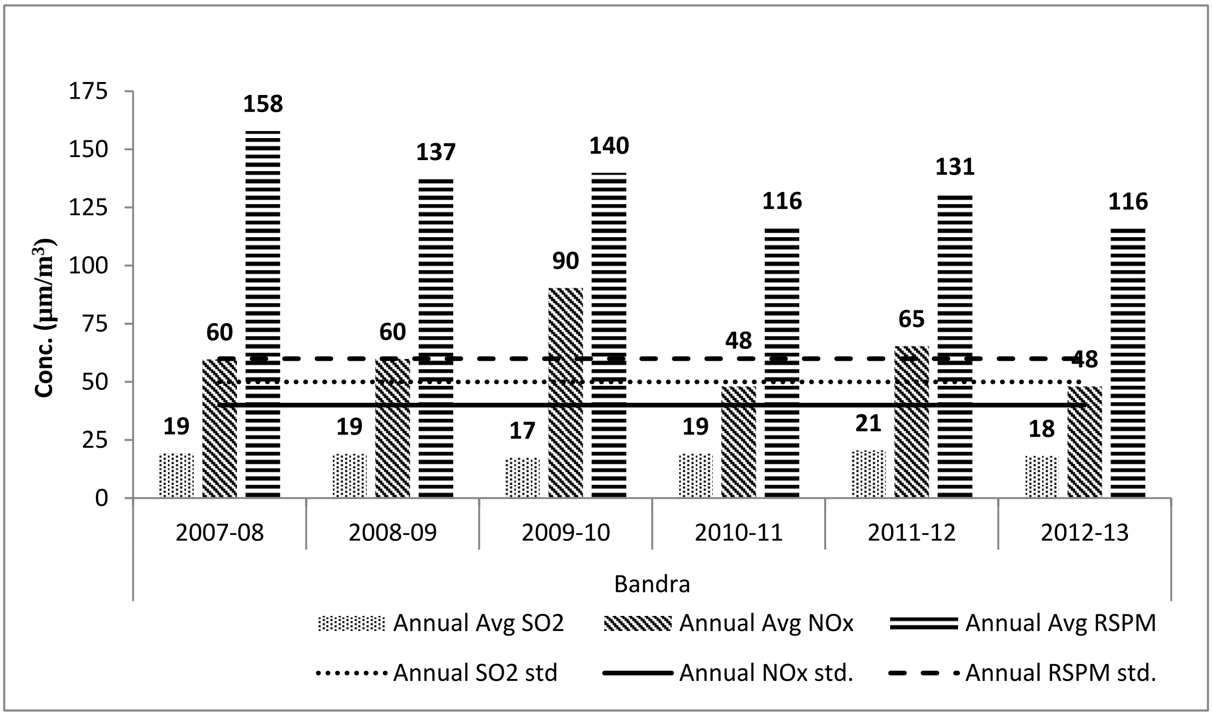


Figure 3: Annual trend in SO_2, NO_X and RSPM levels monitored at Bandra monitoring station under CAAQMS

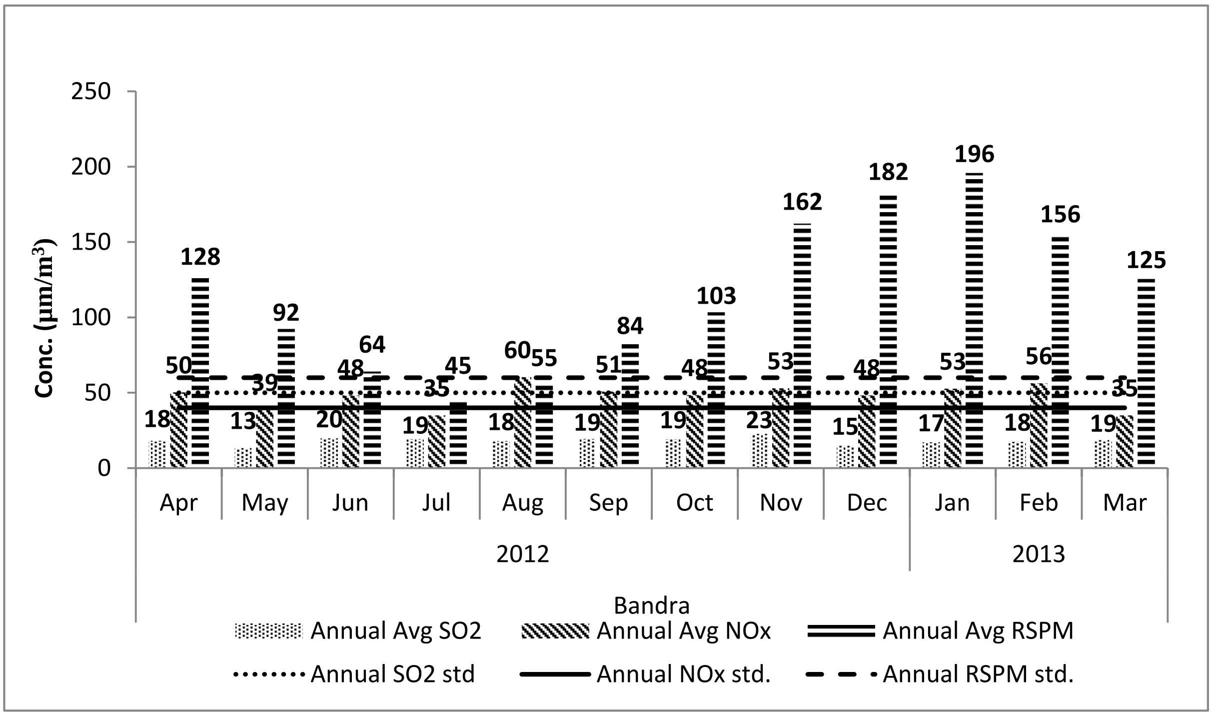


Figure 4: Monthly average readings recorded at Bandra monitoring station under CAAQMS (2012-13)

Table No. 10: Monthly average readings recorded at Bandra monitoring station under CAAQMS (2012-13)

FY 2012-13	N	SO_2		NO_X		RSPM	
		Avg. (µg/m³)	*% days of exceedence*	**Avg. (µg/m³)**	*% days of exceedence*	**Avg. (µg/m³)**	*% days of exceedence*
24 hrs. Standards		*80*		*80*		*100*	
Apr	30	18.2	*Nil*	50.2	*Nil*	127.6	*86.7*
May	31	13.3	*Nil*	38.6	*Nil*	92.3	*29.0*
Jun	29	19.8	*Nil*	48.2	*Nil*	64.0	*Nil*
Jul	29	19.2	*Nil*	35.0	*Nil*	44.7	*Nil*
Aug	31	17.9	*Nil*	60.4	*9.7*	55.1	*Nil*
Sep	29	19.3	*Nil*	50.8	*Nil*	83.5	*34.5*
Oct	29	19.1	*Nil*	48.4	*Nil*	103.4	*48.3*
Nov	30	22.7	*Nil*	52.9	*10.0*	162.3	*70.0*
Dec	30	14.9	*Nil*	48.2	*Nil*	182.2	*96.7*
Jan	30	17.1	*Nil*	52.7	*Nil*	195.8	*96.7*
Feb	27	17.6	*Nil*	56.3	*3.7*	155.8	*92.6*
Mar	30	18.6	*Nil*	35.0	*Nil*	125.5	*60.0*

Source: MPCB, 2013
N = No. of observations

Sion Monitoring Station

Date of Commissioning: **June, 2004**	
Location Details	
Latitude: 19.035533	**Longitude**: 72.8598
Address: Lokmanya Tilak Hospital (Sion Hospital), Sion Traffic Junction, Mumbai	
Type: Residential	**Program**: CAAQMS
Frequency of Monitoring: Daily	
Implementing Agency: Maharashtra Pollution Control Board (MPCB)	

Table No. 11: Readings recorded at Sion monitoring station under CAAQMS

Year	N	SO_2		NO_X		RSPM	
		Avg. (µg/m³)	*% days of exceedence*	Avg. (µg/m³)	*% days of exceedence*	Avg. (µg/m³)	*% days of exceedence*
	Standards	*Annual*	*24 hrs*	*Annual*	*24 hrs*	*Annual*	*24 hrs*
		50	*80*	*40*	*80*	*60*	*100*
2007-08	288	28.2	Nil	**141.5**	**87.5**	**294.7**	95.1
2008-09	84*	26.0	Nil	101.9	59.5	202.2	94.0
2009-10	236	24.1	1.3	**120.3**	66.5	**223.1**	80.1
2010-11	259	22.1	Nil	**115.5**	66.8	**180.8**	85.3
2011-12	200	10.6	0.5	**65.7**	20.0	**149.8**	77.0
2012-13	245	11.3	Nil	**106.3**	60.4	**136.5**	62.4

Source: MPCB, 2013

N = No. of observations

* Since the station was not operational for 9 months, hence monitoring reading for Airoli station for FY 2008-09 are not distributed equally throughout the year. Therefore annual average were not compared with annual standards

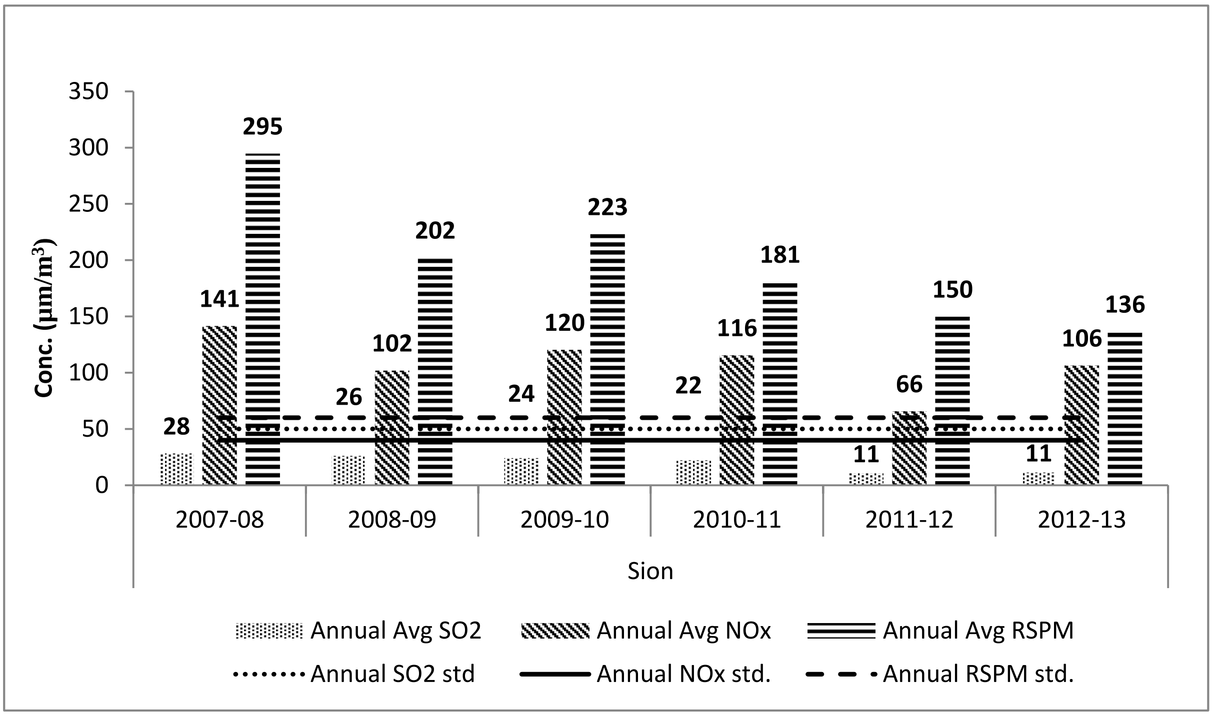


Figure 5: Annual trend in SO_2, NO_X and RSPM levels monitored at Sion under CAAQMS

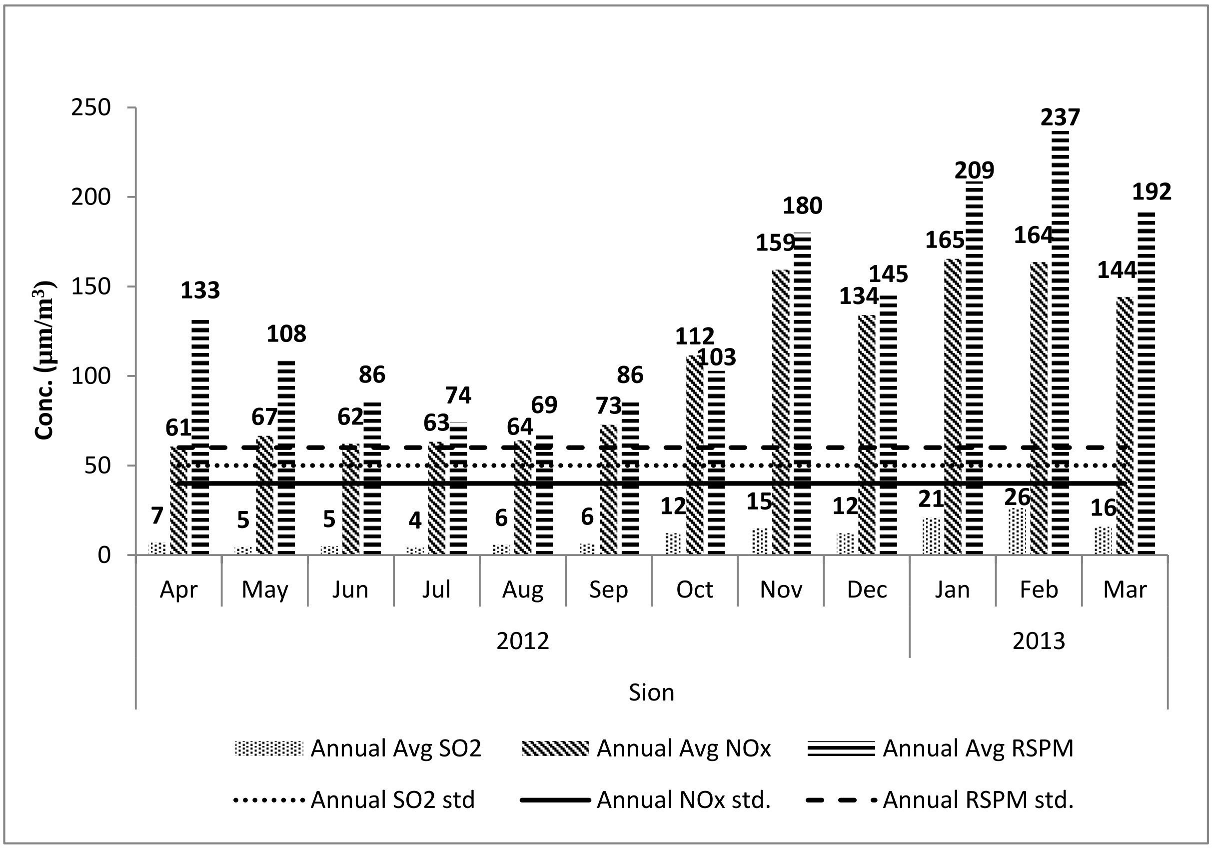


Figure 6: Monthly average readings recorded at Sion under CAAQMS (2012-13)

Table No. 12: Monthly average readings recorded at Sion under CAAQMS (2012-13)

FY 2012-13	N	SO_2		NO_X		RSPM	
		Avg. (µg/m³)	*% days of exceedence*	**Avg. (µg/m³)**	*% days of exceedence*	**Avg. (µg/m³)**	*% days of exceedence*
24 hrs. Standards		*80*		*80*		*100*	
Apr	18	6.9	Nil	60.6	16.7	132.8	77.8
May	23	4.6	Nil	66.6	26.1	108.5	52.2
Jun	21	5.0	Nil	62.2	23.8	85.7	19.0
Jul	22	4.2	Nil	63.3	27.3	74.1	22.7
Aug	20	5.7	Nil	64.1	15.0	68.7	5.0
Sep	19	6.4	Nil	72.8	31.6	85.5	26.3
Oct	13	12.2	Nil	111.5	84.6	102.8	46.2
Nov	18	14.9	Nil	159.3	94.4	180.1	94.4
Dec	26	12.3	Nil	134.0	100.0	144.8	92.3
Jan	21	20.8	Nil	165.4	100.0	208.7	100.0
Feb	21	26.2	Nil	163.6	100.0	236.9	100.0
Mar	23	15.8	Nil	144.1	100.0	192.3	100.0

Source: MPCB, 2013
N = No. of observations

Vashi - Navi Mumbai Monitoring Station

Date of Commissioning**: October, 2006**	
Location Details	
Latitude: 19.076467	**Longitude**: 72.99885
Address: Fire Brigade Station Compound, Vashi, Navi Mumbai.	
Type: Residental	**Program**: CAAQMS
Frequency of Monitoring: Daily	
Implementing Agency: N.M.M.C / M/S Chemtrols Engineering Ltd., Mumbai	

Table No. 13: Readings recorded at Vashi monitoring station - Navi Mumbai under CAAQMS

Year	**N**	**SO_2**		**NO_X**		**RSPM**	
		Avg. (µg/m³)	***% days of exceedence***	**Avg. (µg/m³)**	***% days of exceedence***	**Avg. (µg/m³)**	***% days of exceedence***
	Standards	***Annual***	***24 hrs***	***Annual***	***24 hrs***	***Annual***	***24 hrs***
		50	*80*	*40*	*80*	*60*	*100*
2007-08	269	**53.6**	15.2	**54.1**	16.0	**92.8**	45.7
2008-09	289	22.5	Nil	**51.4**	10.4	**123.5**	59.2
2009-10	329	26.9	1.8	**56.7**	18.5	**96.0**	44.7
2010-11	296	19.7	Nil	**44.6**	8.8	**91.9**	38.2
2011-12	186	19.3	Nil	**43.4**	4.8	**111.4**	58.1
2012-13	250	27.0	4.0	**56.1**	10.8	**110.3**	40.4

Source: MPCB, 2013
N = No. of observations

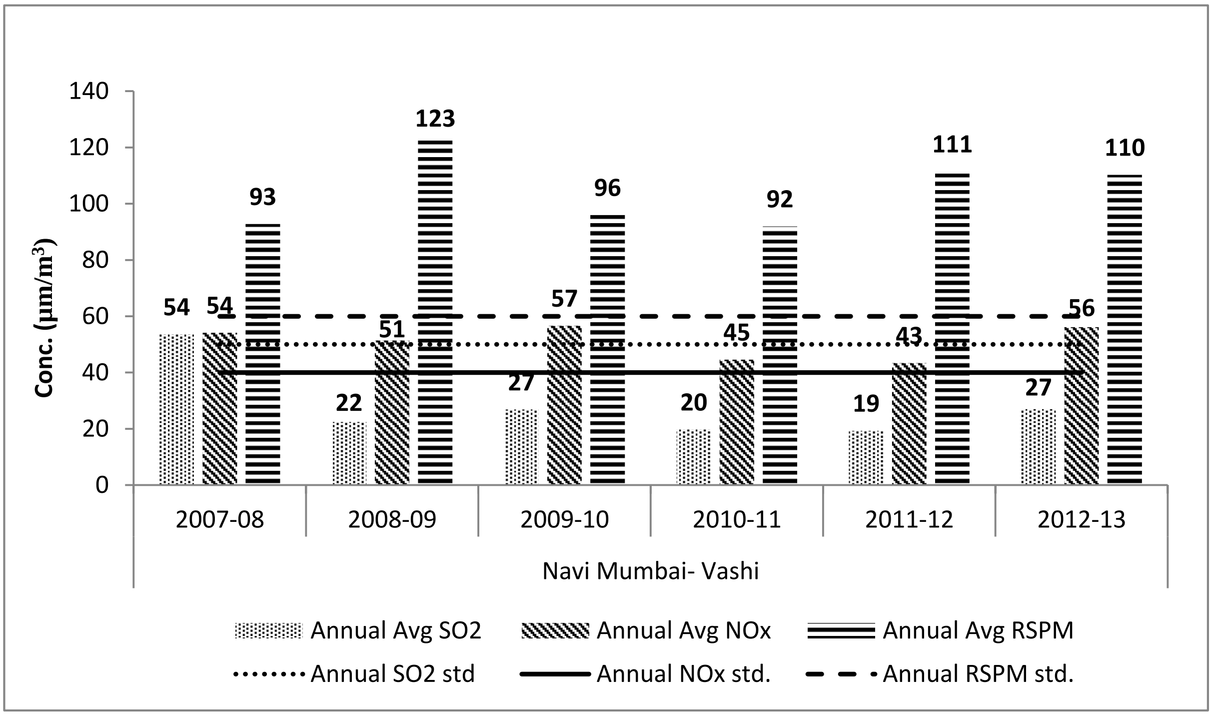


Figure 7: Annual trend in SO_2, NO_X and RSPM levels monitored at Vashi - Navi Mumbai under CAAQMS

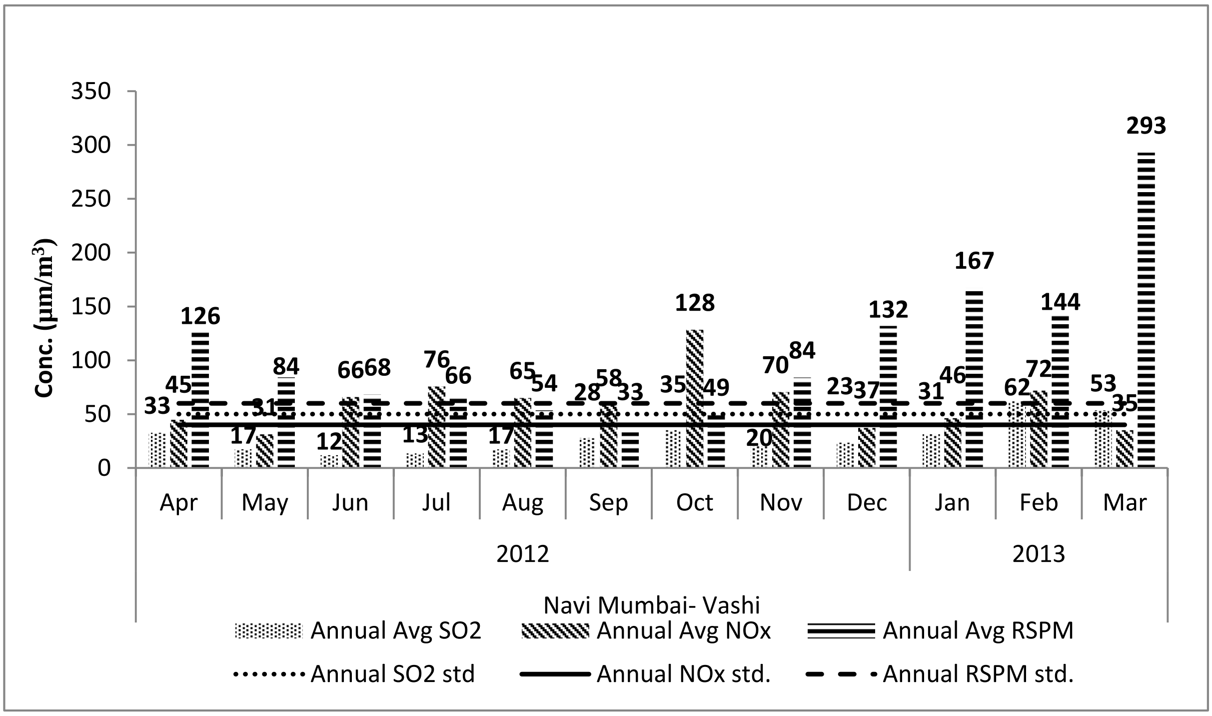


Figure 8: Monthly average readings recorded at Vashi - Navi Mumbai under CAAQMS (2012-13)

Table No. 14: Monthly average readings recorded at Vashi - Navi Mumbai under CAAQMS (2012-13)

FY 2012-13	N	SO_2		NO_X		RSPM	
		Avg. (µg/m³)	*% days of exceedence*	**Avg. (µg/m³)**	*% days of exceedence*	**Avg. (µg/m³)**	*% days of exceedence*
24 hrs. Standards		*80*		*80*		*100*	
Apr	27	32.7	Nil	44.8	3.7	125.9	81.5
May	24	17.4	8.3	31.2	Nil	84.1	8.3
Jun	25	11.8	Nil	65.9	12.0	68.2	Nil
Jul	25	13.5	Nil	75.7	24.0	65.7	Nil
Aug	23	17.3	Nil	65.0	4.3	53.5	Nil
Sep	19	27.7	Nil	58.4	5.3	32.9	Nil
Oct	7	35.1	Nil	128.3	85.7	49.4	14.3
Nov	19	20.2	Nil	70.4	10.5	84.1	15.8
Dec	23	23.5	Nil	37.1	Nil	131.9	78.3
Jan	23	31.3	Nil	46.2	Nil	167.4	100.0
Feb	15	61.8	33.3	71.9	40.0	144.0	80.0
Mar	20	53.5	15.0	35.1	5.0	292.9	100.0

Source: MPCB, 2013

N = No. of observations

National Ambient Air Quality Monitoring (NAMP) in MMR

Airoli Datta Meghe - Navi Mumbai Monitoring Station

Date of Commissioning: **April, 2006**	
Location Details	
Latitude: 19.147833	**Longitude**: 72.98725
Address: Dr.Datta Meghe College Of Engineering/ DAV School, Airoli	
Type: Commercial	**Program**: NAMP
Frequency of Monitoring: 2 Day in A week	
Implementing Agency: Karmaveer Bhaurao Patil College, Vashi	

Table No. 15: Readings recorded at Airoli Datta Meghe monitoring station - Navi Mumbai under NAMP

Year	**N**	**SO_2**		**NO_X**		**RSPM**	
		Avg. (µg/m³)	*% days of exceedence*	**Avg. (µg/m³)**	*% days of exceedence*	**Avg. (µg/m³)**	*% days of exceedence*
	Standards	*Annual*	*24 hrs*	*Annual*	*24 hrs*	*Annual*	*24 hrs*
		50	*80*	*40*	*80*	*60*	*100*
2007-08	101	12.3	Nil	27.0	Nil	**79.4**	28.7
2008-09	107	16.2	Nil	30.8	5.6	**93.6**	29.0
2009-10	103	13.1	Nil	36.2	Nil	**82.9**	27.2
2010-11	100	22.0	Nil	**43.2**	Nil	**125.5**	56.0
2011-12	97	18.1	Nil	**46.8**	1.0	**100.1**	38.1
2012-13	103	18.4	Nil	**46.0**	1.0	**71.4**	16.5

Source: MPCB, 2013
N = No. of observations

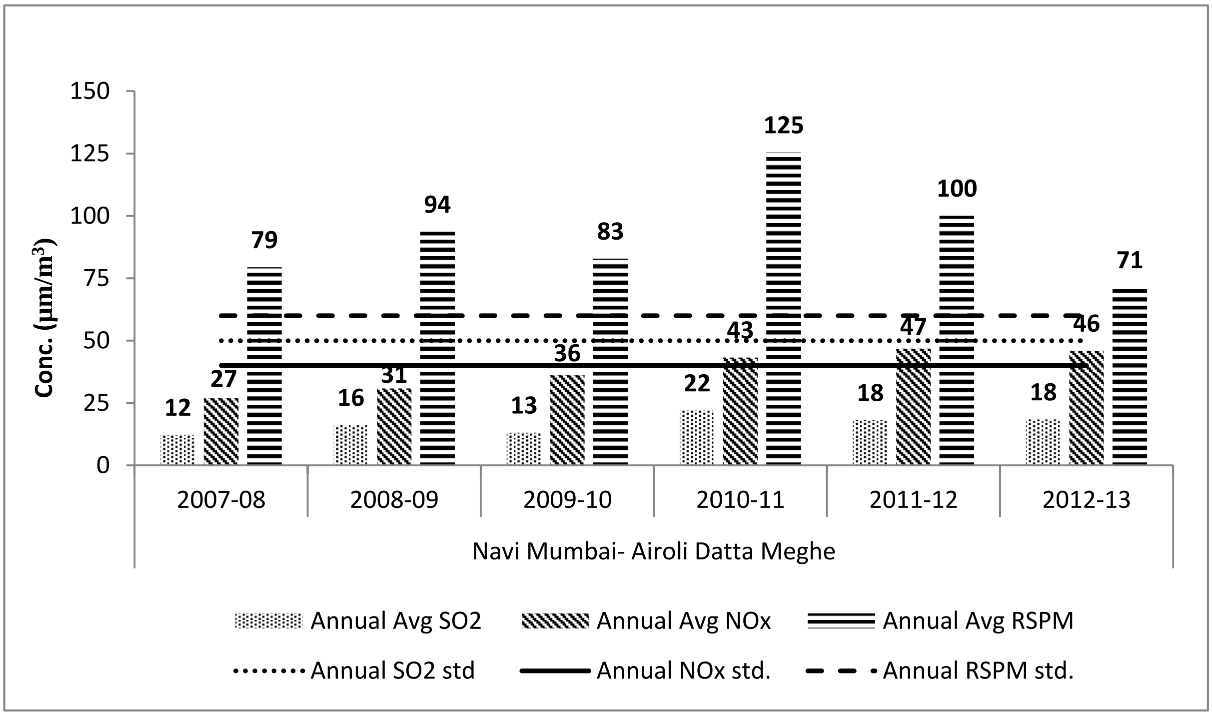


Figure 9: Annual trend in SO_2, NO_X and RSPM levels monitored at Airoli Datta Meghe - Navi Mumbai under NAMP

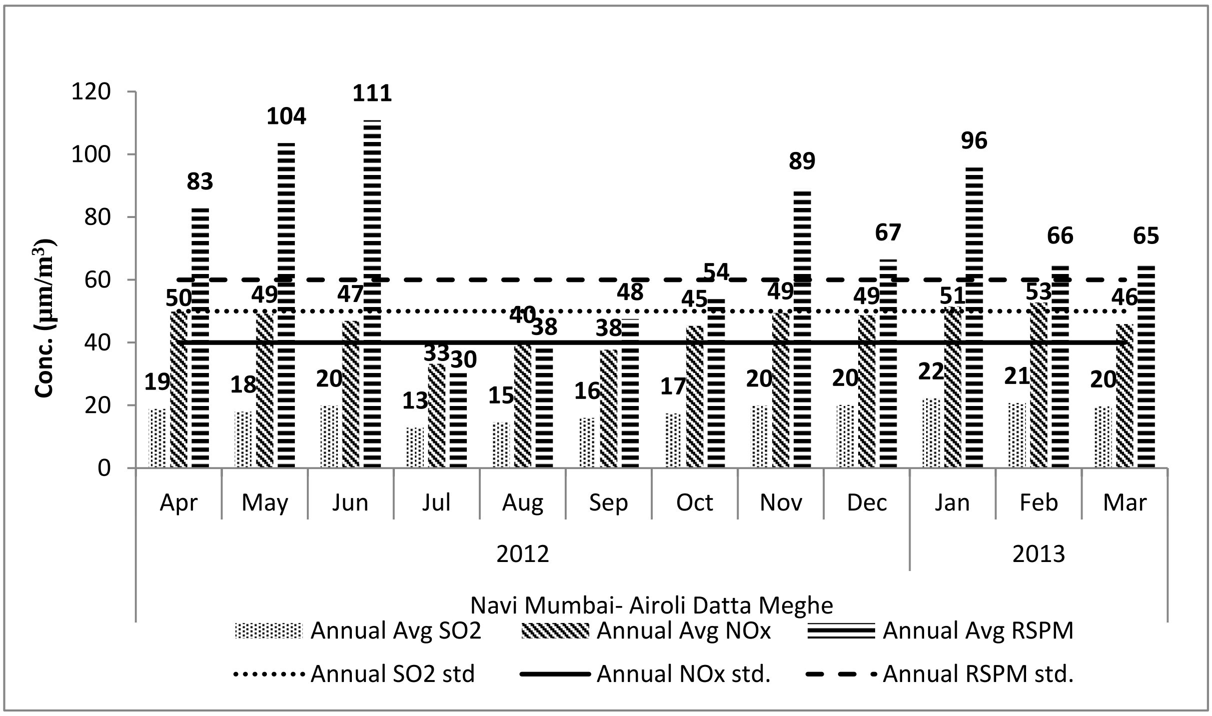


Figure 10: Monthly average readings recorded at Airoli Datta Meghe - Navi Mumbai under NAMP (2012-13)

Table No. 16: Monthly average readings recorded at Airoli Datta Meghe - Navi Mumbai under NAMP (2012-13)

FY 2012-13	N	SO_2		NO_X		RSPM	
		Avg. (µg/m³)	*% days of exceedence*	**Avg. (µg/m³)**	*% days of exceedence*	**Avg. (µg/m³)**	*% days of exceedence*
24 hrs. Standards		*80*		*80*		*100*	
Apr	8	18.9	Nil	49.9	Nil	82.8	25.0
May	9	18.0	Nil	49.2	Nil	103.6	66.7
Jun	9	19.9	Nil	46.9	Nil	110.9	11.1
Jul	8	12.9	Nil	33.3	Nil	30.3	Nil
Aug	9	14.6	Nil	40.2	Nil	38.1	Nil
Sep	8	16.0	Nil	37.8	Nil	47.5	Nil
Oct	9	17.4	Nil	45.3	Nil	53.9	Nil
Nov	9	19.9	Nil	49.4	11.1	89.2	22.2
Dec	8	20.1	Nil	48.8	Nil	66.5	12.5
Jan	9	22.2	Nil	51.4	Nil	95.8	33.3
Feb	8	20.8	Nil	52.8	Nil	65.5	12.5
Mar	9	19.7	Nil	45.9	Nil	65.4	11.1

Source: MPCB, 2013

N = No. of observations

Ambernath Monitoring Station

Date of Commissioning: **December 2005**	
Location Details	
Latitude: 19.211547	**Longitude**: 73.187592
Address: Municipal Council Building, Ambernath	
Type: Industrial	**Program**: NAMP
Frequency of Monitoring: Daily	
Implementing Agency: Maharashtra Pollution Control Board (MPCB)	

Table No. 17: Readings recorded at Ambernath monitoring station under NAMP

Year	**N**	**SO_2**		**NO_X**		**RSPM**	
		Avg. (µg/m³)	***% days of exceedence***	**Avg. (µg/m³)**	***% days of exceedence***	**Avg. (µg/m³)**	***% days of exceedence***
Standards		***Annual***	***24 Hrs***	***Annual***	***24 Hrs***	***Annual***	***24 Hrs***
		50	*80*	*40*	*80*	*60*	*100*
2007-08	101	31.3	*Nil*	**40.5**	*2.0*	**106.3**	*53.5*
2008-09	26	29.3	*Nil*	52.8	Nil	70.2	*11.5*
2012-13	92	42.5	*2.2*	**90.7**	*51.1*	**117.6**	*63.0*

Source: MPCB, 2013

N = No. of observations

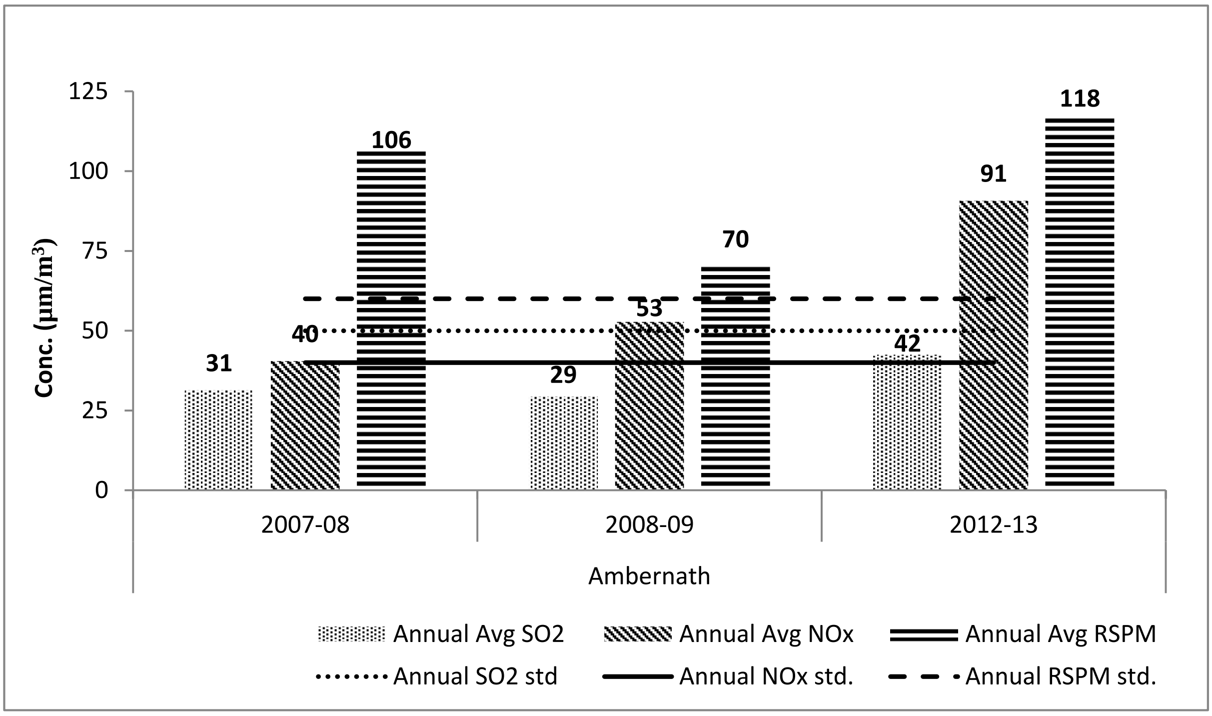


Figure 11: Annual trend in SO_2, NO_X and RSPM levels monitored at Ambernath under NAMP

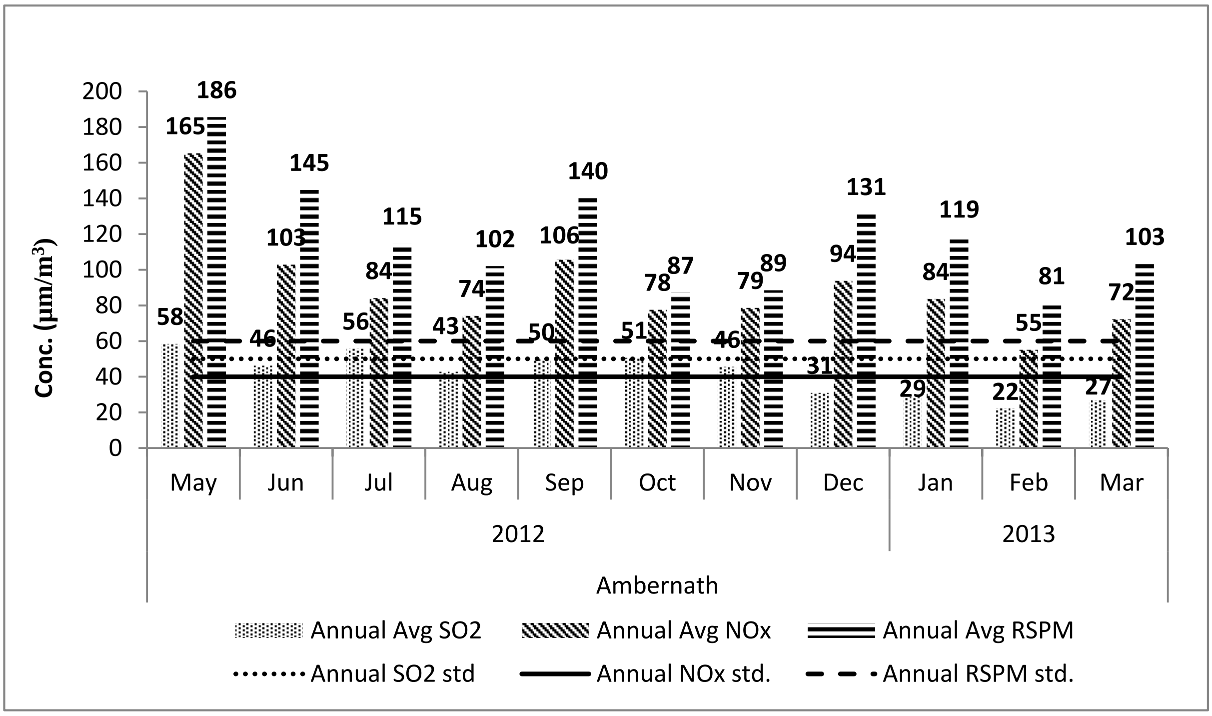


Figure 12: Monthly average readings recorded at Ambernath under NAMP (2012-13)

Table No. 18: Monthly average readings recorded at Ambernath under NAMP (2012-13)

FY 2012-13	N	SO_2		NO_X		RSPM	
		Avg. (µg/m³)	*% days of exceedence*	Avg. (µg/m³)	*% days of exceedence*	Avg. (µg/m³)	*% days of exceedence*
24 hrs. Standards		*80*		*80*		*100*	
May	9	58.4	*11.1*	165.3	*100.0*	185.6	*100.0*
Jun	8	46.3	*Nil*	102.9	*75.0*	144.8	*87.5*
Jul	9	55.8	*Nil*	84.1	*55.6*	114.7	*66.7*
Aug	9	42.8	*Nil*	74.1	*22.2*	102.0	*44.4*
Sep	8	49.8	*Nil*	105.6	*75.0*	140.1	*87.5*
Oct	9	50.7	*11.1*	77.6	*44.4*	87.1	*33.3*
Nov	10	45.6	*Nil*	78.6	*50.0*	88.5	*20.0*
Dec	9	31.0	*Nil*	93.8	*66.7*	131.2	*77.8*
Jan	5	28.6	*Nil*	83.6	*40.0*	118.6	*100.0*
Feb	8	22.4	*Nil*	55.1	*Nil*	81.3	*25.0*
Mar	8	26.9	*Nil*	72.3	*25.0*	103.3	*75.0*

Source: MPCB, 2013

N = No. of observations

Badlapur Monitoring Station

Date of Commissioning: **June 2005**	
Location Details	
Latitude: 19.156167	**Longitude**: 73.237783
Address: Badlapur- BIWA Office	
Type: Residential	**Program**: NAMP
Frequency of Monitoring: 2Day in A week	
Implementing Agency: C.H.M.College, Ulhasnagar	

Table No. 19: Readings recorded at Badlapur monitoring station under NAMP

Year	**N**	**SO_2**		**NO_X**		**RSPM**	
		Avg. (µg/m³)	***% days of exceedence***	**Avg. (µg/m³)**	***% days of exceedence***	**Avg. (µg/m³)**	***% days of exceedence***
	Standards	***Annual***	***24 hrs***	***Annual***	***24 hrs***	***Annual***	***24 hrs***
		50	*80*	*40*	*80*	*60*	*100*
2007-08	104	30.2	*Nil*	**41.5**	*Nil*	**93.1**	*24.0*
2008-09	102	35.0	*2.0*	**76.3**	*43.1*	**98.0**	*41.2*
2009-10	84	55.2	*17.9*	84.6	*53.6*	103.4	*60.7*
2010-11	94	35.6	*1.1*	**75.2**	*33.0*	**118.2**	*67.0*
2011-12	95	41.0	*10.5*	**67.9**	*46.3*	**120.9**	*69.5*
2012-13	93	41.0	*4.3*	**69.5**	*35.5*	**99.5**	*44.1*

Source: MPCB, 2013

N = No. of observations

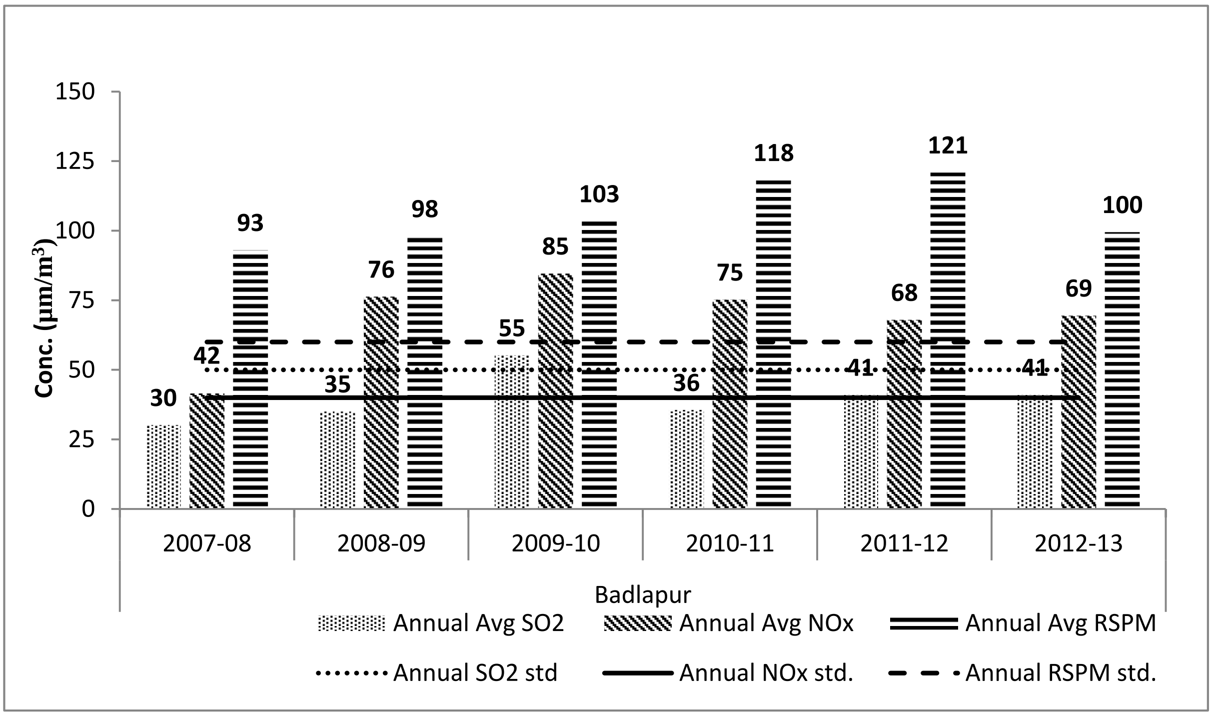


Figure 13: Annual trend in SO_2, NO_X and RSPM levels monitored at Badlapur monitoring station under NAMP

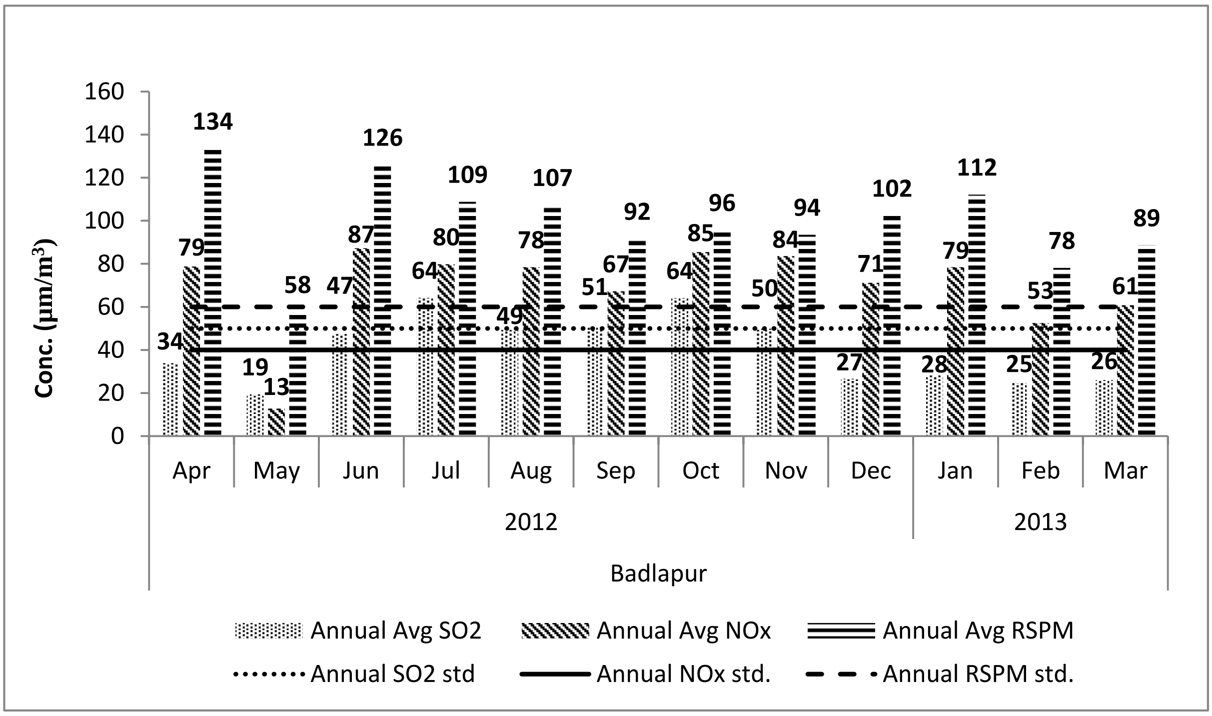


Figure 14: Monthly average readings recorded at Badlapur monitoring station under NAMP (2012-13)

Table No. 20: Monthly average readings recorded at Badlapur monitoring station under NAMP (2012-13)

FY 2012-13	N	SO_2		NO_X		RSPM	
		Avg. (µg/m³)	*% days of exceedence*	**Avg. (µg/m³)**	*% days of exceedence*	**Avg. (µg/m³)**	*% days of exceedence*
24 hrs. Standards		*80*		*80*		*100*	
Apr	8	33.9	*Nil*	78.8	*50.0*	133.5	*100.0*
May	8	19.4	*Nil*	12.8	*Nil*	57.6	*Nil*
Jun	8	47.4	*Nil*	87.3	*50.0*	126.0	*100.0*
Jul	9	64.2	*11.1*	79.8	*55.6*	108.8	*55.6*
Aug	9	49.4	*Nil*	78.4	*33.3*	107.3	*55.6*
Sep	8	50.5	*Nil*	67.3	*25.0*	91.6	*25.0*
Oct	7	64.1	*42.9*	85.4	*57.1*	95.7	*42.9*
Nov	8	49.9	*Nil*	83.6	*50.0*	93.5	*25.0*
Dec	6	26.7	*Nil*	71.2	*50.0*	102.3	*50.0*
Jan	6	28.2	*Nil*	78.5	*50.0*	112.2	*50.0*
Feb	8	24.6	*Nil*	52.5	*12.5*	78.1	*12.5*
Mar	8	26.0	*Nil*	60.8	*Nil*	88.6	*12.5*

Source: MPCB, 2013
N = No. of observations

Balkum/Kolshet - Thane Monitoring Station

Date of Commissioning: **July 2005**	
Location Details	
Latitude: 19.23345	**Longitude**: 72.988333
Address: M/S Clariant (Chemical Unit), Kolshet, Thane	
Type: Industrial	**Program**: NAMP
Frequency of Monitoring: 1Day in A week	
Implementing Agency: Thane Municipal Corporation	

Table No. 21: Readings recorded at Balkum/Kolshet monitoring station under NAMP

Year	**N**	**SO_2**		**NO_X**		**RSPM**	
		Avg. (µg/m³)	***% days of exceedence***	**Avg. (µg/m³)**	***% days of exceedence***	**Avg. (µg/m³)**	***% days of exceedence***
	Standards	***Annual***	***24 hrs***	***Annual***	***24 hrs***	***Annual***	***24 hrs***
		50	*80*	*40*	*80*	*60*	*100*
2007-08	96	13.8	Nil	14.1	Nil	53.3	Nil
2008-09	94	14.8	Nil	20.9	Nil	**62.9**	Nil
2009-10	80	13.3	Nil	20.8	Nil	57.2	Nil
2010-11	21	12.0	Nil	13.1	Nil	48.5	Nil
2011-12	45	19.3	Nil	12.8	Nil	57.5	Nil
2012-13	97	18.1	Nil	13.5	Nil	**72.9**	20.6

Source: MPCB, 2013

N = No. of observations

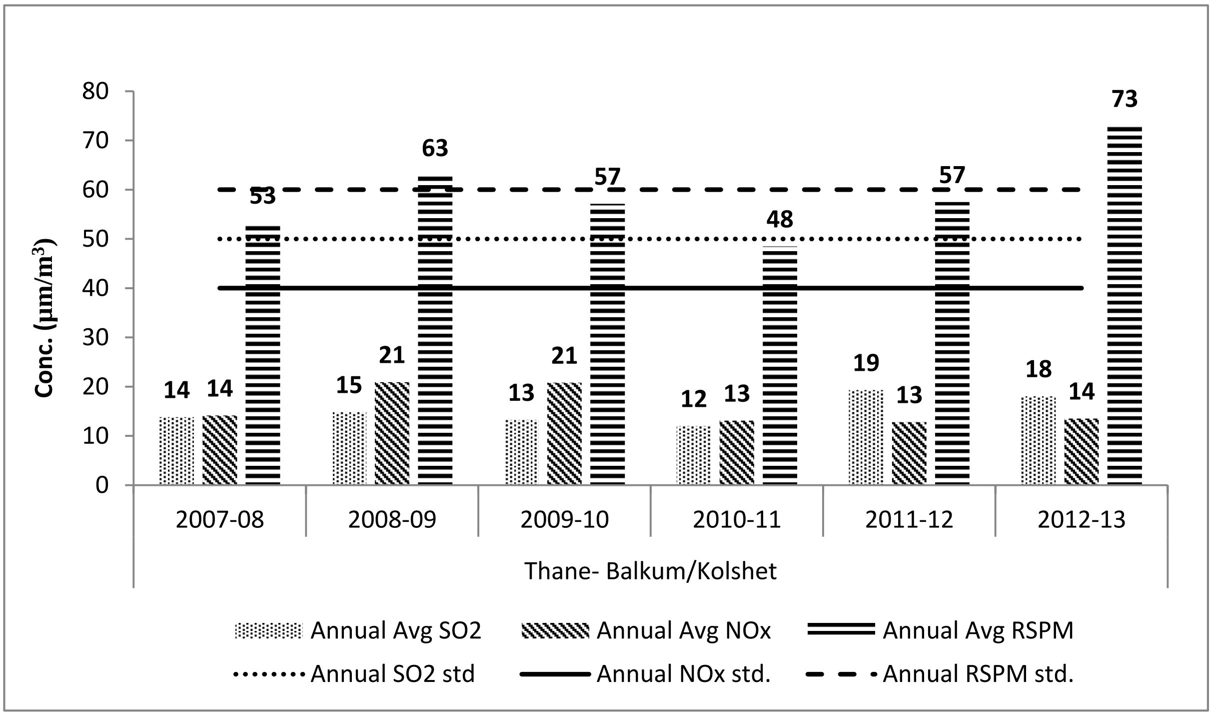


Figure 15: Annual trend in SO_2, NO_X and RSPM levels monitored at Balkum/Kolshet monitoring station under NAMP

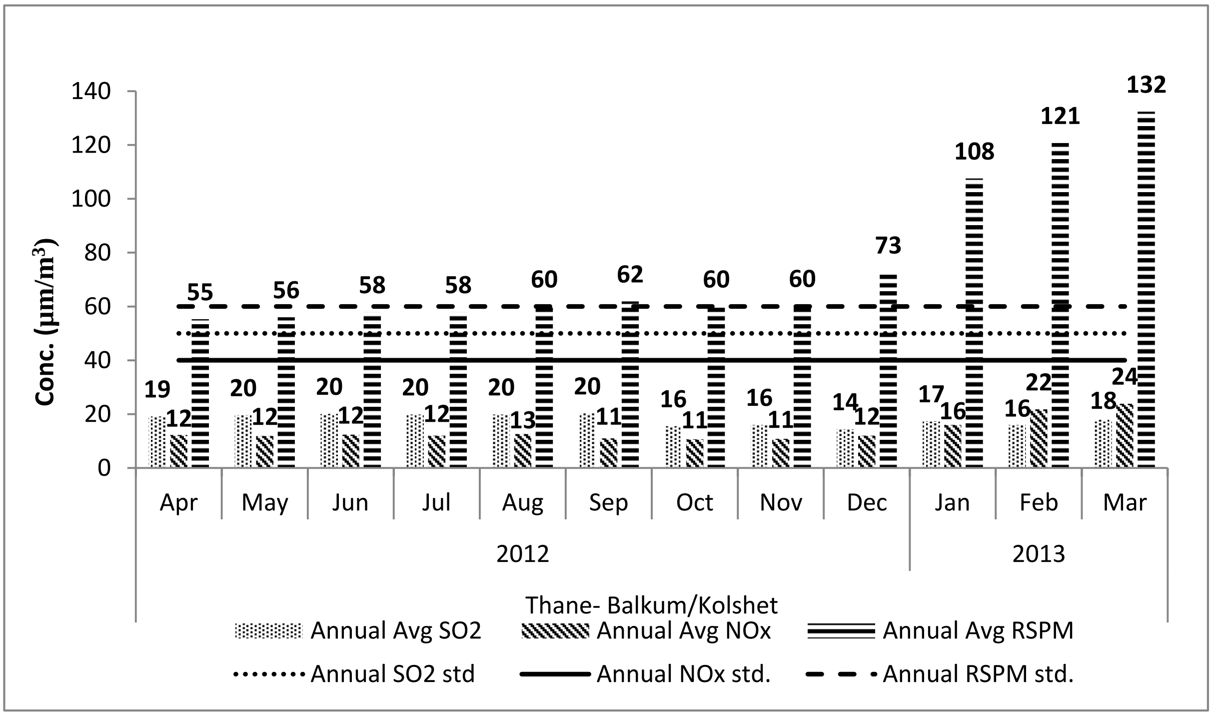


Figure 16: Monthly average readings recorded at Balkum/Kolshet monitoring station under NAMP (2012-13)

Table No. 22: Monthly average readings recorded at Balkum/Kolshet monitoring station under NAMP (2012-13)

FY 2012-13	N	SO_2		NO_X		RSPM	
		Avg. (µg/m³)	*% days of exceedence*	Avg. (µg/m³)	*% days of exceedence*	Avg. (µg/m³)	*% days of exceedence*
24 hrs. Standards		*80*		*80*		*100*	
Apr	8	19.1	Nil	12.3	Nil	55.3	Nil
May	10	19.6	Nil	11.9	Nil	56.0	Nil
Jun	8	20.1	Nil	12.4	Nil	57.9	Nil
Jul	8	19.9	Nil	12.0	Nil	57.9	Nil
Aug	8	19.9	Nil	12.6	Nil	60.0	Nil
Sep	8	20.3	Nil	11.0	Nil	61.9	Nil
Oct	8	15.5	Nil	10.6	Nil	60.0	Nil
Nov	10	16.0	Nil	10.8	Nil	60.2	Nil
Dec	8	14.4	Nil	12.0	Nil	72.6	Nil
Jan	9	17.3	Nil	16.0	Nil	107.6	88.9
Feb	4	16.0	Nil	21.8	Nil	120.8	100.0
Mar	8	17.9	Nil	23.9	Nil	132.4	100.0

Source: MPCB, 2013
N = No. of observations

Dombivali - Phase II MIDC Monitoring Station

Date of Commissioning: **May 2012**	
Location Details	
Latitude: 19.214733	**Longitude**: 73.105629
Address: Phase-II C.E.T.P, MIDC, Dombivali	
Type: Industrial	**Program**: SAMP
Frequency of Monitoring: 2 Day in A week	

Table No. 23: Readings recorded at Dombivali monitoring station - Phase II MIDC under NAMP

Year	N	SO_2		NO_X		RSPM		SPM
		Avg. (µg/m³)	% days of exceedence	Avg. (µg/m³)	% days of exceedence	Avg. (µg/m³)	% days of exceedence	Avg. (µg/m³)
Standards		Annual	24 hrs	Annual	24 hrs	Annual	24 hrs	Annual
		50	80	40	80	60	100	-
2007-08	96	37.5	Nil	40.7	1.0	98.3	37.5	NA
2008-09	25	34.5	Nil	55.0	Nil	67.8	20.0	NA
2012-13	92	49.7	6.5	94.4	56.5	123.0	62.0	147.7

Source: MPCB, 2013

N = No. of observations

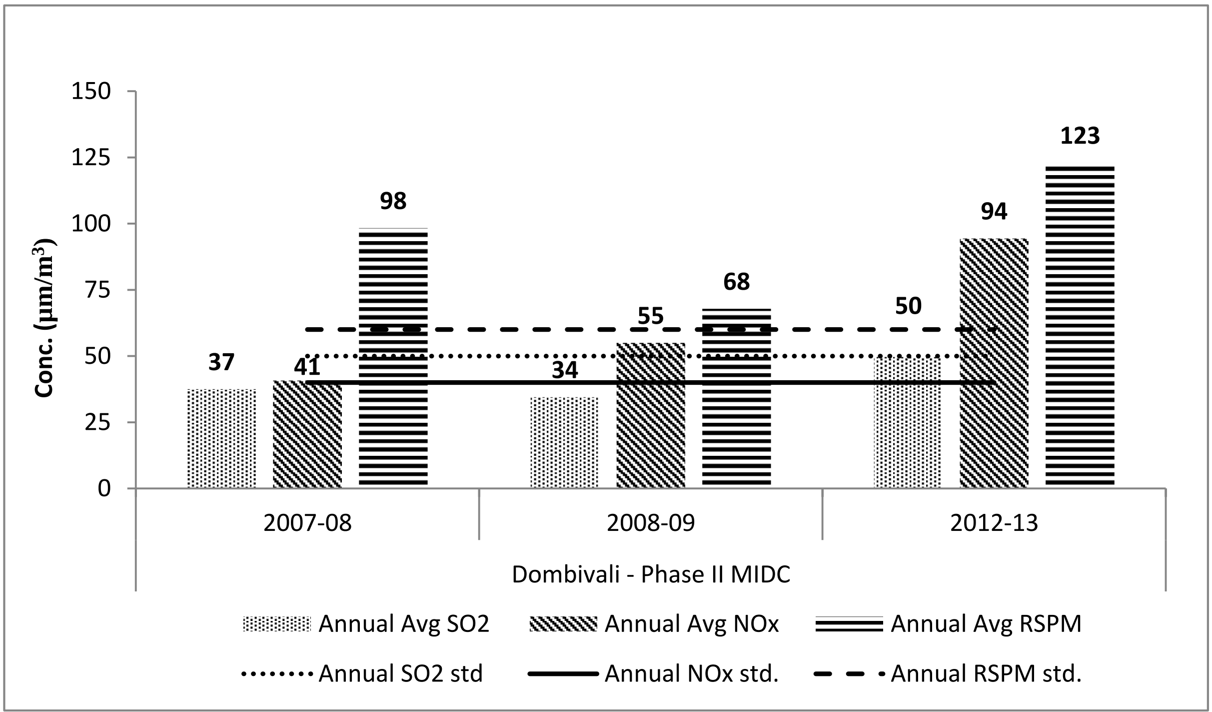


Figure 17: Annual trend in SO_2, NO_X and RSPM levels monitored at Dombivali monitoring station - Phase II MIDC under NAMP

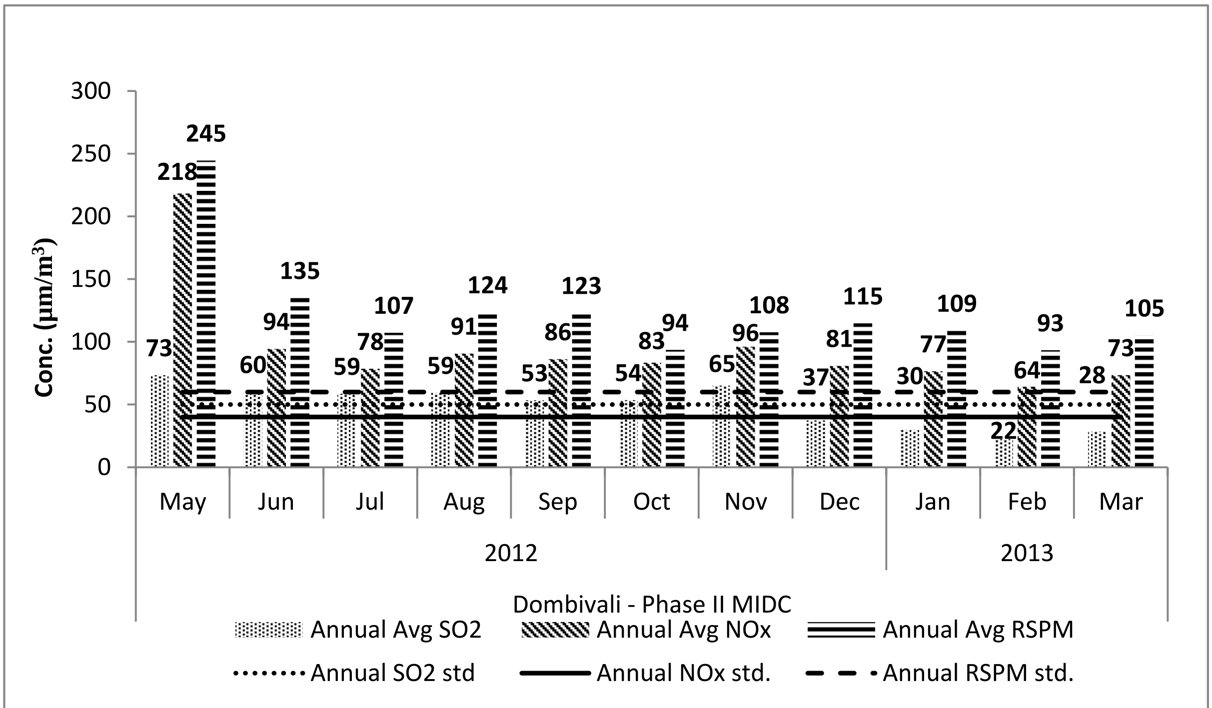


Figure 18: Monthly average readings recorded at Dombivali monitoring station - Phase II MIDC under NAMP (2012-13)

Table No. 24: Monthly average readings recorded at Dombivali monitoring station - Phase II MIDC under NAMP (2012-13)

FY 2012-13	N	SO_2		NO_X		RSPM	
		Avg. (µg/m³)	*% days of exceedence*	**Avg. (µg/m³)**	*% days of exceedence*	**Avg. (µg/m³)**	*% days of exceedence*
24 hrs. Standards		*80*		*80*		*100*	
May	8	73.4	12.5	218.3	100.0	244.5	100.0
Jun	9	60.0	11.1	94.3	66.7	135.0	66.7
Jul	9	58.6	11.1	78.4	55.6	107.2	66.7
Aug	9	59.3	11.1	90.6	66.7	123.6	77.8
Sep	8	53.4	Nil	86.1	62.5	123.0	75.0
Oct	9	53.6	11.1	83.3	55.6	93.6	22.2
Nov	8	65.1	12.5	96.1	75.0	107.6	62.5
Dec	9	37.3	Nil	80.8	44.4	114.7	44.4
Jan	6	29.8	Nil	76.5	33.3	108.8	83.3
Feb	8	22.4	Nil	64.3	12.5	93.3	25.0

Source: MPCB, 2013

N = No. of observations

Kalbadevi - Monitoring Station

Date of Commissioning: **-December 2005**	
Location Details	
Latitude: 18.945707	**Longitude**: 72.8293884
Address: Bank of India, Kalbadevi Branch, Mumbai	
Type: Residential	**Program**: NAMP
Frequency of Monitoring: 2 Day in A week	
Implementing Agency: National Environmental Engineering Research Institute (NEERI)	

Table No. 25: Readings recorded at Kalbadevi monitoring station under NAMP

Year	**N**	**SO_2**		**NO_X**		**RSPM**	
		Avg. (µg/m³)	**% days of exceedence**	**Avg. (µg/m³)**	**% days of exceedence**	**Avg. (µg/m³)**	**% days of exceedence**
Standards		**Annual**	**24 hrs**	**Annual**	**24 hrs**	**Annual**	**24 hrs**
		50	80	40	80	60	100
2008-09	25	11	NA	62	NA	124	NA
2009-10	77	5	NA	34	NA	**92**	NA
2010-11	94	4	NA	22	NA	**85**	NA
2011-12	93	5	NA	28	NA	**91**	NA
2012-13	87	4	NA	16	NA	**132**	NA

Source: NEERI-Mumbai, 2013
N = No. of observations

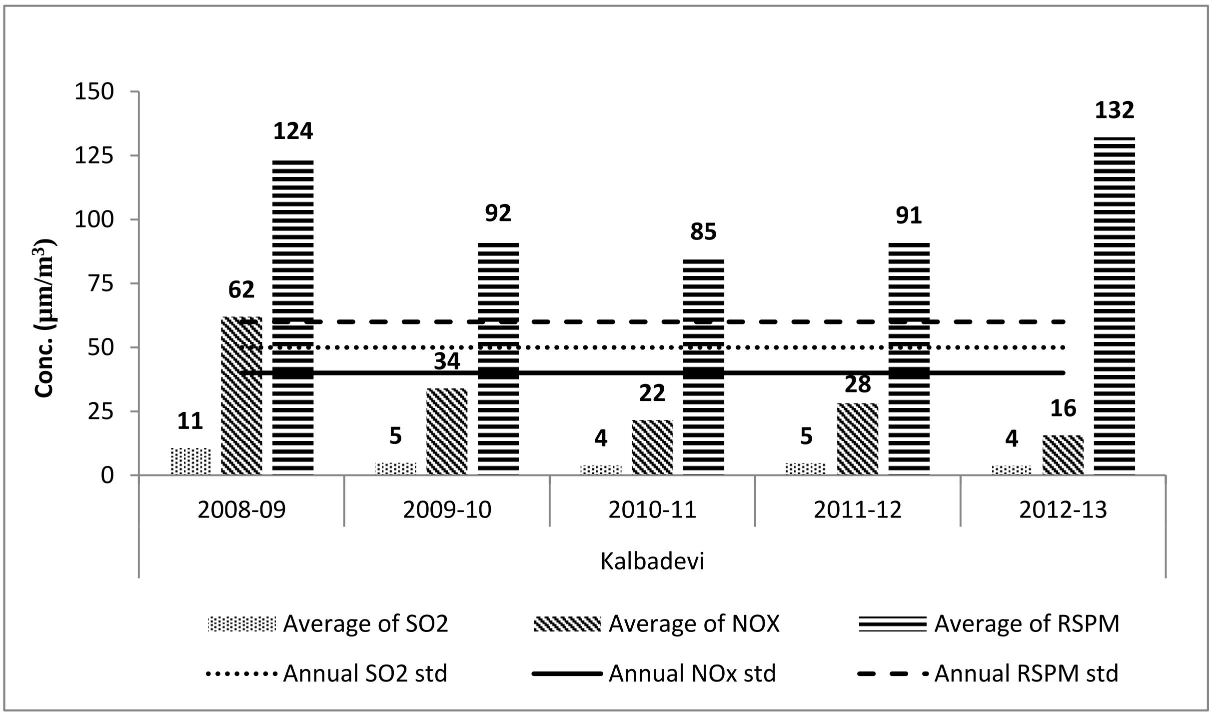


Figure 19: Annual trend in SO_2, NO_X and RSPM levels monitored at Kalbadevi monitoring station under NAMP

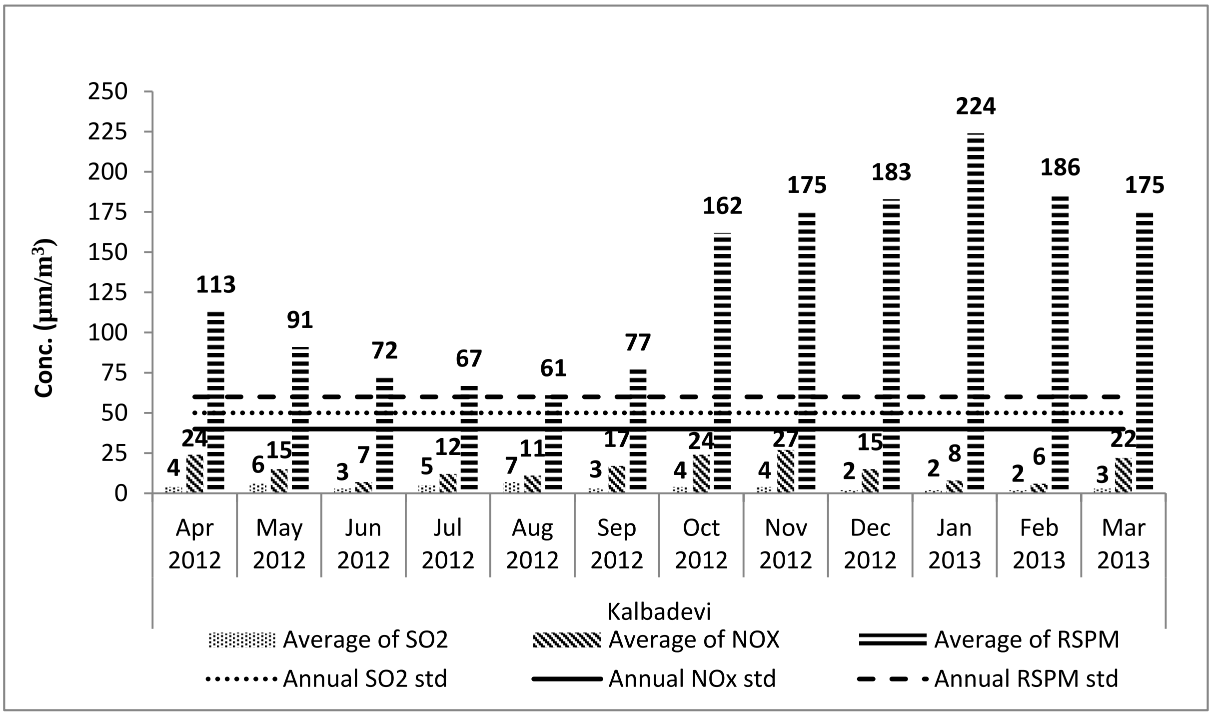


Figure 20: Monthly average readings recorded at Kalbadevi monitoring station under NAMP AMP (2012-13)

Table No. 26: Monthly average readings recorded at Kalbadevi monitoring station under NAMP (2012-13)

FY 2012-13	N	SO_2		NO_X		RSPM	
		Avg. (µg/m³)	*% days of exceedence*	**Avg. (µg/m³)**	*% days of exceedence*	**Avg. (µg/m³)**	*% days of exceedence*
24 hrs. Standards		*80*		*80*		*100*	
Apr	6	4	NA	24	NA	113	NA
May	8	6	NA	15	NA	91	NA
Jun	8	3	NA	7	NA	72	NA
Jul	8	5	NA	12	NA	67	NA
Aug	6	7	NA	11	NA	61	NA
Sep	6	3	NA	17	NA	77	NA
Oct	7	4	NA	24	NA	162	NA
Nov	7	4	NA	27	NA	175	NA
Dec	8	2	NA	15	NA	183	NA
Jan	8	2	NA	8	NA	224	NA
Feb	7	2	NA	6	NA	186	NA
Mar	8	3	NA	22	NA	175	NA

Source: NEERI-Mumbai, 2013
N = No. of observations

Kharghar - Navi Mumbai Monitoring Station

Date of Commissioning**: April 2006**	
Location Details	
Latitude: 19.0415	**Longitude**: 73.069933
Address: Nimisha Hospital Building / CIDCO Nodal Office, Kharghar	
Type: Residential	**Program**: NAMP
Frequency of Monitoring: 2 Day in A week	
Implementing Agency: Karmaveer Bhaurao Patil College, Vashi	

Table No. 27: Readings recorded at Kharghar monitoring station - Navi Mumbai under NAMP

Year	**N**	**SO_2**		**NO_X**		**RSPM**	
		Avg. (µg/m³)	***% days of exceedence***	**Avg. (µg/m³)**	***% days of exceedence***	**Avg. (µg/m³)**	***% days of exceedence***
	Standards	***Annual***	***24 hrs***	***Annual***	***24 hrs***	***Annual***	***24 hrs***
		50	*80*	*40*	*80*	*60*	*100*
2007-08	94	9.8	Nil	30.8	Nil	**108.3**	44.7
2008-09	94	13.1	1.1	39.9	4.3	**115.4**	47.9
2009-10	111	9.7	Nil	34.9	Nil	**75.3**	26.1
2010-11	105	16.6	Nil	36.5	Nil	**122.0**	52.4
2011-12	95	16.0	Nil	**43.1**	Nil	**122.3**	61.1
2012-13	102	15.8	Nil	**41.0**	Nil	**121.9**	55.9

Source: MPCB, 2013
N = No. of observations

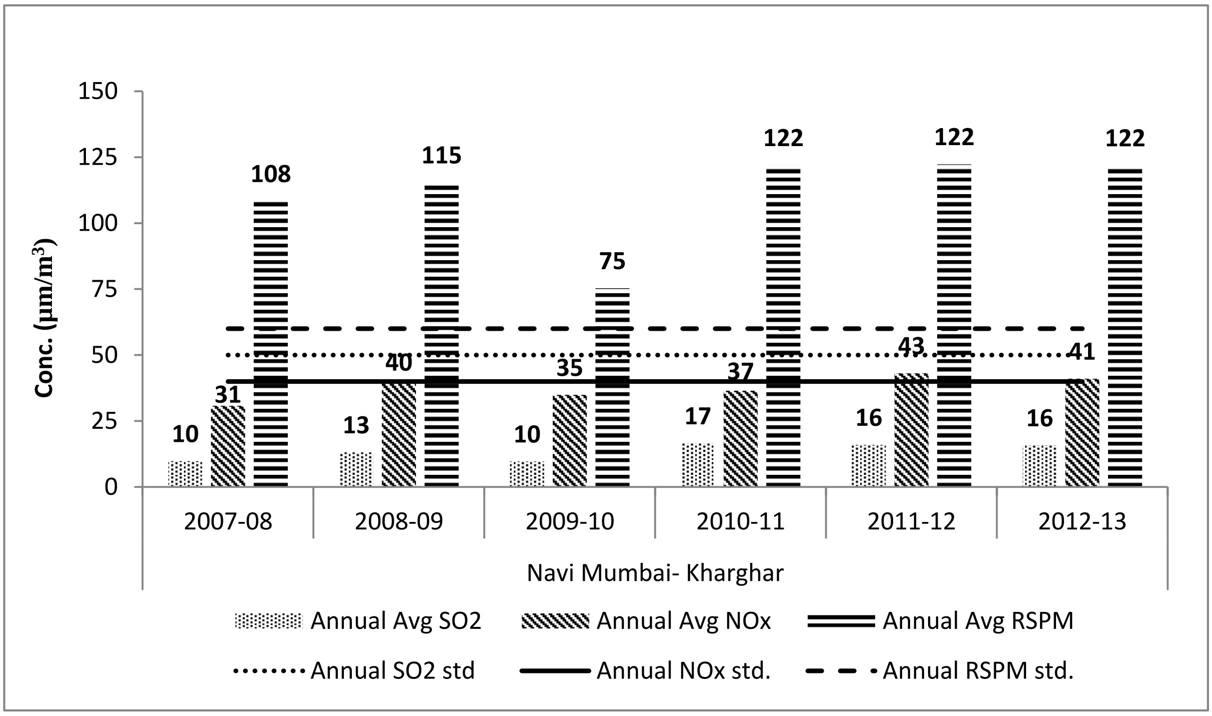


Figure 21: Annual trend in SO_2, NO_X and RSPM levels monitored at Kharghar monitoring station - Navi Mumbai under NAMP

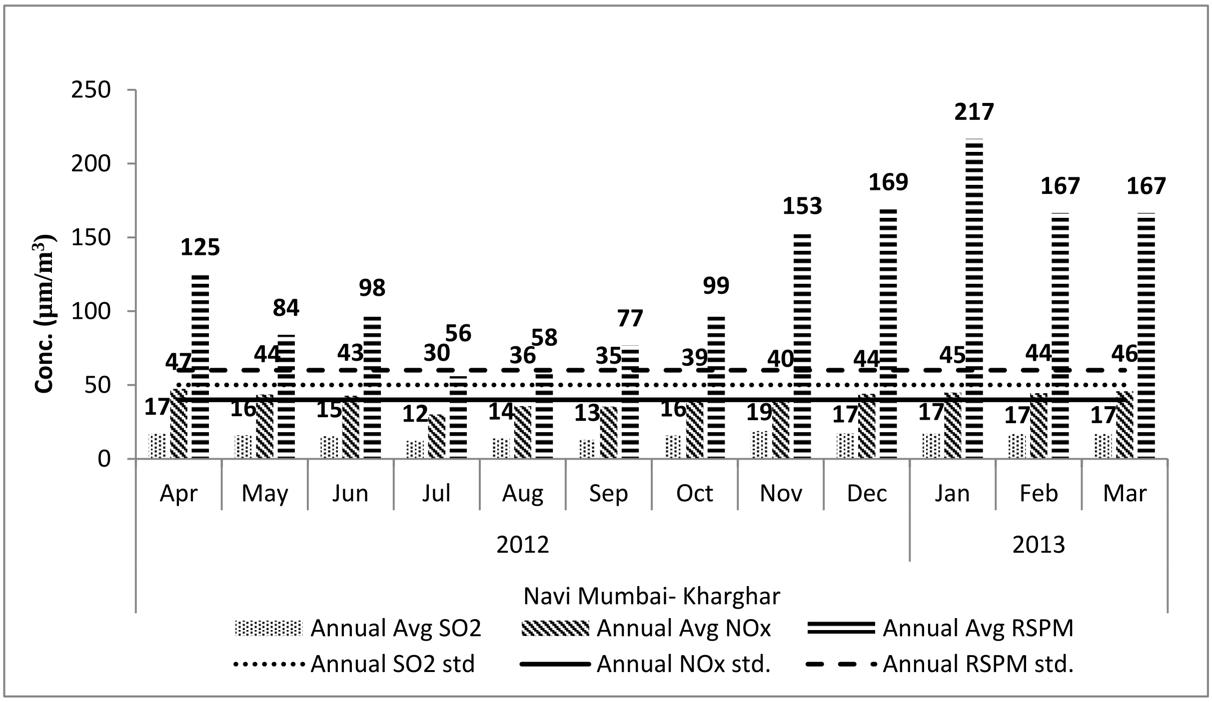


Figure 22: Monthly average readings recorded at Kharghar monitoring station - Navi Mumbai under NAMP (2012-13)

Table No. 28: Monthly average readings recorded at Kharghar monitoring station - Navi Mumbai under NAMP (2012-13)

FY 2012-13	N	SO_2		NO_X		RSPM	
		Avg. (µg/m³)	*% days of exceedence*	Avg. (µg/m³)	*% days of exceedence*	Avg. (µg/m³)	*% days of exceedence*
24 hrs. Standards		*80*		*80*		*100*	
Apr	8	17.0	Nil	47.4	Nil	125.1	62.5
May	8	16.0	Nil	43.6	Nil	84.0	50.0
Jun	9	15.3	Nil	42.8	Nil	97.6	44.4
Jul	9	12.2	Nil	30.1	Nil	56.0	Nil
Aug	9	13.8	Nil	35.7	Nil	58.4	11.1
Sep	8	12.9	Nil	35.4	Nil	76.9	12.5
Oct	9	15.9	Nil	39.4	Nil	99.0	33.3
Nov	9	18.8	Nil	40.4	Nil	153.0	77.8
Dec	8	17.3	Nil	44.0	Nil	169.1	100.0
Jan	9	17.1	Nil	44.9	Nil	216.8	100.0
Feb	7	16.7	Nil	44.4	Nil	166.6	100.0
Mar	9	16.8	Nil	45.8	Nil	166.6	88.9

Source: MPCB, 2013

N = No. of observations

Kopri - Thane Monitoring Station

Date of Commissioning: **February 2006**	
Location Details	
Latitude: 19.182033	**Longitude**: 72.971417
Address: Old T.M.C. Maternity Hospital, Kopri, Thane	
Type: Residential	**Program**: NAMP
Frequency of Monitoring: 2 Day in A week	
Implementing Agency: Thane Municipal Corporation	

Table No. 29: Readings recorded at Kopri monitoring station under NAMP

Year	**N**	**SO_2**		**NO_X**		**RSPM**		**SPM**
		Avg. (µg/m³)	***% days of exceedence***	**Avg. (µg/m³)**	***% days of exceedence***	**Avg. (µg/m³)**	***% days of exceedence***	**Avg. (µg/m³)**
	Standards	***Annual***	***24 hrs***	***Annual***	***24 hrs***	***Annual***	***24 hrs***	***Annual***
		50	*80*	*40*	*80*	*60*	*100*	*-*
2007-08	111	11.1	Nil	10.8	Nil	50.3	Nil	151.8
2008-09	103	11.4	Nil	16.3	Nil	59.5	Nil	118.9
2009-10	97	10.6	Nil	12.8	Nil	49.9	Nil	79.4
2010-11	117	11.6	Nil	12.2	Nil	46.2	Nil	70.9
2011-12	123	12.4	Nil	11.0	Nil	59.6	4.9	83.0
2012-13	110	20.2	Nil	15.2	Nil	85.8	25.5	92.4

Source: MPCB, 2013
N = No. of observations

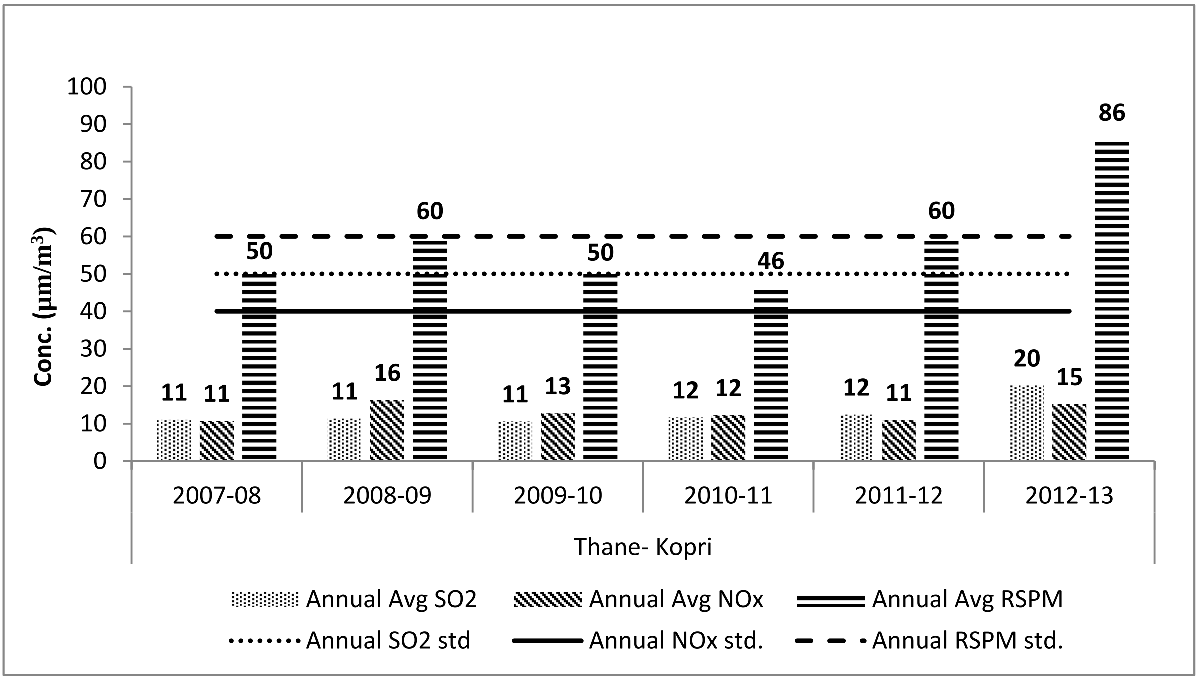


Figure 23: Annual trend in SO_2, NO_X and RSPM levels monitored at Kopri monitoring station under NAMP

Table No. 30: Monthly average readings recorded at Kopri monitoring station under NAMP (2012-13)

FY 2012-13	N	SO_2		NO_X		RSPM		SPM
		Avg. (µg/m³)	*% days of exceedence*	**Avg. (µg/m³)**	*% days of exceedence*	**Avg. (µg/m³)**	*% days of exceedence*	**Avg. (µg/m³)**
	24 hrs. Standards	*80*		*80*		*100*		
Apr	8	19.3	Nil	12.6	Nil	55.3	Nil	77.3
May	8	19.4	Nil	12.8	Nil	57.6	Nil	78.0
Jun	9	19.2	Nil	12.2	Nil	59.2	Nil	83.3
Jul	8	19.6	Nil	12.4	Nil	58.8	Nil	82.8
Aug	10	19.7	Nil	11.8	Nil	60.5	Nil	85.5
Sep	8	20.3	Nil	11.6	Nil	62.0	Nil	86.8
Oct	17	18.2	Nil	11.3	Nil	62.4	Nil	84.1
Nov	8	20.5	Nil	11.5	Nil	69.3	Nil	96.1

FY	N	SO_2		NO_X		RSPM		SPM
Dec	8	21.9	Nil	12.6	Nil	92.6	2	117.3
Jan	8	22.0	Nil	18.3	Nil	137.9	8	145.0
Feb	6	21.8	Nil	25.3	Nil	157.5	6	NA
Mar	12	22.3	Nil	30.4	Nil	169.3	12	NA

Source: MPCB, 2013
N = No. of observations

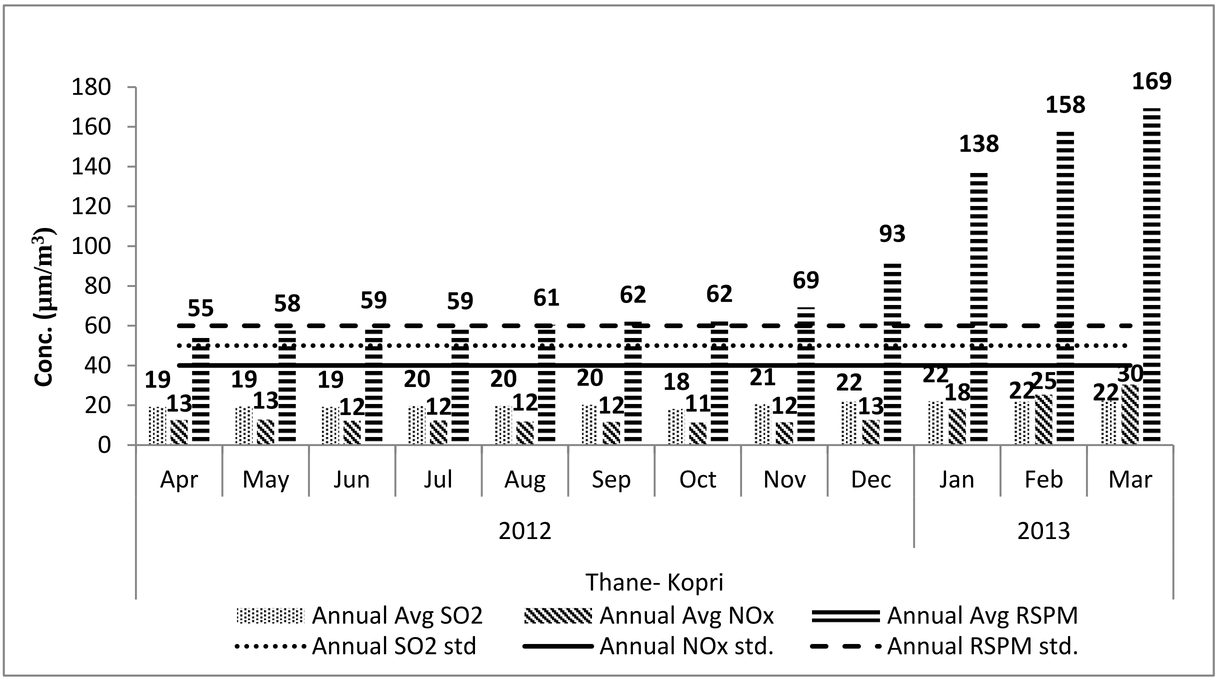


Figure 24: Monthly average readings recorded at Kopri monitoring station under NAMP (2012-13)

Mahape - Navi Mumbai Monitoring Station

Date of Commissioning: **April 2006**	
Location Details	
Latitude: 19.1136	**Longitude**: 73.01115
Address: MPCB Central Lab, Nirmal Bhavan, Mahape	
Type: Industrial	**Program**: NAMP
Frequency of Monitoring: 2 Day in A week	
Implementing Agency: Karmaveer Bhaurao Patil College, Vashi	

Table No. 31: Readings recorded at Mahape monitoring station - Navi Mumbai under NAMP

Year	**N**	**SO_2**		**NO_X**		**RSPM**	
		Avg. (µg/m³)	***% days of exceedence***	**Avg. (µg/m³)**	***% days of exceedence***	**Avg. (µg/m³)**	***% days of exceedence***
	Standards	*Annual*	*24 hrs*	*Annual*	*24 hrs*	*Annual*	*24 hrs*
		50	*80*	*40*	*80*	*60*	*100*
2007-08	98	17.5	Nil	31.6	3.1	**93.7**	37.8
2008-09	88	21.9	2.3	43.5	9.1	**131.1**	56.8
2009-10	105	15.3	Nil	**42.3**	Nil	**94.9**	45.7
2010-11	90	22.0	Nil	**41.2**	Nil	**100.5**	41.1
2011-12	69	17.1	Nil	43.9	Nil	**132.8**	63.8
2012-13	117	17.7	Nil	**44.9**	1.7	**121.3**	53.0

Source: MPCB, 2013
N = No. of observations

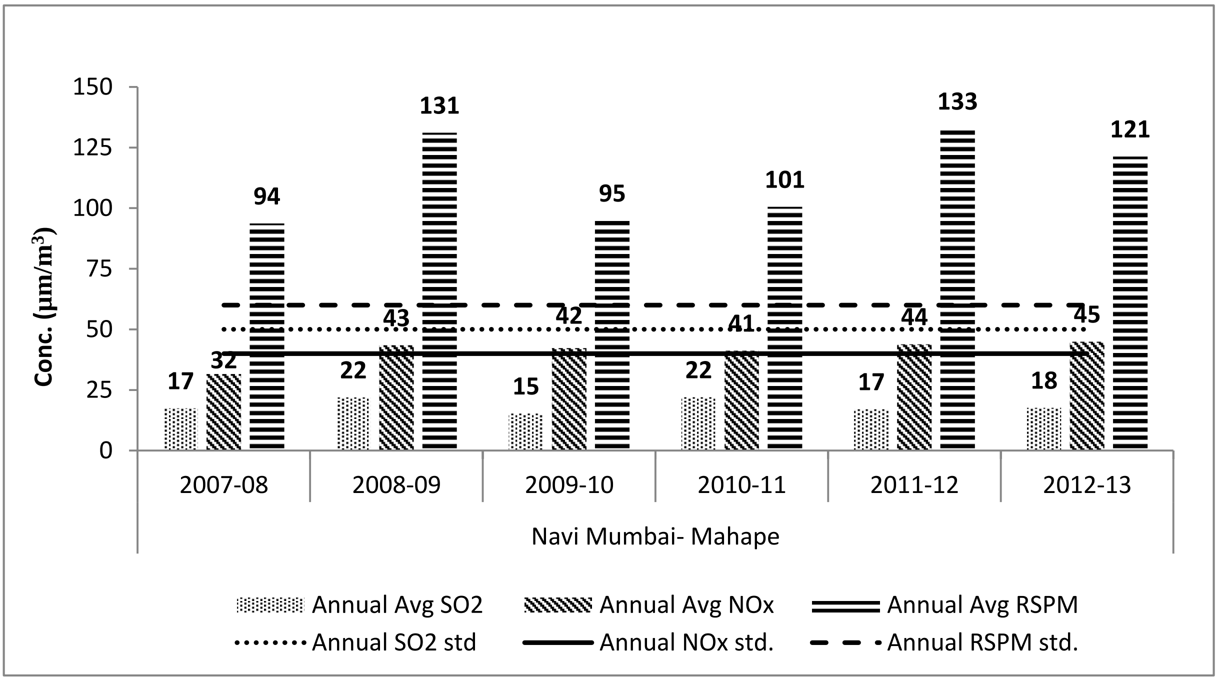


Figure 25: Annual trend in SO_2, NO_X and RSPM levels monitored at Mahape monitoring station - Navi Mumbai under NAMP

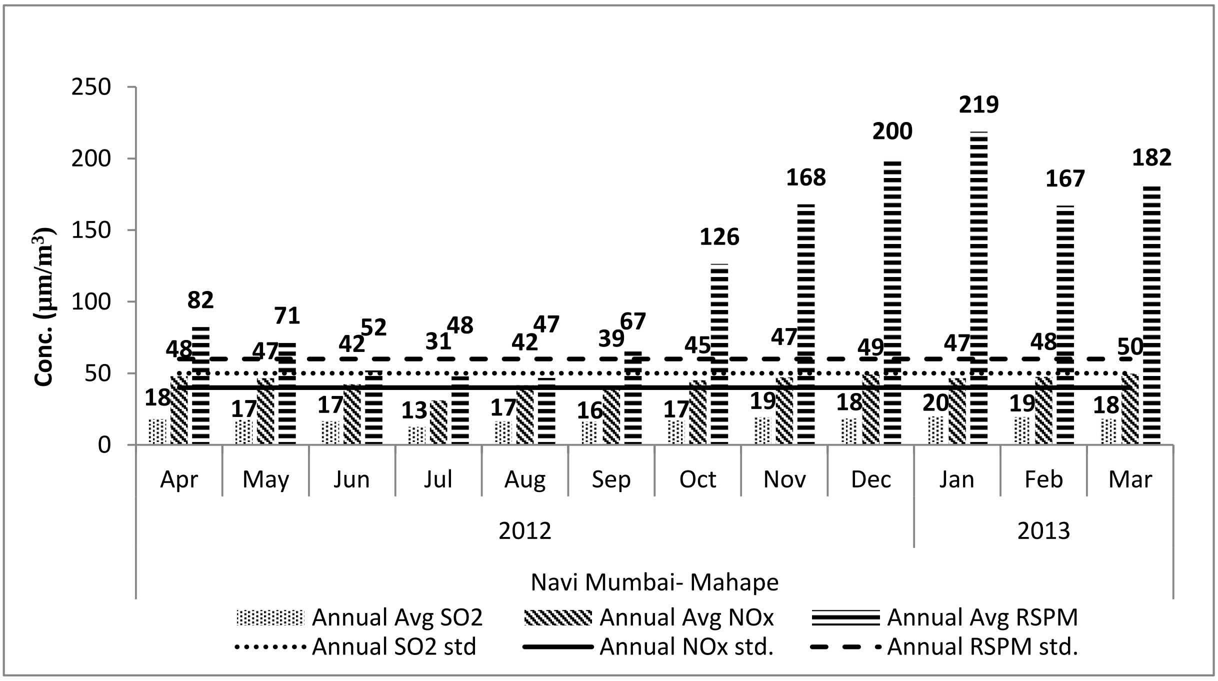


Figure 26: Monthly average readings recorded at Mahape monitoring station - Navi Mumbai under NAMP (2012-13)

Table No. 32: Monthly average readings recorded at Mahape monitoring station - Navi Mumbai under NAMP (2012-13)

FY 2012-13	N	SO_2		NO_X		RSPM	
		Avg. (µg/m³)	*% days of exceedence*	Avg. (µg/m³)	*% days of exceedence*	Avg. (µg/m³)	*% days of exceedence*
24 hrs. Standards		*80*		*80*		*100*	
Apr	8	18.0	Nil	48.0	Nil	82.3	25.0
May	14	17.4	Nil	46.6	Nil	71.4	14.3
Jun	9	16.6	Nil	42.3	Nil	52.0	Nil
Jul	7	12.7	Nil	31.1	Nil	47.9	14.3
Aug	8	16.5	Nil	41.6	Nil	46.8	12.5
Sep	10	16.4	Nil	38.6	Nil	67.4	10.0
Oct	9	17.1	Nil	45.2	Nil	126.4	66.7
Nov	17	19.3	Nil	47.2	11.8	167.9	100.0
Dec	9	18.4	Nil	49.2	Nil	200.2	100.0
Jan	8	19.9	Nil	46.6	Nil	218.8	100.0
Feb	9	19.4	Nil	47.6	Nil	167.1	66.7
Mar	9	18.2	Nil	49.8	Nil	181.8	100.0

Source: MPCB, 2013

N = No. of observations

Naupada - Thane Monitoring Station

Date of Commissioning**: July 2005**	
Location Details	
Latitude: 19.188167	**Longitude**: 72.9678
Address: T.M.C. Regional Office, Naupada, Shahu Market, Thane.	
Type: Commercail	**Program**: NAMP
Frequency of Monitoring: 2 Day in A week	
Implementing Agency: Thane Municipal Corporation	

Table No. 33: Readings recorded at Naupada monitoring station - Thane under NAMP

		Avg. (µg/m³)	***% days of exceedence***	**Avg. (µg/m³)**	***% days of exceedence***	**Avg. (µg/m³)**	***% days of exceedence***	**Avg. (µg/m³)**
Standards		***Annual***	***24 hrs***	***Annual***	***24 hrs***	***Annual***	***24 hrs***	***Annual***
		50	*80*	*40*	*80*	*60*	*100*	*-*
2007-08	104	11.1	Nil	10.8	Nil	50.2	Nil	152.9
2008-09	100	11.3	Nil	15.5	Nil	59.6	Nil	118.9
2009-10	112	14.3	Nil	20.6	Nil	54.6	Nil	87.6
2010-11	122	14.0	Nil	14.1	Nil	47.5	Nil	73.2
2011-12	123	13.4	Nil	11.7	Nil	56.0	3.3	77.5
2012-13	103	20.6	Nil	16.0	Nil	**93.1**	27.2	97.9

Source: MPCB, 2013
N = No. of observations

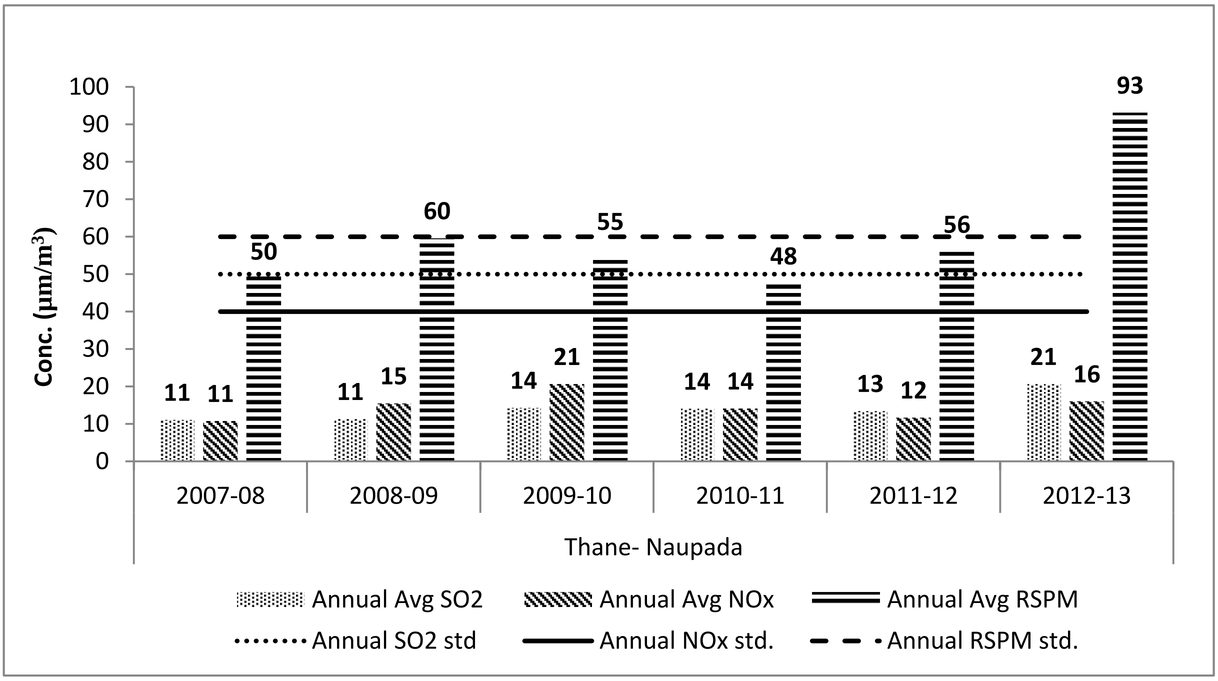


Figure 27: Annual trend in SO_2, NO_X and RSPM levels monitored at Naupada monitoring station - Thane under NAMP

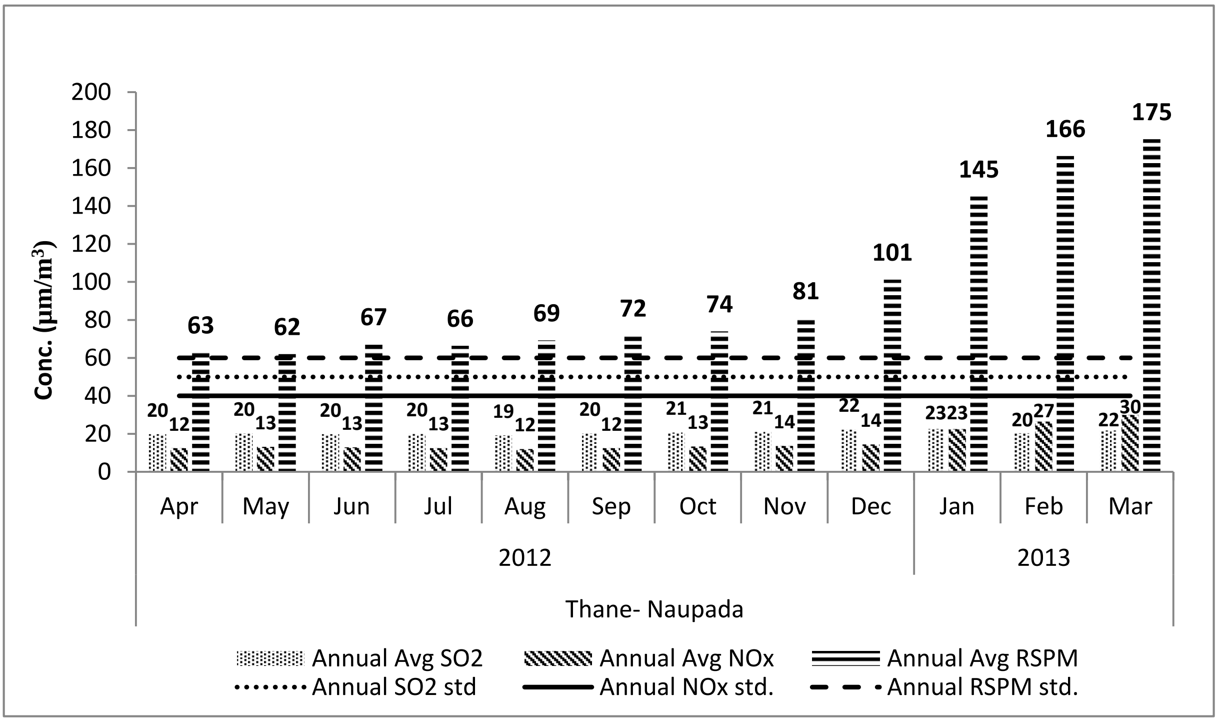


Figure 28: Monthly average readings recorded at Naupada monitoring station - Thane under NAMP (2012-13)

Table No. 34: Monthly average readings recorded at Naupada monitoring station - Thane under NAMP (2012-13)

FY 2012-13	N	SO_2		NO_X		RSPM	
		Avg. (µg/m³)	*% days of exceedence*	Avg. (µg/m³)	*% days of exceedence*	Avg. (µg/m³)	*% days of exceedence*
24 hrs. Standards		*80*		*80*		*100*	
Apr	9	19.8	Nil	12.4	Nil	62.9	Nil
May	8	20.1	Nil	13.1	Nil	62.0	Nil
Jun	9	19.8	Nil	12.9	Nil	67.2	Nil
Jul	10	19.9	Nil	12.5	Nil	66.4	Nil
Aug	8	19.3	Nil	12.0	Nil	69.3	Nil
Sep	9	20.1	Nil	12.4	Nil	71.8	Nil
Oct	9	20.7	Nil	13.3	Nil	74.0	Nil
Nov	8	21.0	Nil	13.6	Nil	80.9	Nil
Dec	10	22.2	Nil	14.4	Nil	101.2	50.0
Jan	8	22.6	Nil	22.5	Nil	145.0	100.0
Feb	6	20.3	Nil	26.5	Nil	166.3	100.0
Mar	9	21.8	Nil	30.0	Nil	175.2	100.0

Source: MPCB, 2013
N = No. of observations

Nerul - Navi Mumbai Monitoring Station

Date of Commissioning:	
Location Details	
Latitude: 19.043722	**Longitude**: 73.0243206
Address: D Y Patil College, Nerul, Navi Mumbai	
Type: Residental	**Program**: NAMP
Frequency of Monitoring: 2 Day in A week	
Implementing Agency: Karmaveer Bhaurao Patil College, Vashi	
Contact Person: -	

Table No. 35: Readings recorded at Nerul monitoring station - Navi Mumbai under NAMP

Year	N	SO_2		NO_X		RSPM	
		Avg. (µg/m³)	***% days of exceedence***	**Avg. (µg/m³)**	***% days of exceedence***	**Avg. (µg/m³)**	***% days of exceedence***
	Standards	***Annual***	***24 hrs***	***Annual***	***24 hrs***	***Annual***	***24 hrs***
		50	*80*	*40*	*80*	*60*	*100*
2007-08	105	16.7	Nil	32.7	1.0	**89.7**	39.0
2008-09	113	19.7	4.4	**40.5**	10.6	**97.7**	48.7
2009-10	104	10.4	Nil	36.5	1.0	**70.8**	30.8
2010-11	96	14.0	Nil	33.3	Nil	**119.5**	46.9
2011-12	98	15.4	Nil	**43.2**	Nil	**117.9**	56.1
2012-13	95	15.4	Nil	**40.3**	Nil	**95.4**	42.1

Source: MPCB, 2013

N = No. of observations

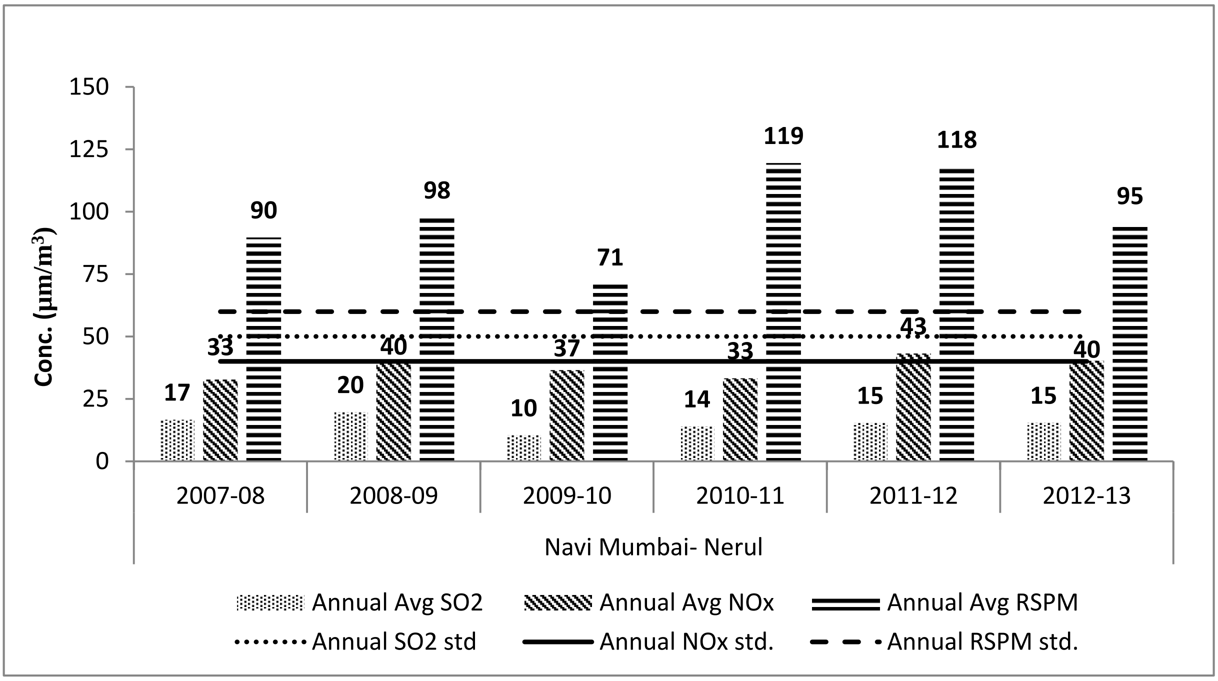


Figure 29: Annual trend in SO_2, NO_X and RSPM levels monitored Nerul monitoring station - Navi Mumbai under NAMP

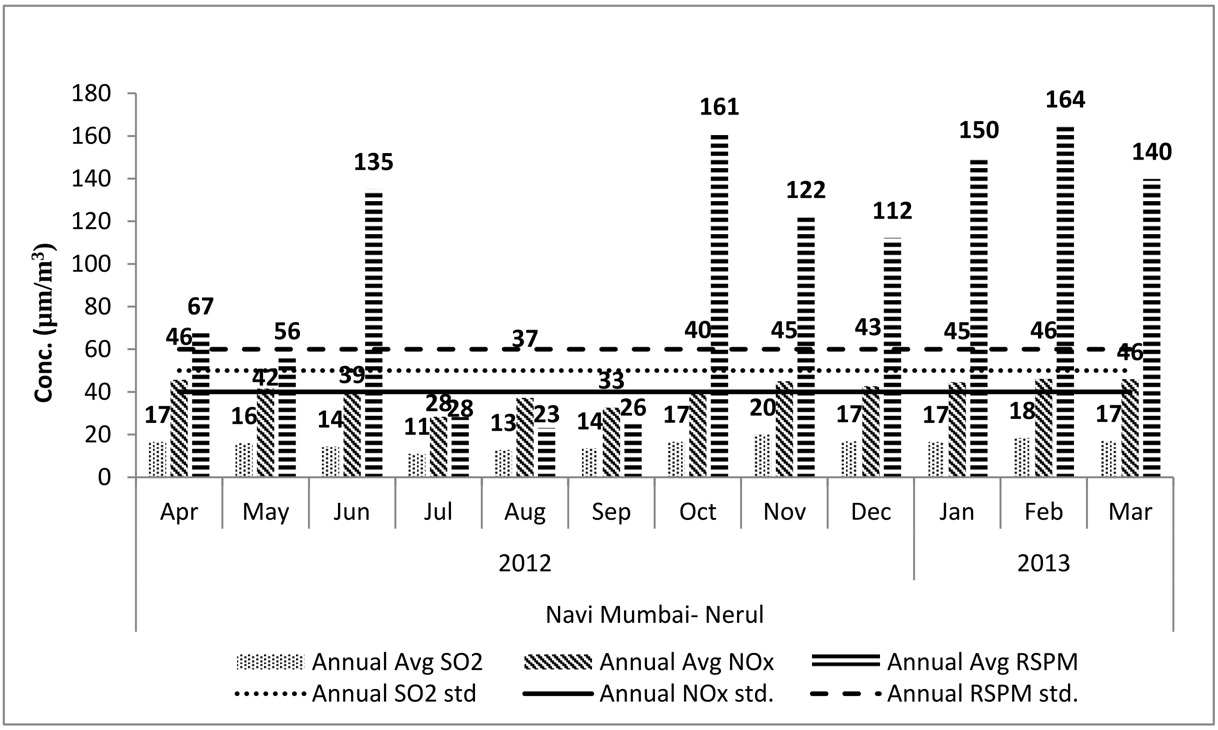


Figure 30: Monthly average readings recorded at Nerul monitoring station - Navi Mumbai under NAMP (2012-13)

Table No. 36: Monthly average readings recorded at Nerul monitoring station - Navi Mumbai under NAMP (2012-13)

FY 2012-13	N	SO_2		NO_X		RSPM	
		Avg. (µg/m³)	*% days of exceedence*	**Avg. (µg/m³)**	*% days of exceedence*	**Avg. (µg/m³)**	*% days of exceedence*
24 hrs. Standards		*80*		*80*		*100*	
Apr	9	16.6	Nil	45.7	Nil	67.4	11.1
May	9	16.0	Nil	41.6	Nil	55.8	Nil
Jun	8	14.4	Nil	39.0	Nil	135.1	50.0
Jul	9	11.0	Nil	28.3	Nil	28.2	Nil
Aug	9	12.8	Nil	37.2	Nil	23.1	Nil
Sep	8	13.5	Nil	32.6	Nil	26.3	Nil
Oct	9	16.7	Nil	40.1	Nil	161.0	66.7
Nov	1	20.0	Nil	45.0	Nil	122.0	100.0
Dec	9	16.9	Nil	42.7	Nil	112.2	66.7
Jan	9	16.6	Nil	44.6	Nil	150.1	100.0
Feb	7	18.4	Nil	46.1	Nil	164.4	100.0
Mar	8	17.0	Nil	46.0	Nil	139.9	75.0

Source: MPCB, 2013

N = No. of observations

Panvel Monitoring Station

Date of Commissioning: **April 2006**	
Location Details	
Latitude: 18.989933	**Longitude**: 73.11765
Address: Water Works Building, Behind S.T.Stand, Panvel	
Type:Residental	**Program**: NAMP
Frequency of Monitoring: 2 Day in A week	
Implementing Agency: Karmaveer Bhaurao Patil College, Vashi	
Contact Person: Prof.Shreepad Jogdand	

Table No. 37: Readings recorded at Panvel monitoring station under NAMP

Year	**N**	**SO_2**		**NO_X**		**RSPM**	
		Avg. (µg/m³)	***% days of exceedence***	**Avg. (µg/m³)**	***% days of exceedence***	**Avg. (µg/m³)**	***% days of exceedence***
	Standards	***Annual***	***24 hrs***	***Annual***	***24 hrs***	***Annual***	***24 hrs***
		50	*80*	*40*	*80*	*60*	*100*
2007-08	119	12.4	Nil	37.3	7.6	**142.5**	58.8
2008-09	106	14.1	0.9	39.8	3.8	**131.7**	65.1
2009-10	102	12.5	Nil	**41.7**	1.0	**70.6**	26.5
2010-11	100	15.2	Nil	34.8	Nil	**119.4**	51.0
2011-12	97	15.2	Nil	**42.0**	Nil	**139.6**	66.0
2012-13	103	16.0	Nil	**41.6**	1.0	**168.0**	69.9

Source: MPCB, 2013
N = No. of observations

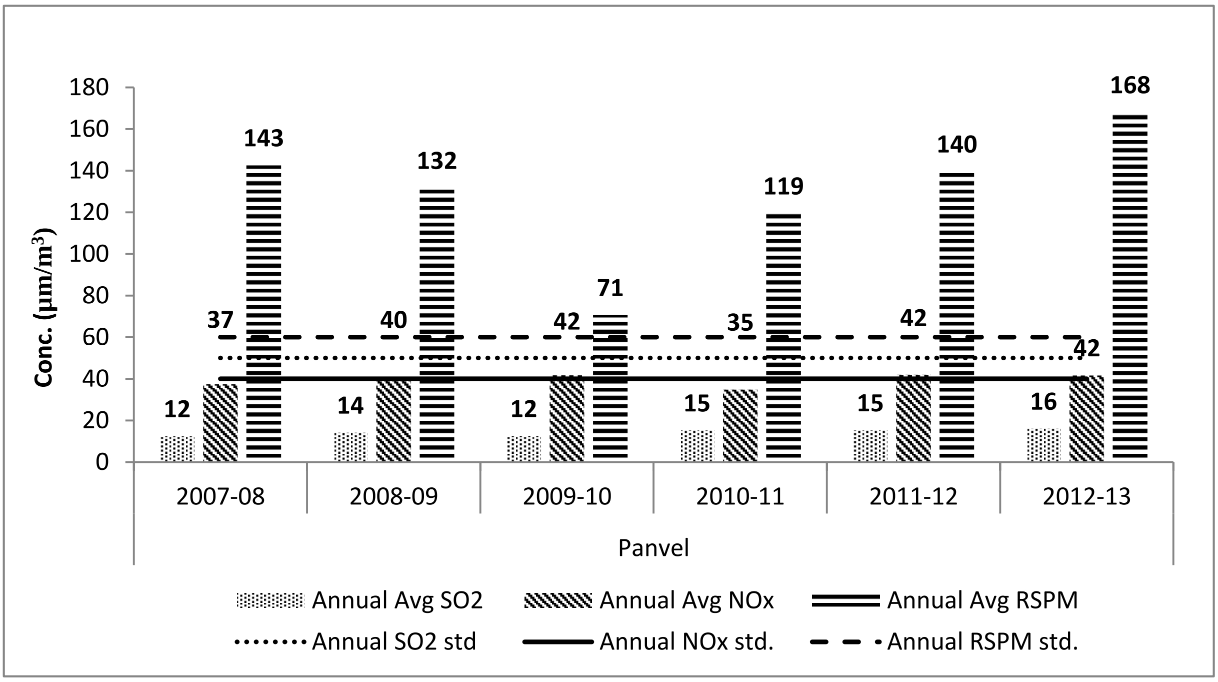


Figure 31: Annual trend in SO_2, NO_X and RSPM levels monitored at Panvel monitoring station under NAMP

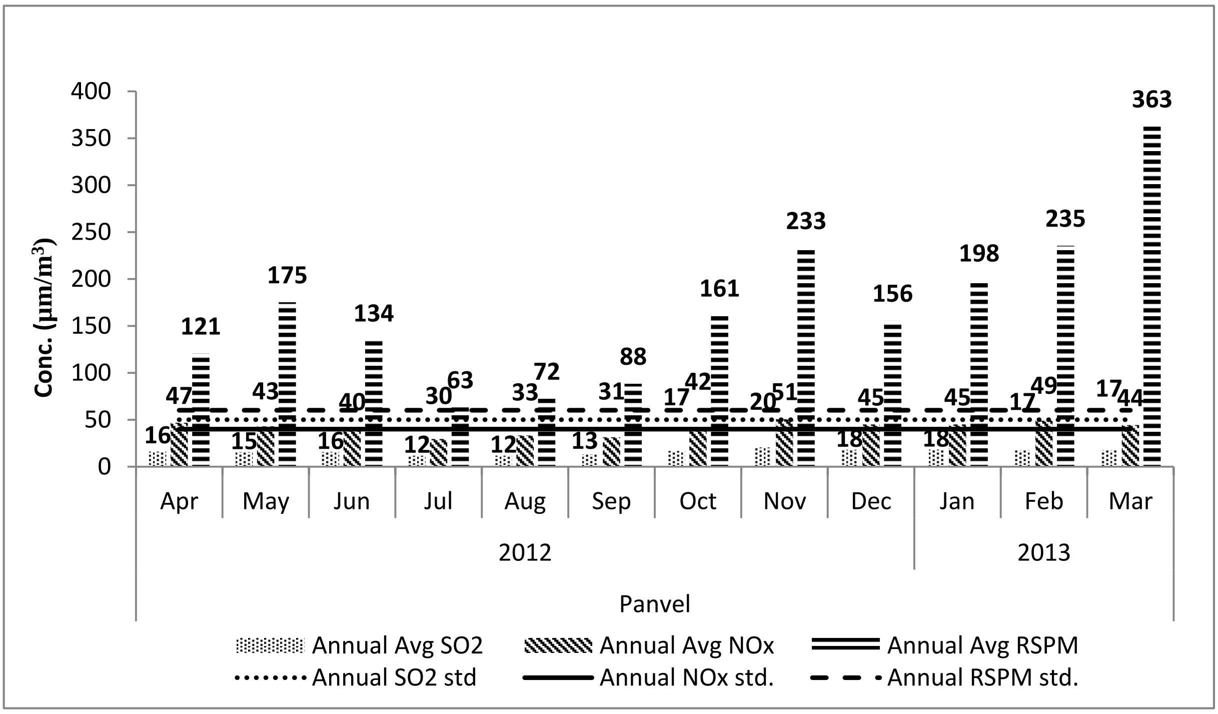


Figure 32: Monthly average readings recorded at Panvel monitoring station under NAMP (2012-13)

Table No. 38: Monthly average readings recorded at Panvel monitoring station under NAMP (2012-13)

FY 2012-13	N	SO_2		NO_X		RSPM	
		Avg. (μg/m³)	*% days of exceedence*	Avg. (μg/m³)	*% days of exceedence*	Avg. (μg/m³)	*% days of exceedence*
24 hrs. Standards		*80*		*80*		*100*	
Apr	8	16.0	Nil	46.6	Nil	120.5	75.0
May	9	15.4	Nil	42.9	Nil	175.1	77.8
Jun	9	15.7	Nil	40.0	Nil	134.4	88.9
Jul	8	11.6	Nil	29.5	Nil	63.3	12.5
Aug	8	11.8	Nil	33.3	Nil	72.4	12.5
Sep	9	13.0	Nil	31.3	Nil	88.3	33.3
Oct	9	16.7	Nil	41.8	Nil	161.0	66.7
Nov	9	20.4	Nil	50.7	11.1	232.9	100.0
Dec	9	18.0	Nil	44.9	Nil	155.6	100.0
Jan	8	18.3	Nil	45.0	Nil	198.4	75.0
Feb	8	17.4	Nil	48.9	Nil	235.4	100.0
Mar	9	17.4	Nil	44.2	Nil	362.6	88.9

Source: MPCB, 2013
N = No. of observations

Parel - Monitoring Station

Date of Commissioning: **April 2006**	
Location Details	
Latitude: 19.006011N	**Longitude**: 72.839613E
Address: Parel T.T, BMC Southward Office, Dr. Ambedkar Road	
Type: Industrial	**Program**: NAMP
Frequency of Monitoring: 2 Day in A week	
Implementing Agency: National Environmental Engineering Research Institute (NEERI)	

Table No. 39: Readings recorded at Parel monitoring station under NAMP

Year	N	SO_2		NO_X		RSPM	
		Avg. (µg/m³)	% days of exceedence	Avg. (µg/m³)	% days of exceedence	Avg. (µg/m³)	% days of exceedence
Standards		Annual	24 hrs	Annual	24 hrs	Annual	24 hrs
		50	80	40	80	60	100
2008-09	23	9	NA	59	NA	170	NA
2009-10	93	4	NA	37	NA	**127**	NA
2010-11	98	6	NA	26	NA	**131**	NA
2011-12	94	5	NA	25	NA	**155**	NA
2012-13	85	5	NA	16	NA	134	NA

Source: NEERI-Mumbai, 2013
N = No. of observations

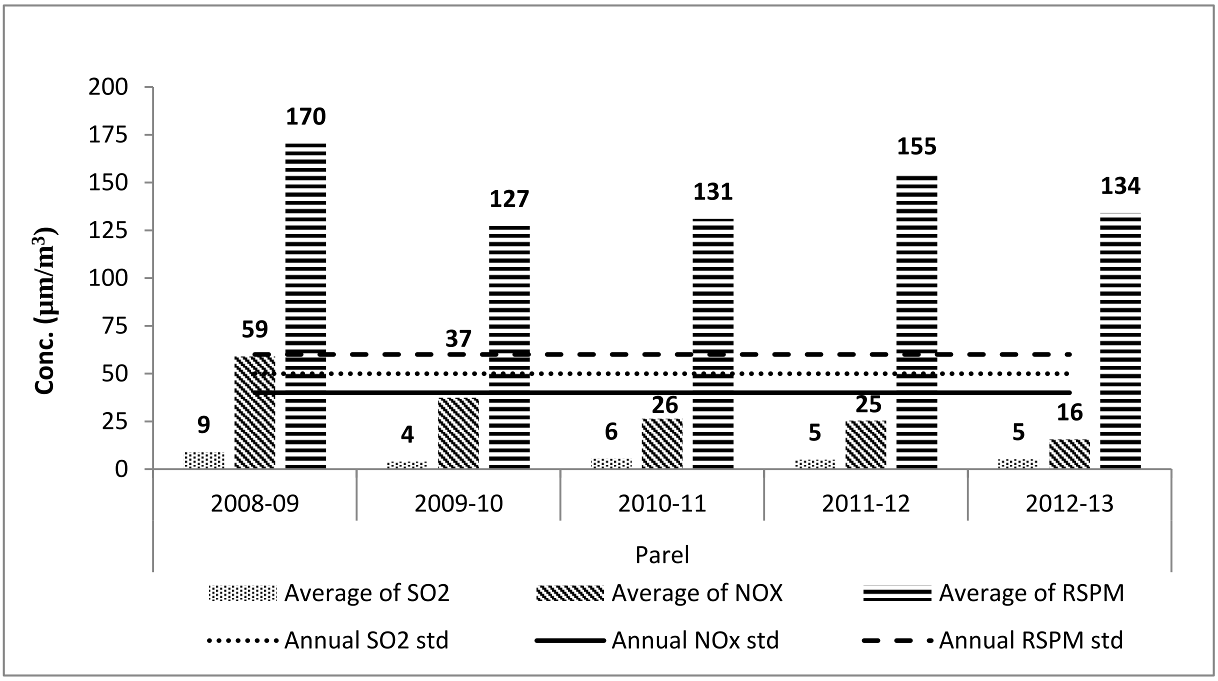


Figure 33: Annual trend in SO2, NOX and RSPM levels monitored at Parel monitoring station under NAMP

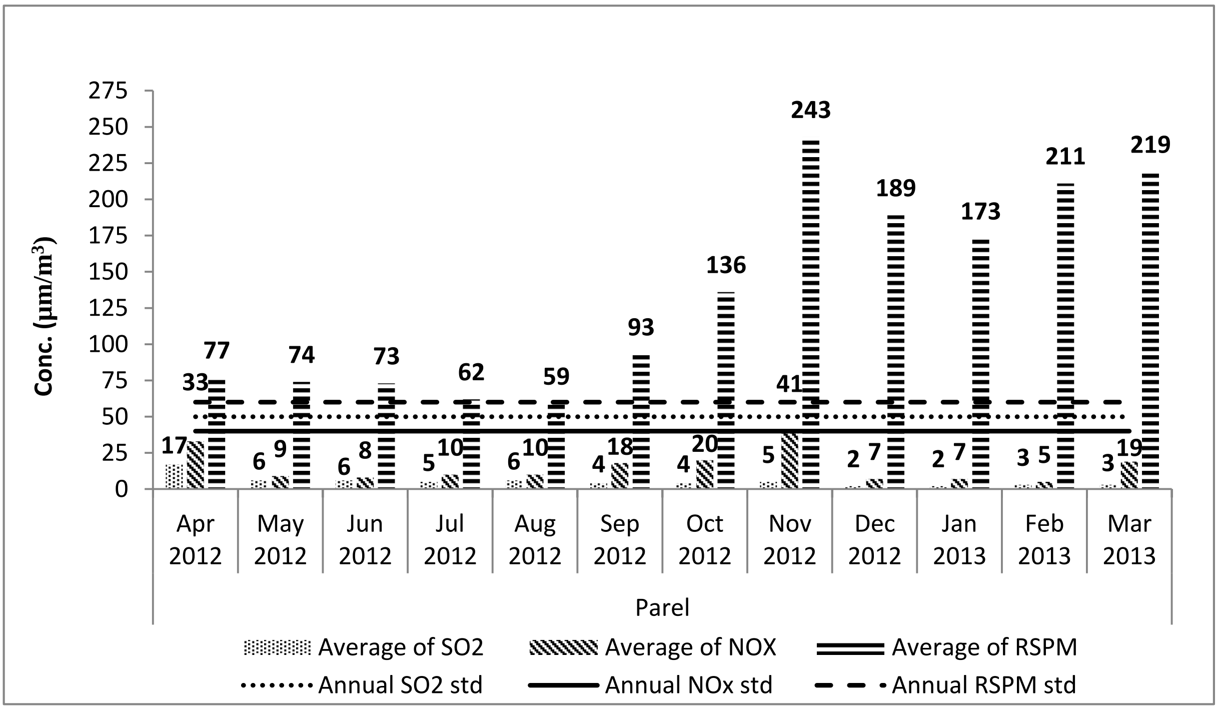


Figure 34: Monthly average readings recorded at Parel monitoring station under NAMP (2012-13)

Table No. 40: Monthly average readings recorded at Parel monitoring station under NAMP (2012-13)

FY 2012-13	N	SO2		NOx		RSPM		SPM
		Avg. (µg/m³)	*% days of exceedence*	Avg. (µg/m³)	*% days of exceedence*	Avg. (µg/m³)	*% days of exceedence*	Avg. (µg/m³)
	24 hrs. Standards	*80*		*80*		*100*		
Apr	4	17	NA	33	NA	77	NA	50
May	8	6	NA	9	NA	74	NA	50
Jun	7	6	NA	8	NA	73	NA	50
Jul	8	5	NA	10	NA	62	NA	50
Aug	6	6	NA	10	NA	59	NA	50
Sep	8	4	NA	18	NA	93	NA	50
Oct	8	4	NA	20	NA	136	NA	50
Nov	8	5	NA	41	NA	243	NA	50
Dec	6	2	NA	7	NA	189	NA	50
Jan	8	2	NA	7	NA	173	NA	50
Feb	7	3	NA	5	NA	211	NA	50
Mar	7	3	NA	19	NA	219	NA	50

Source: NEERI-Mumbai, 2013
N = No. of observations

Taloja - Navi Mumbai Monitoring Station

Date of Commissioning: **April 2006**	
Location Details	
Latitude: 19.061117	**Longitude**: 73.116283
Address: MIDC Common Facility Building, MIDC, Taloja	
Type: Industrial	**Program**: NAMP
Frequency of Monitoring: 2 Day in A week	
Implementing Agency: Karmaveer Bhaurao Patil College, Vashi	

Table No. 41: Readings recorded at Taloja monitoring station under NAMP

Year	**N**	**SO_2**		**NO_X**		**RSPM**	
		Avg. (µg/m³)	***% days of exceedence***	**Avg. (µg/m³)**	***% days of exceedence***	**Avg. (µg/m³)**	***% days of exceedence***
	Standards	***Annual***	***24 hrs***	***Annual***	***24 hrs***	***Annual***	***24 hrs***
		50	*80*	*40*	*80*	*60*	*100*
2007-08	101	22.3	Nil	39.2	6.9	**112.8**	52.5
2008-09	107	28.9	3.7	**45.8**	9.3	**240.8**	74.8
2009-10	100	22.8	Nil	**54.7**	5.0	**199.7**	86.0
2010-11	106	27.4	Nil	**48.4**	0.9	**194.3**	91.5
2011-12	93	19.9	Nil	**50.5**	1.1	**148.0**	74.2
2012-13	104	17.6	Nil	**44.8**	Nil	**128.6**	64.4

Source: MPCB, 2013
N = No. of observations

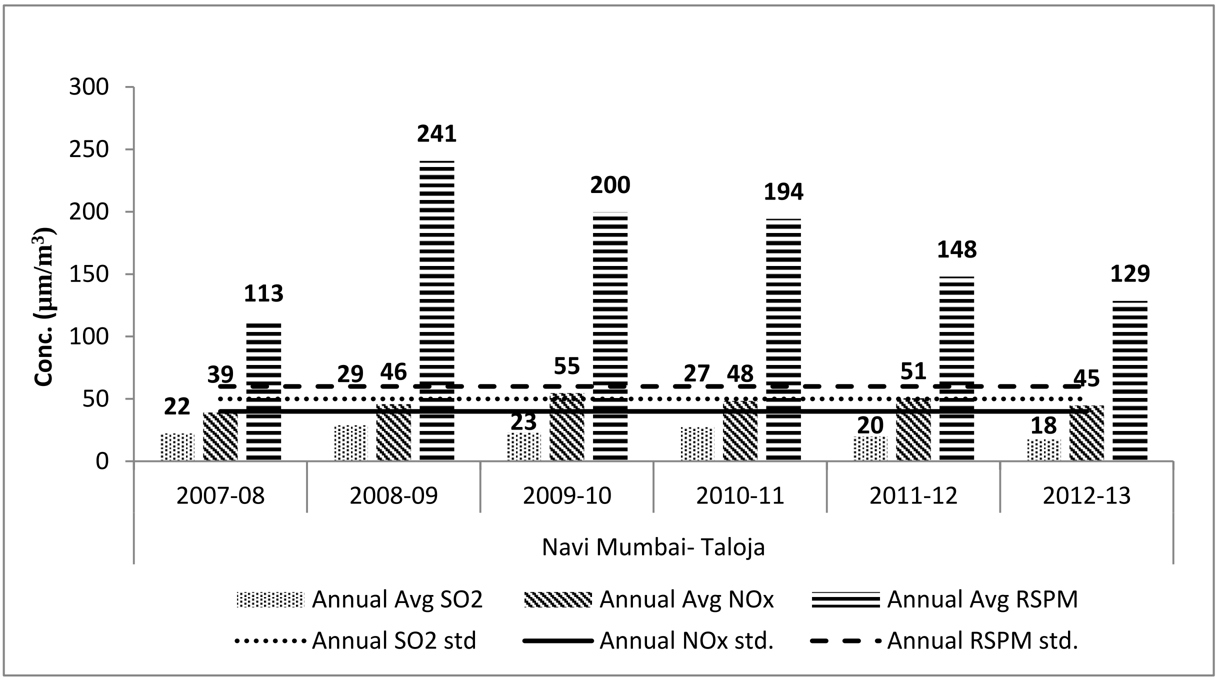


Figure 35: Annual trend in SO_2, NO_X and RSPM levels monitored at Taloja monitoring station- Navi Mumbai under NAMP

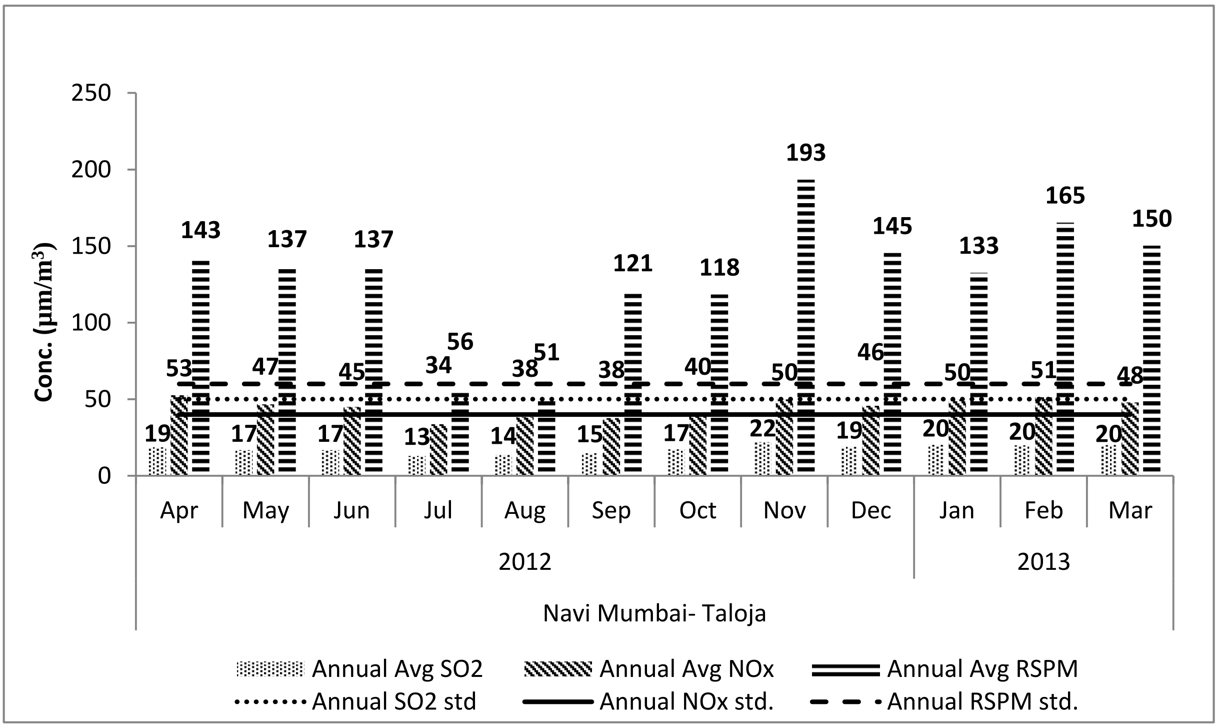


Figure 36: Monthly average readings recorded at Taloja monitoring station - Navi Mumbai under NAMP (2012-13)

Table No. 42: Monthly average readings recorded at Taloja monitoring station - Navi Mumbai under NAMP (2012-13)

FY 2012-13	N	SO_2		NO_X		RSPM	
		Avg. (µg/m³)	*% days of exceedence*	Avg. (µg/m³)	*% days of exceedence*	Avg. (µg/m³)	*% days of exceedence*
24 hrs. Standards		*80*		*80*		*100*	
Apr	9	18.7	Nil	52.6	Nil	142.8	77.8
May	9	16.8	Nil	46.7	Nil	136.9	88.9
Jun	8	16.8	Nil	45.0	Nil	136.8	87.5
Jul	9	13.0	Nil	33.7	Nil	56.0	Nil
Aug	9	13.6	Nil	38.3	Nil	50.8	Nil
Sep	8	14.8	Nil	37.6	Nil	121.1	37.5
Oct	9	17.2	Nil	39.7	Nil	118.3	77.8
Nov	9	22.0	Nil	49.9	Nil	193.3	88.9
Dec	9	18.9	Nil	45.7	Nil	145.4	88.9
Jan	9	20.2	Nil	49.9	Nil	132.6	55.6
Feb	8	19.9	Nil	51.4	Nil	165.4	87.5
Mar	8	20.1	Nil	47.9	Nil	150.3	87.5

Source: MPCB, 2013

N = No. of observations

Ulhasnagar - CHM college Monitoring Station

Date of Commissioning: **June 2006**	
Location Details	
Latitude: 19.2201	**Longitude**: 73.16425
Address: C.H.M.College Campus, Ulhasnagar	
Type: Residental	**Program**: NAMP
Frequency of Monitoring: 2 Day in A week	
Implementing Agency: C.H.M.College, Ulhasnagar	
Contact Person: Prof.Padma Deshmukh	

Table No. 43: Readings recorded at Ulhasnagar monitoring station - CHM college under NAMP

Year	N	SO_2		NO_X		RSPM		SPM
		Avg. (µg/m³)	*% days of exceedence*	Avg. (µg/m³)	*% days of exceedence*	Avg. (µg/m³)	*% days of exceedence*	Avg. (µg/m³)
	Standards	*Annual*	*24 hrs*	*Annual*	*24 hrs*	*Annual*	*24 hrs*	*Annual*
		50	*80*	*40*	*80*	*60*	*100*	-
2007-08	53	30.5	Nil	42.2	1.9	90.4	7.5	155.0
2008-09	92	30.1	2.2	**57.5**	28.3	**86.6**	20.7	118.2
2009-10	88	46.4	8.0	**70.8**	39.8	**92.3**	30.7	126.3
2010-11	99	30.4	Nil	**66.7**	21.2	**98.6**	55.6	123.1
2011-12	102	36.9	2.0	**64.1**	21.6	**108.9**	58.8	128.5
2012-13	100	33.6	Nil	**58.0**	14.0	**84.9**	22.0	105.4

Source: MPCB, 2013

N = No. of observations

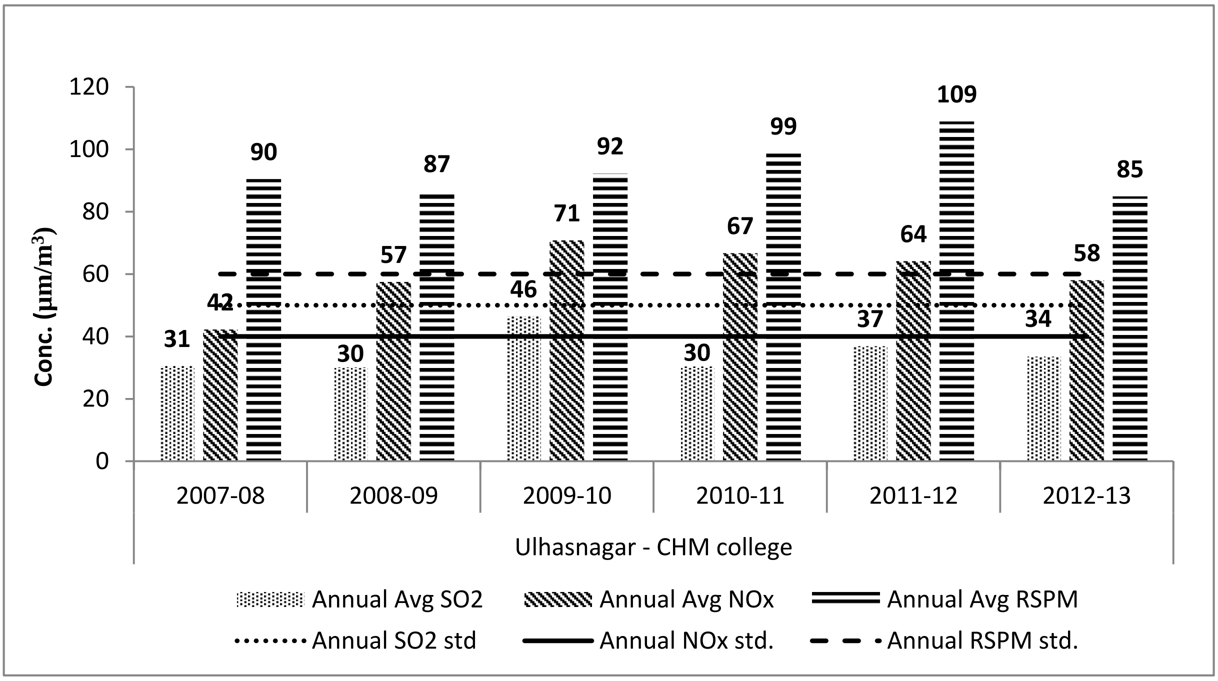


Figure 37: Annual trend in SO_2, NO_X and RSPM levels monitored at Ulhasnagar monitoring station - CHM College under NAMP

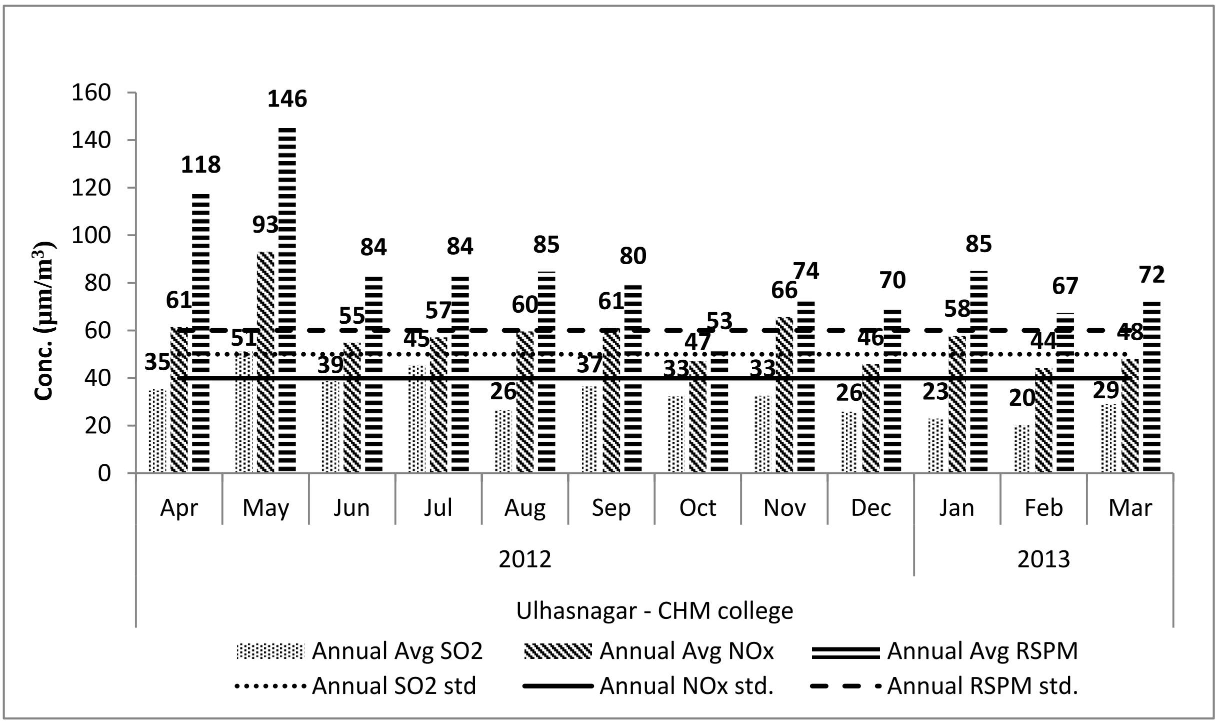


Figure 38: Monthly average readings recorded at Ulhasnagar - CHM College monitoring station under NAMP (2012-13)

Table No. 44: Monthly average readings recorded at Ulhasnagar - CHM college monitoring station under NAMP (2012-13)

FY 2012-13	N	SO_2		NO_X		RSPM	
		Avg. (µg/m³)	*% days of exceedence*	**Avg. (µg/m³)**	*% days of exceedence*	**Avg. (µg/m³)**	*% days of exceed ence*
24 hrs. Standards		*80*		*80*		*100*	
Apr	9	35.4	Nil	61.4	11.1	118.3	66.7
May	9	51.2	Nil	93.1	100.0	146.0	100.0
Jun	8	38.6	Nil	54.9	Nil	83.6	12.5
Jul	9	45.2	Nil	57.1	Nil	84.0	Nil
Aug	9	26.4	Nil	59.6	11.1	84.8	11.1
Sep	8	36.6	Nil	61.0	12.5	80.0	25.0
Oct	10	32.5	Nil	47.2	Nil	52.6	Nil
Nov	8	32.6	Nil	65.6	12.5	73.6	Nil
Dec	9	25.9	Nil	45.8	Nil	69.8	Nil
Jan	5	23.0	Nil	57.8	20.0	85.0	40.0
Feb	8	20.4	Nil	44.3	Nil	67.4	Nil
Mar	8	29.1	Nil	48.0	Nil	72.1	12.5

Source: MPCB, 2013

N = No. of observations

Ulhasnagar - Powai Chowk Monitoring Station

Date of Commissioning: **June 2006**	
Location Details	
Latitude: 19.2239	**Longitude**: 73.1545
Address: Octroi Naka, Pawai Chowk, Vithalwadi, Ulhasnagar	
Type: Residental	**Program**: NAMP
Frequency of Monitoring: 2 Day in A week	
Implementing Agency: C.H.M.College, Ulhasnagar	

Table No. 45: Readings recorded at Ulhasnagar - Powai Chowk monitoring station under NAMP

Year	**N**	**SO_2**		**NO_X**		**RSPM**	
		Avg. (µg/m³)	***% days of exceedence***	**Avg. (µg/m³)**	***% days of exceedence***	**Avg. (µg/m³)**	***% days of exceedence***
	Standards	*Annual*	*24 hrs*	*Annual*	*24 hrs*	*Annual*	*24 hrs*
		50	*80*	*40*	*80*	*60*	*100*
2007-08	98	25.4	Nil	37.0	Nil	**90.5**	18.4
2008-09	98	32.8	4.1	**68.9**	29.6	**94.7**	41.8
2009-10	89	52.9	11.2	95.6	67.4	**119.1**	76.4
2010-11	96	30.9	Nil	**73.1**	34.4	**113.7**	68.8
2011-12	102	43.3	5.9	**74.1**	52.0	**122.3**	61.8
2012-13	101	43.2	1.0	**80.8**	53.5	**105.8**	53.5

Source: MPCB, 2013
N = No. of observations

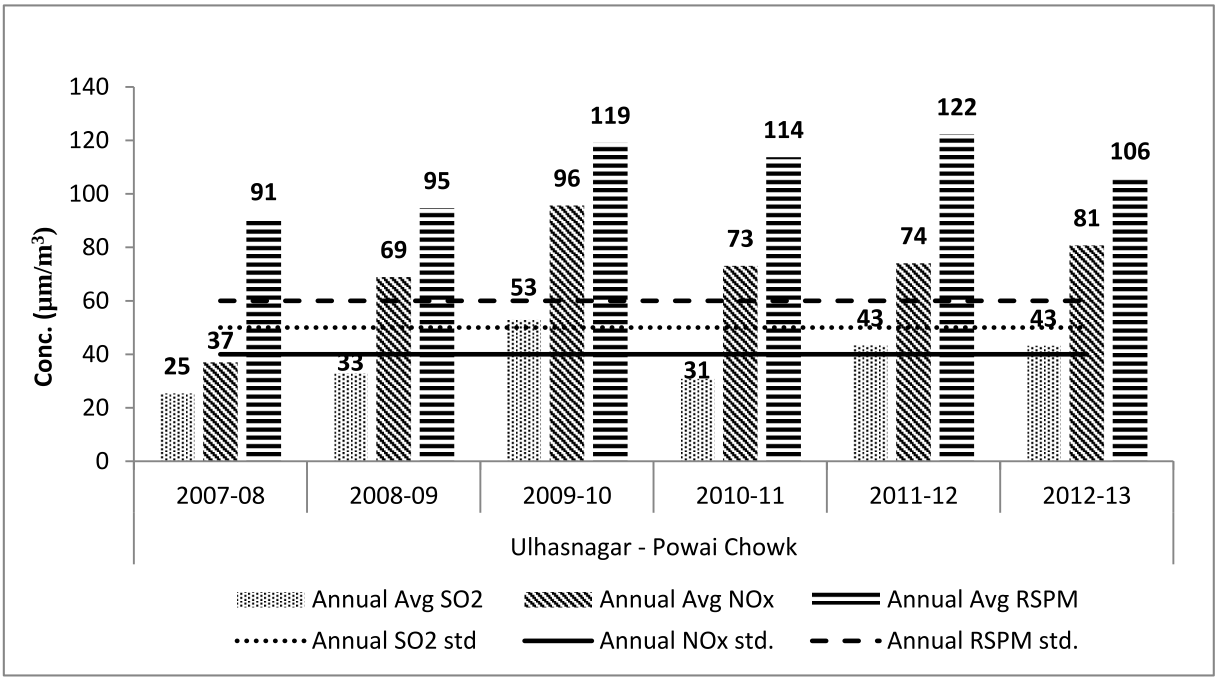


Figure 39: Annual trend in SO_2, NO_X and RSPM levels monitored at Ulhasnagar - Powai Chowk monitoring station under NAMP

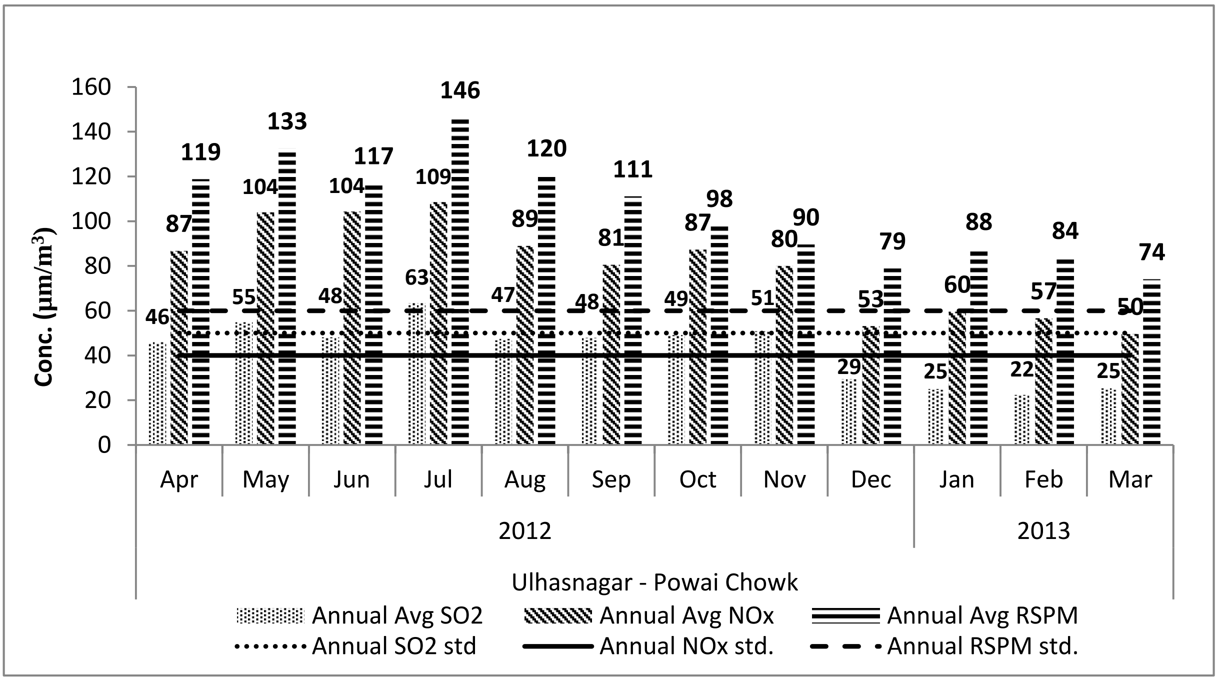


Figure 40: Monthly average readings recorded at Ulhasnagar - Powai Chowk monitoring station under NAMP (2012-13)

Table No. 46: Monthly average readings recorded at Ulhasnagar - Powai Chowk monitoring station under NAMP (2012-13)

FY 2012-13	N	SO_2		NO_X		RSPM	
		Avg. (µg/m³)	*% days of exceedence*	Avg. (µg/m³)	*% days of exceedence*	Avg. (µg/m³)	*% days of exceedence*
24 hrs. Standards		*80*		*80*		*100*	
Apr	9	45.9	Nil	86.8	66.7	118.8	66.7
May	9	54.9	Nil	104.0	100.0	132.6	100.0
Jun	8	48.1	Nil	104.4	75.0	117.0	75.0
Jul	9	63.4	11.1	108.6	88.9	146.4	100.0
Aug	9	47.4	Nil	89.0	55.6	120.4	66.7
Sep	9	47.9	Nil	80.6	55.6	111.1	55.6
Oct	9	49.1	Nil	87.3	66.7	97.9	44.4
Nov	8	50.9	Nil	80.0	50.0	89.6	37.5
Dec	9	29.4	Nil	53.1	22.2	78.9	22.2
Jan	5	25.0	Nil	59.6	20.0	87.6	20.0
Feb	8	22.4	Nil	56.6	25.0	83.6	25.0
Mar	9	25.3	Nil	49.7	Nil	74.1	11.1

Source: MPCB, 2013
N = No. of observations

Worli Monitoring Station

Date of Commissioning: **1990**	
Location Details	
Latitude: 19.001487	**Longitude**: 72.814518
Address: NEERI Office,Worli, Mumbai	
Type: Residental	**Program**: NAMP
Frequency of Monitoring: 2 Day in A week	
Implementing Agency: National Environmental Engineering Research Institute (NEERI)	

Table No. 47: Readings recorded at Worli monitoring station under NAMP

Year	**N**	**SO_2**		**NO_X**		**RSPM**	
		Avg. (µg/m³)	***% days of exceedence***	**Avg. (µg/m³)**	***% days of exceedence***	**Avg. (µg/m³)**	***% days of exceedence***
	Standards	***Annual***	***24 hrs***	***Annual***	***24 hrs***	***Annual***	***24 hrs***
		50	*80*	*40*	*80*	*60*	*100*
2007-08	26	50	NA	61	NA	142	NA
2008-09	97	6	NA	36	NA	**120**	NA
2009-10	100	4	NA	26	NA	**99**	NA
2011-12	94	5	NA	32	NA	**102**	NA
2012-13	89	4	NA	17	NA	87	NA

Source: NEERI-Mumbai, 2013
N = No. of observations

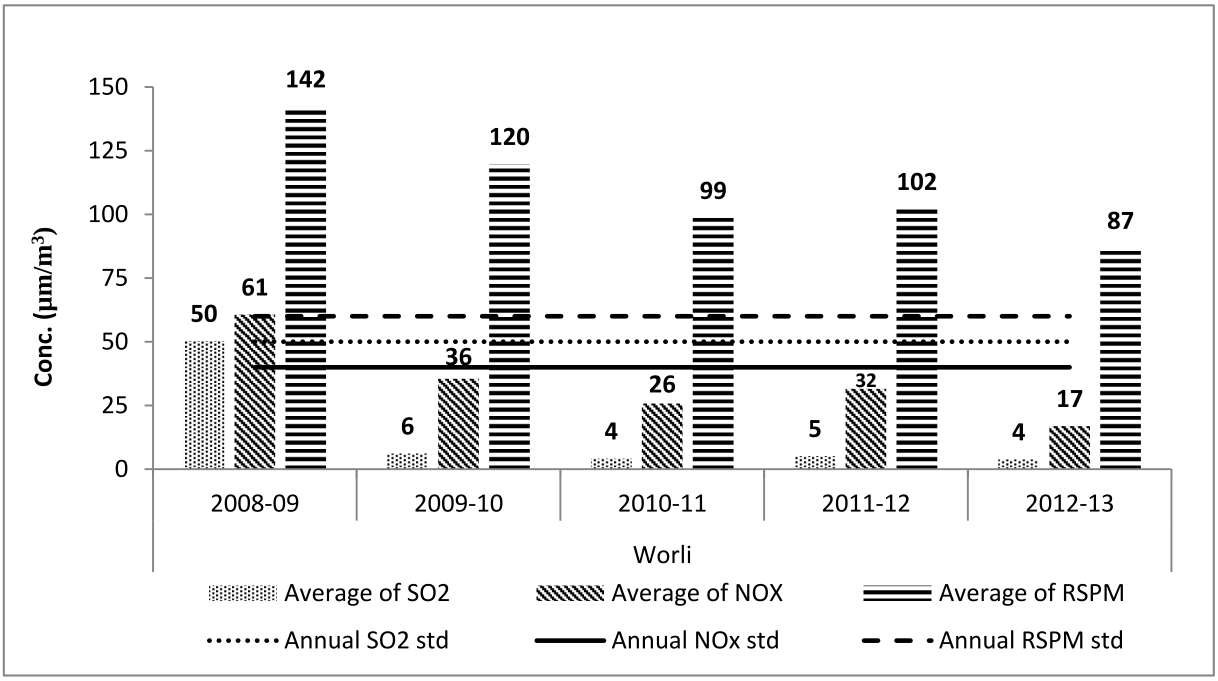


Figure 41: Annual trend in SO_2, NO_X and RSPM levels monitored at Worli monitoring station under NAMP

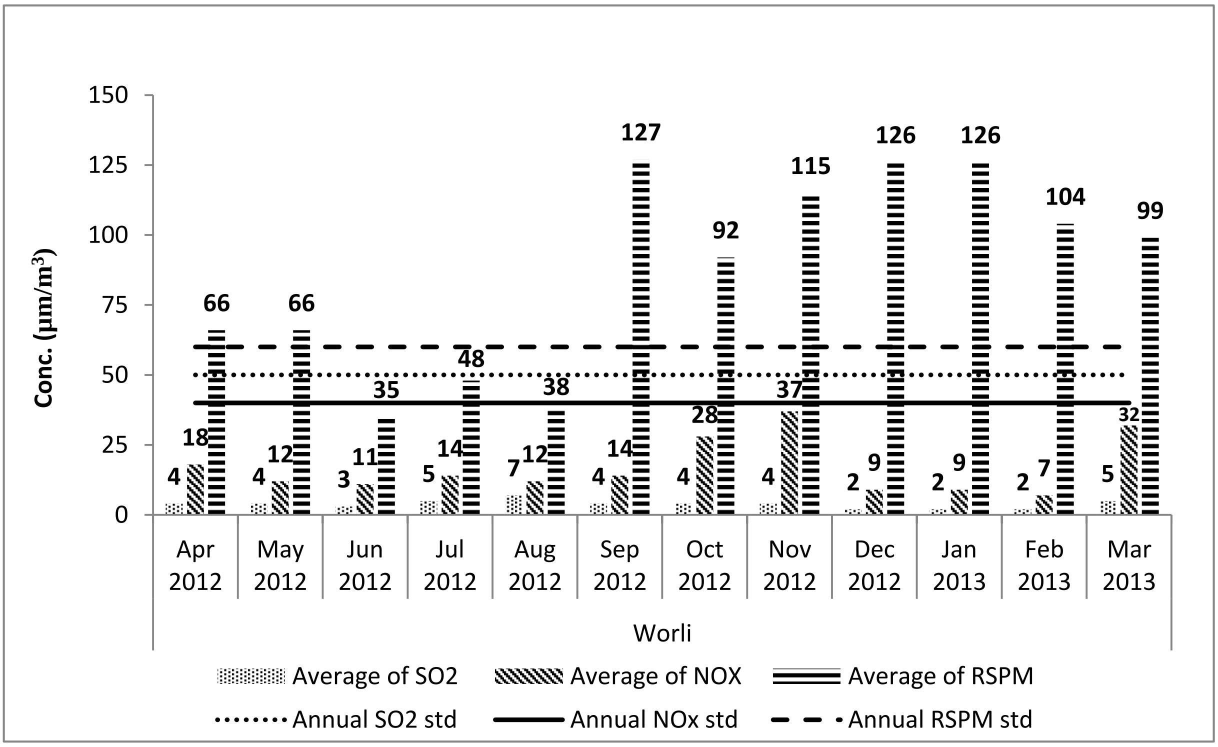


Figure 42: Monthly average readings recorded at Worli under NAMP (2012-13)

Table No. 48: Monthly average readings recorded at Worli monitoring station under NAMP (2012-13)

FY 2012-13	N	SO_2		NO_X		RSPM		SPM
		Avg. (µg/m³)	*% days of exceedence*	**Avg. (µg/m³)**	*% days of exceedence*	**Avg. (µg/m³)**	*% days of exceedence*	**Avg. (µg/m³)**
	24 hrs. Standards	*80*		*80*		*100*		
Apr	4	4	NA	18	NA	66	NA	50
May	8	4	NA	12	NA	66	NA	50
Jun	8	3	NA	11	NA	35	NA	50
Jul	8	5	NA	14	NA	48	NA	50
Aug	7	7	NA	12	NA	38	NA	50
Sep	6	4	NA	14	NA	127	NA	50
Oct	7	4	NA	28	NA	92	NA	50
Nov	8	4	NA	37	NA	115	NA	50
Dec	8	2	NA	9	NA	126	NA	50
Jan	9	2	NA	9	NA	126	NA	50
Feb	8	2	NA	7	NA	104	NA	50
Mar	8	5	NA	32	NA	99	NA	50

Source: NEERI-Mumbai, 2013
N = No. of observations

State Ambient Air Quality Monitoring (SAMP) in MMR

Bhiwandi - I. G. M Hospital Monitoring Station

Date of Commissioning: **April 2011**	
Location Details	
Latitude: 19.299175	**Longitude**: 73.066911
Address: IGM Hospital, opp. New corporation building, Nr. Rajiv Gandhi flyover, Bhiwandi	
Type: Sensitive	**Program**: SAMP
Frequency of Monitoring: 2 Day in A week	
Implementing Agency: Bhiwandi Municiple Corporation	

Table No. 49: Readings recorded at Bhiwandi - I. G. M Hospital monitoring station under SAMP

Year	**N**	**SO_2**		**NO_X**		**RSPM**	
		Avg. (µg/m³)	***% days of exceedence***	**Avg. (µg/m³)**	***% days of exceedence***	**Avg. (µg/m³)**	***% days of exceedence***
	Standards	***Annual***	***24 hrs***	***Annual***	***24 hrs***	***Annual***	***24 hrs***
		50	*80*	*40*	*80*	*60*	*100*
2011-12	26	22.6	Nil	29.3	Nil	62.2	Nil
2012-13	96	25.7	Nil	34.6	Nil	63.1	Nil

Source: MPCB, 2013

N = No. of observations

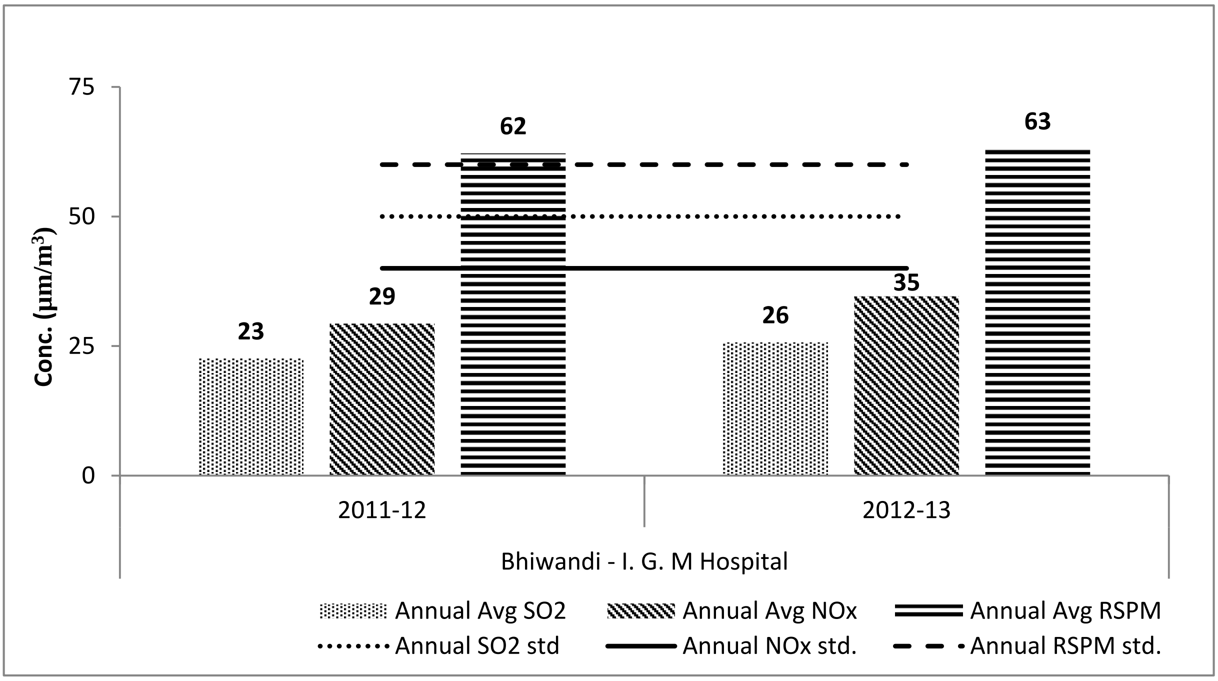


Figure 43: Annual trend in SO_2, NO_X and RSPM levels monitored at Bhiwandi - I. G. M Hospital monitoring station under SAMP

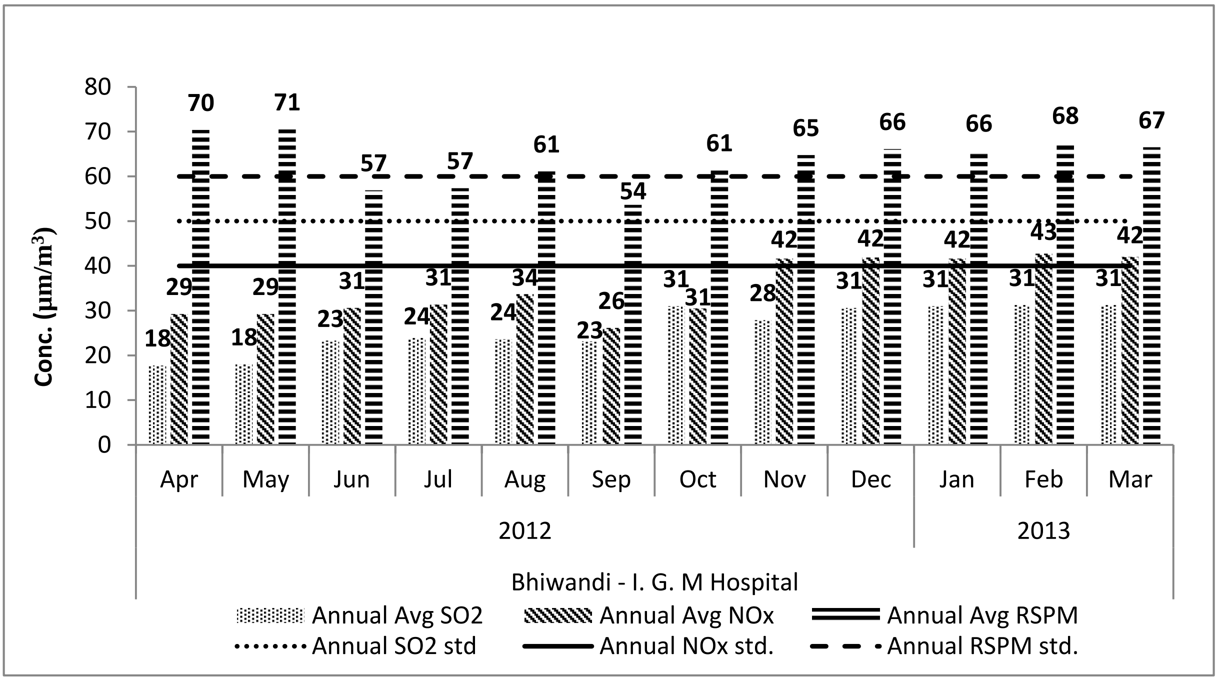


Figure 44: Monthly average readings recorded at Bhiwandi - I. G. M Hospital under SAMP (2012-13)

Table No. 50: Monthly average readings recorded at Bhiwandi - I. G. M Hospital under SAMP (2012-13)

FY 2012-13	N	SO_2		NO_X		RSPM		SPM
		Avg. (µg/m³)	*% days of exceedence*	Avg. (µg/m³)	*% days of exceedence*	Avg. (µg/m³)	*% days of exceedence*	Avg. (µg/m³)
	24 hrs. Standards	*80*		*80*		*100*		
Apr	8	17.8	Nil	29.3	Nil	70.4	Nil	117.4
May	8	18.0	Nil	29.3	Nil	70.5	Nil	117.5
Jun	10	23.3	Nil	30.6	Nil	56.9	Nil	122.1
Jul	8	23.9	Nil	31.4	Nil	57.4	Nil	124.6
Aug	10	23.6	Nil	33.7	Nil	61.1	Nil	133.3
Sep	8	23.1	Nil	26.1	Nil	53.6	Nil	85.4
Oct	8	31.0	Nil	30.5	Nil	61.4	Nil	85.3
Nov	8	27.9	Nil	41.6	Nil	64.8	Nil	132.5
Dec	8	30.6	Nil	41.9	Nil	66.1	Nil	132.4
Jan	8	31.0	Nil	41.6	Nil	65.8	Nil	132.4
Feb	4	31.3	Nil	42.8	Nil	67.5	Nil	135.5
Mar	8	31.3	Nil	42.0	Nil	66.5	Nil	133.5

Source: MPCB, 2013

N = No. of observations

Bhiwandi - Prematai Hall Monitoring Station

Date of Commissioning: **April 2012**	
Location Details	
Latitude: 19.285423	**Longitude**: 73.057816
Address: Opp. BNN college, Damankar Naka, Bhiwandi	
Type: Commercial	**Program**: SAMP
Frequency of Monitoring: 2 times in a week	
Implementing Agency: Bhiwandi Municipal Corporation	

Table No. 51: Readings recorded at Bhiwandi - Prematai Hall monitoring station under SAMP

Year	**N**	**SO_2**		**NO_X**		**RSPM**		**SPM**
		Avg. (µg/m³)	***% days of exceedence***	**Avg. (µg/m³)**	***% days of exceedence***	**Avg. (µg/m³)**	***% days of exceedence***	**Avg. (µg/m³)**
	Standards	***Annual***	***24 hrs***	***Annual***	***24 hrs***	***Annual***	***24 hrs***	***Annual***
		50	*80*	*40*	*80*	*60*	*100*	*-*
2011-12	103	15.3	Nil	24.1	Nil	52.0	Nil	93.1
2012-13	102	24.2	Nil	33.2	Nil	58.5	Nil	113.5

Source: MPCB, 2013
N = No. of observations

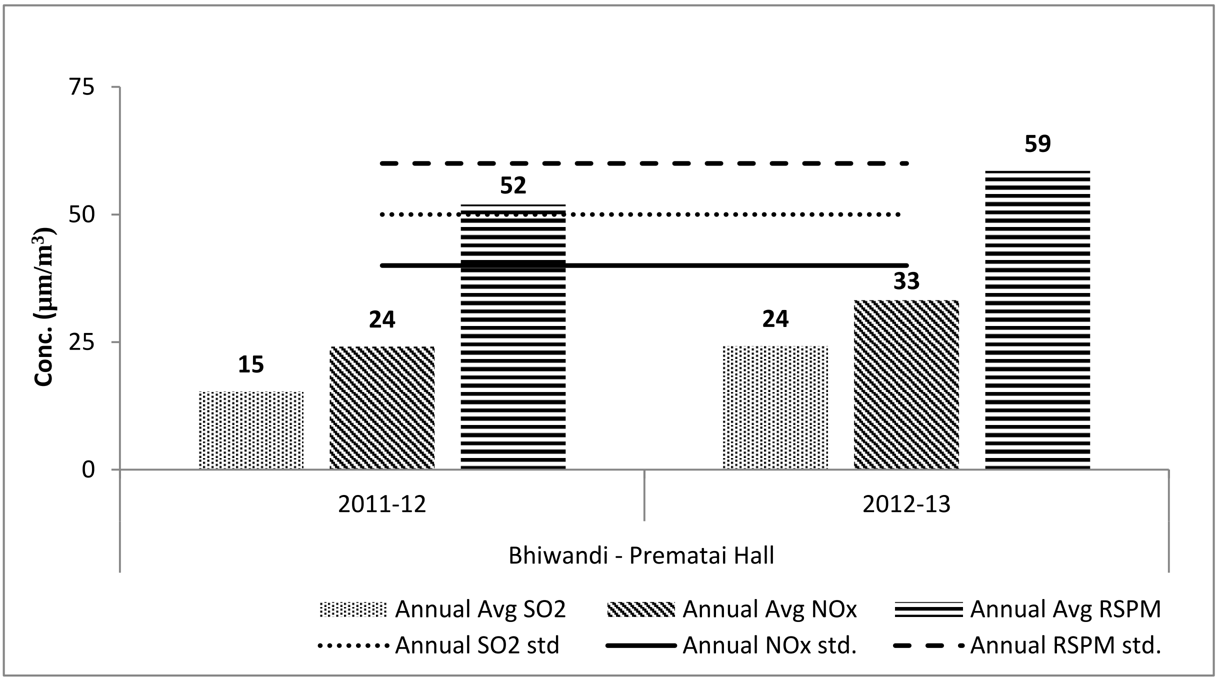


Figure 45: Annual trend in SO_2, NO_X and RSPM levels monitored at Bhiwandi - Prematai Hall monitoring station under SAMP

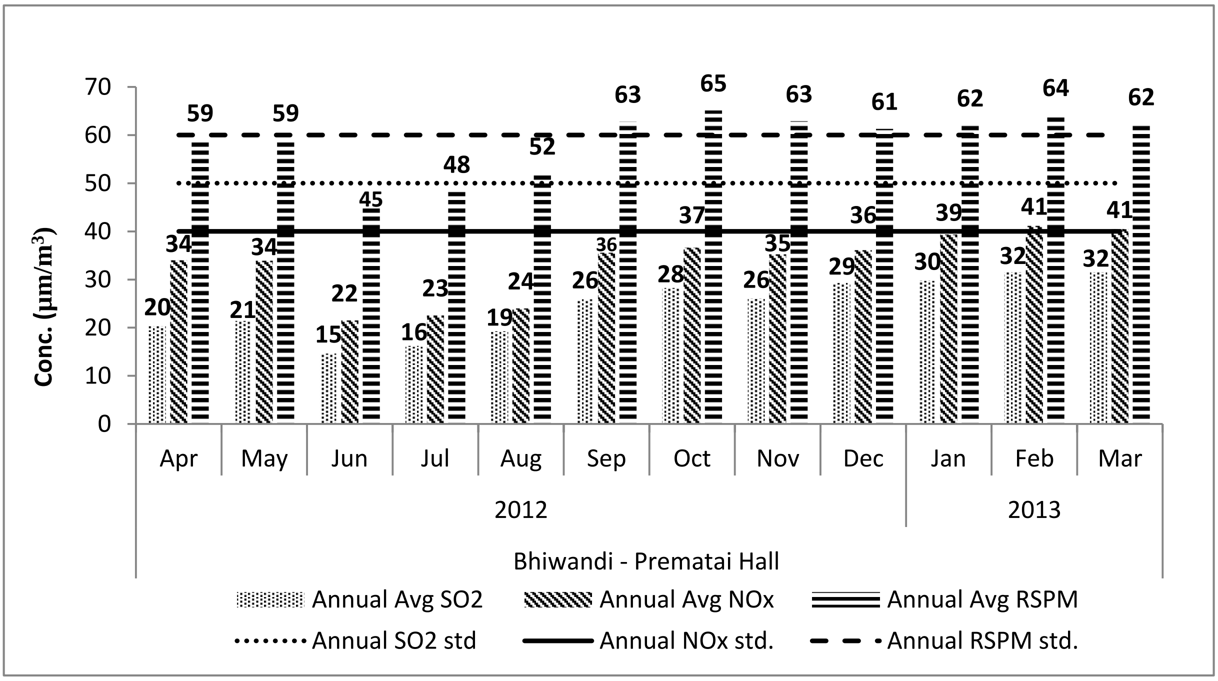


Figure 46: Monthly average readings recorded at Bhiwandi - Prematai Hall under SAMP (2012-13)

Table No. 52: Monthly average readings recorded at Bhiwandi - Prematai Hall under SAMP (2012-13)

FY 2012-13	N	SO_2		NO_X		RSPM	
		Avg. (µg/m³)	*% days of exceedence*	**Avg. (µg/m³)**	*% days of exceedence*	**Avg. (µg/m³)**	*% days of exceedence*
24 hrs. Standards		*80*		*80*		*100*	
Apr	10	20.3	Nil	34.0	Nil	58.9	Nil
May	10	21.4	Nil	33.9	Nil	58.9	Nil
Jun	8	14.6	Nil	21.5	Nil	45.3	Nil
Jul	9	16.2	Nil	22.6	Nil	48.2	Nil
Aug	8	19.3	Nil	24.0	Nil	52.0	Nil
Sep	9	25.9	Nil	35.6	Nil	62.8	Nil
Oct	8	28.3	Nil	36.6	Nil	65.1	Nil
Nov	8	26.0	Nil	35.3	Nil	62.9	Nil
Dec	10	29.3	Nil	36.1	Nil	61.3	Nil
Jan	8	29.8	Nil	39.4	Nil	62.0	Nil
Feb	6	31.5	Nil	41.2	Nil	64.2	Nil
Mar	8	31.5	Nil	40.5	Nil	62.3	Nil

Source: MPCB, 2013
N = No. of observations

Dombivali - MIDC Office Monitoring Station

Date of Commissioning**: May 2012**	
Location Details	
Latitude: 19.214733	**Longitude**: 73.105629
Address: Nr. Gharda Circle, Manpada Road, Dombivali (E)	
Type: Industrial	**Program**: SAMP
Frequency of Monitoring: 2 Day in A week	
Implementing Agency: CHM College, Ulhasnagar	

Table No. 53: Readings recorded at Dombivali - MIDC Office monitoring station under SAMP

Year	**N**	**SO_2**		**NO_X**		**RSPM**	
		Avg. (µg/m³)	***% days of exceedence***	**Avg. (µg/m³)**	***% days of exceedence***	**Avg. (µg/m³)**	***% days of exceedence***
	Standards	***Annual***	***24 hrs***	***Annual***	***24 hrs***	***Annual***	***24 hrs***
		50	*80*	*40*	*80*	*60*	*100*
2012-13	74	36.5	4.1	61.4	23.0	86.0	28.4

Source: MPCB, 2013
N = No. of observations

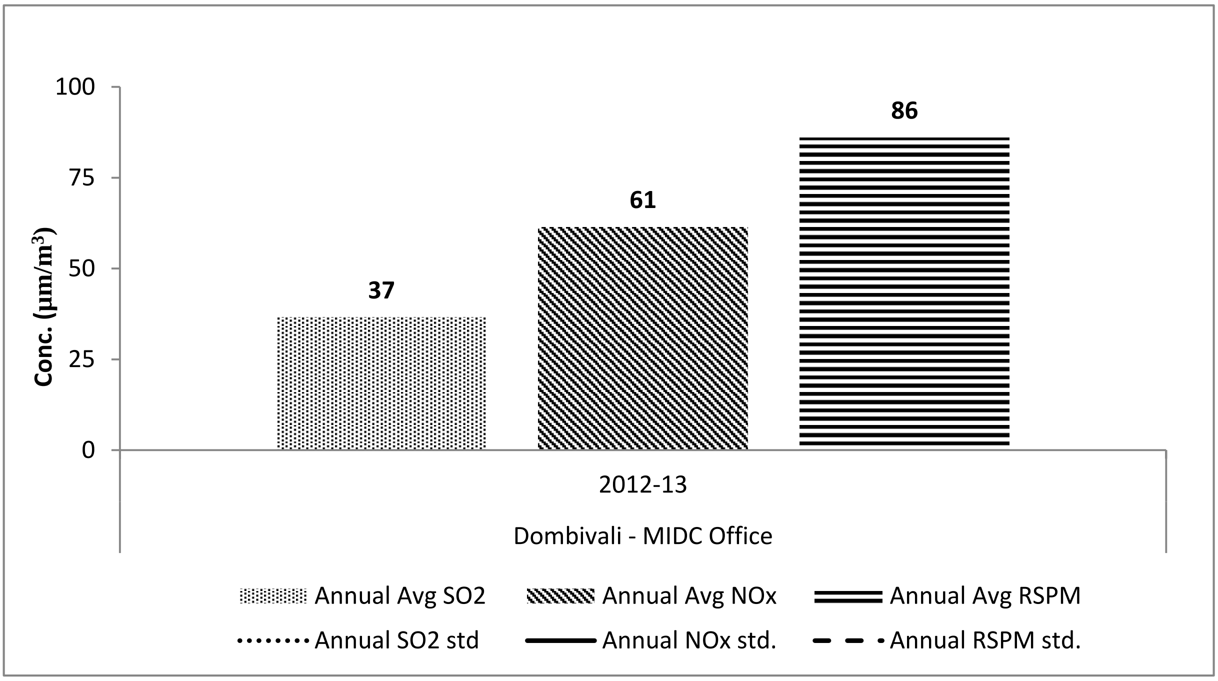


Figure 47: Annual trend in SO_2, NO_X and RSPM levels monitored at Dombivali - MIDC Office monitoring station SAMP

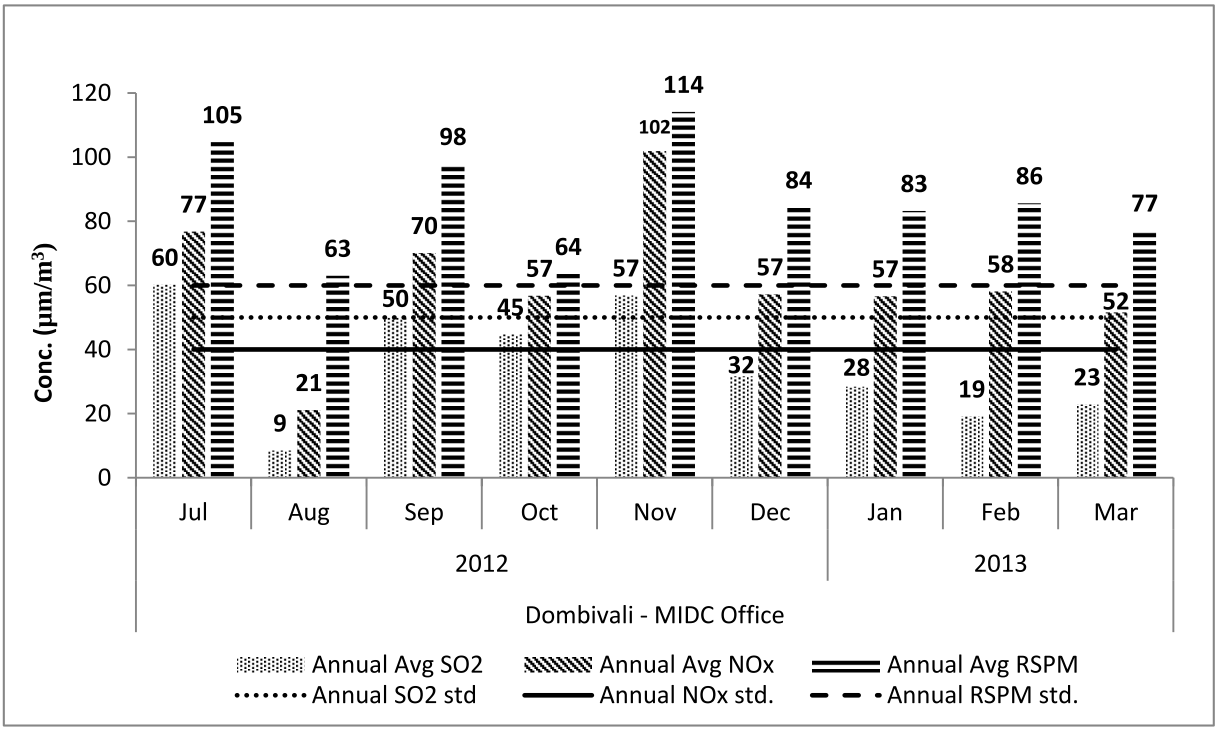


Figure 48: Monthly average readings recorded at Dombivali - MIDC Office monitoring station under SAMP (2012-13)

Table No. 54: Monthly average readings recorded at Dombivali - MIDC Office monitoring station under SAMP (2012-13)

FY 2012-13	N	SO_2		NO_X		RSPM	
		Avg. (µg/m³)	*% days of exceedence*	Avg. (µg/m³)	*% days of exceedence*	Avg. (µg/m³)	*% days of exceedence*
24 hrs. Standards		*80*		*80*		*100*	
Jul	9	60.2	*22.2*	76.8	*44.4*	104.7	*44.4*
Aug	8	8.5	*Nil*	21.1	*Nil*	63.0	*12.5*
Sep	9	49.9	*Nil*	70.1	*22.2*	97.9	*55.6*
Oct	9	44.7	*11.1*	56.8	*11.1*	63.6	*11.1*
Nov	8	56.9	*Nil*	101.9	*87.5*	114.1	*75.0*
Dec	9	31.7	*Nil*	57.2	*11.1*	84.3	*11.1*
Jan	5	28.4	*Nil*	56.6	*Nil*	83.2	*Nil*
Feb	8	19.1	*Nil*	58.1	*25.0*	85.6	*25.0*
Mar	9	22.9	*Nil*	51.6	*Nil*	77.1	*11.1*

Source: MPCB, 2013
N = No. of observations

Kalyan Monitoring Station

Date of Commissioning**: April 2011**	
Location Details	
Latitude: 19.224783	**Longitude**: 73.138926
Address: Kalyan Municipal Building, Kalyan	
Type: Commercial	**Program**: SAMP
Frequency of Monitoring: 2 Day in A week	
Implementing Agency: KDMC	

Table No. 55: Readings recorded at Kalyan monitoring station under SAMP

Year	**N**	**SO_2**		**NO_X**		**RSPM**	
		Avg. (µg/m³)	***% days of exceedence***	**Avg. (µg/m³)**	***% days of exceedence***	**Avg. (µg/m³)**	***% days of exceedence***
	Standards	***Annual***	***24 hrs***	***Annual***	***24 hrs***	***Annual***	***24 hrs***
		50	*80*	*40*	*80*	*60*	*100*
2011-12	82	21.5	Nil	33.8	Nil	71.2	1.2
2012-13	103	29.0	Nil	37.8	Nil	65.4	Nil

Source: MPCB, 2013
N = No. of observations

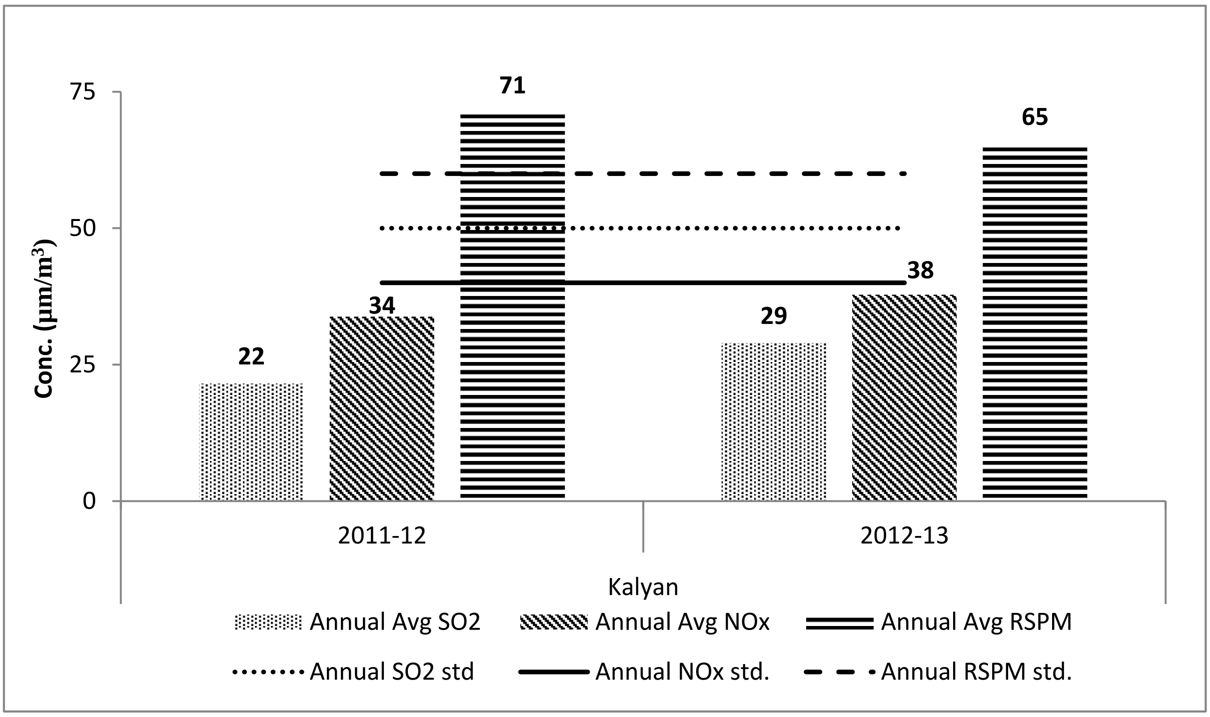


Figure 49: Annual trend in SO_2, NO_X and RSPM levels monitored at Kalyan monitoring station under SAMP

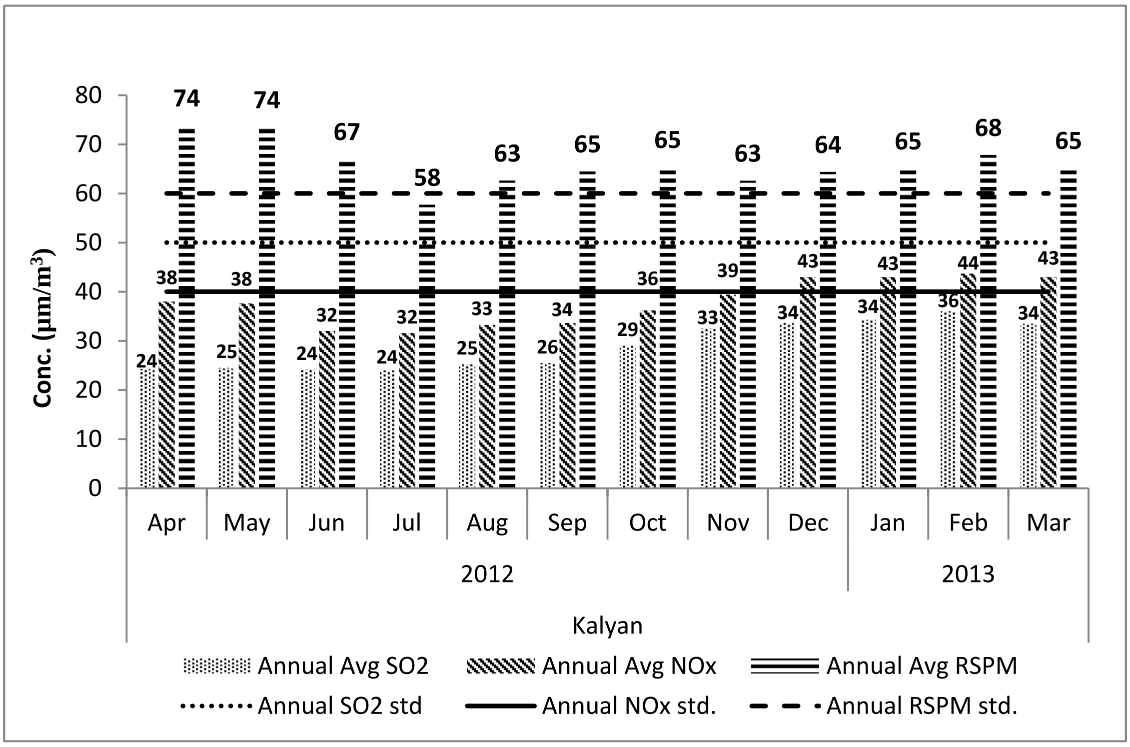


Figure 50: Monthly average readings recorded at Kalyan monitoring station under SAMP (2012-13)

Table No. 56: Monthly average readings recorded at Kalyan monitoring station under SAMP (2012-13)

FY 2012-13	N	SO_2		NO_X		RSPM	
		Avg. (µg/m³)	*% days of exceedence*	Avg. (µg/m³)	*% days of exceedence*	Avg. (µg/m³)	*% days of exceedence*
	24 hrs. Standards	*80*		*80*		*100*	
Apr	7	24.3	Nil	38.0	Nil	73.9	Nil
May	8	24.5	Nil	37.6	Nil	73.5	Nil
Jun	8	24.1	Nil	32.0	Nil	67.0	Nil
Jul	10	24.0	Nil	31.6	Nil	57.7	Nil
Aug	8	25.3	Nil	33.3	Nil	62.6	Nil
Sep	8	25.5	Nil	33.6	Nil	64.5	Nil
Oct	10	29.0	Nil	36.2	Nil	65.4	Nil
Nov	10	32.5	Nil	39.4	Nil	62.6	Nil
Dec	8	33.6	Nil	43.0	Nil	64.4	Nil
Jan	10	34.3	Nil	43.0	Nil	65.1	Nil
Feb	6	36.0	Nil	43.7	Nil	67.8	Nil
Mar	10	33.5	Nil	43.0	Nil	65.2	Nil

Source: MPCB, 2013
N = No. of observations

Annex 12. Calculations for estimating the number of AAQMS in MMR

District/ Taluka	Population as per Census 2011, (Provisional figures)	Existing number of ambient air monitoring stations					Recommended no. of stations			
		Under AAMP by PCB	By ULB	By industries	Regularity in monitoring		For SPM	For SO_2	For NO_X	Recommended min no. of stations
					Intermittent	Regular				
Mumbai City	3145966	4	1		5	5	15	11	10	15
Mumbai Suburban										
Andheri	2421190	1	2		3	3	14	10	10	14
Borivali	3088698		1		1	1	15	11	10	15
Kurla	3816428		2	4	6	6	17	12	10	17
Thane										
Ambernath	567234	2			2	2	7	5	7	7
Bhiwandi	1143081	2	6		8	2	10	8	10	10
Kalyan	1563329	3	7		10	3	11	8	10	11
Thane	3768607	8	63		71	8	17	12	10	17
Ulhasnagar	506937	2			2	2	7	5	7	7
Vasai	1341907		32		32		11	8	10	11
Raigad										
Alibagh	235177			2	2	2	5	4	5	5
Karjat	211792				0		5	4	5	5
Khalapur	207955			2	2	2	5	4	5	5
Panvel	754111	3	6		9	3	9	6	9	9
Pen	195744				0		5	3	5	5
Uran	159103			3	3	3	5	3	5	5
Total										**160**

Annex 13. Minutes of Meetings conducted with ULB's for Climate Change

Interviews compiled

Corporations and Councils

Vasai-Virar Municipal Corporation (VVMC)

Discussion date: 7th June 2013

Government attendees

1. Mrs. Sangeeta Dhaigude , Deputy Municipal Commissioner, Vasai-Virar Municipal corporation.

TERI attendees:

1. Ms. Aditi Phansalkar, Research Associate, TERI, Mumbai
2. Ms. Prutha Lanjekar, Research Associate, TERI Mumbai.
3. Mr. Pradeep Desai, Consultant, TERI Mumbai.

Discussion summary

1. **Awareness about climate change**

   The respondent was quite aware about the ongoing global climate change discourses. Having received training in Germany in Sustainable Development, she had a holistic perspective on the subject. She emphasised on the fact that the damages caused to nature by mankind are irreversible and what is left with us needs to be preserved with immediate attention. Attributing the causes to the anthropogenic impacts on nature, she stressed on taking proactive and collective initiatives at all levels.

Picture No. 1: Discussions with Mrs. Sangeeta Dhaigude, Deputy Commissioner, VVMC

2. Observations and perceptions

The respondent has definitely observed a conspicuous change in the patterns of climatic parameters like rainfall and temperatures Shift in monsoon arrival, increase in the discomfort levels, and decrease in winter seasons were some of the key observations of Mrs. Dhaigude. She also expressed concerns over the fact that these changes may have prominent impacts on agriculture as well as water.

3. Mitigation measures and initiatives undertaken

VVMC has undertaken several initiatives to curtail the impacts on Environment. Plastic is banned in the region. There are several initiatives undertaken by the corporation to educate and make the masses aware about the Reduce, Reuse and Recycle concept. While, this is being done, other initiatives like afforestation program, especially the mountains nearby are focused presently. 7,00,000 tree plantations are in pipeline. Furthermore, VVMC has also made available the tree saplings free of cost to the aspiring individuals in order to encourage the citizens to plant more trees in the vicinity. There are also some voluntary guidelines followed with in the corporation underlining a norm, where if one tree is cut for any developmental purpose 5 trees need to planted elsewhere to mitigate the impact. Disaster Management cell exists in the corporation, but presently looks after disasters like fire incidences, tree fells, landslides etc.

4. Preparedness of the region towards future climate disasters

The Maharashtra State Climate Change Adaptation Action Plan, prepared by TERI for Government of Maharashtra was discussed. While vulnerabilities and future impacts of climate change were discussed, the present situation of the corporation and its preparedness towards such events was also assessed. Mrs. Dhaigude expressed concern over the increasing flood situations which are frequenting the region. With proper leadership, proactive measures and a good level of understanding of all the government policies in place and its implementation together can reduce the impact of future climate variability.

Mira-Bhayendar Municipal Corporation (MBMC)

Discussion date: 7th June 2013

Government attendees:

1. Mr. Panpatte, Deputy Municipal Commissioner, Mira-Bhayendar Municipal Corporation.

TERI attendees:

1. Ms. Aditi Phansalkar, Research Associate, TERI, Mumbai
2. Ms. Prutha Lanjekar, Research Associate, TERI Mumbai.
3. Mr. Pradeep Desai, Consultant, TERI Mumbai.

Discussion summary

1. **Awareness about climate change**

   The respondent related the changes in the climate as a product of industrialisation and rapid urbanisation. Various newspapers and news formed the major source of information for him. While this was known, the respondent was not very well versed with the concepts like sea level rise, future increase in the rainfall, changing global temperature trends etc. Conferences and workshops also formed another major source of information for the gaining knowledge on the subject. The concept of climate change was first heard by Mr. Panpatte some 5-7 years back. Having gained training in Urban Management, Mr. Panpatte considered this subject of critical importance given the increasing urban context.

Picture No. 2: Discussion with Mr. Panpatte, Deputy Municipal Commissioner, MBMC

Observations and perceptions

Mr. Panpatte observed a definite change in the rainfall patterns on the past 4-5 years. Uncertain and often delayed arrival of monsoon was one major change highlighted by him. Changes in the annual averages of rainfall are observed. Decrease in the humidity levels have been observed, thus making the weather drier. Further he also mentioned about the increased temperatures every year resulting in the decrease in comfort levels and increase in the use of air conditioners in the urban areas. However, Mr. Panpatte also attributed the causes of changing climate, to increase in the number of buildings. Further he agreed to the fact the unprecedented increase in the concretisation has resulted in the increased urban temperatures.

As very interestingly pointed out by Mr. Panpatte, the decrease in the open spaces in the city, which form the natural shock absorbers for any given urban agglomeration, are being encroached today, thus making the cities more vulnerable to rise in temperatures. He further added that, the human interferences and his greed to conquer upon nature are the key driving forces of these global disturbances.

2. Mitigation measures and initiatives undertaken

MBMC has also taken few initiatives to preserve the environmental impacts. The corporation has Disaster Management Cell which houses 4-5 people and is active only for the four months of monsoon. Moreover disasters like, tree fall, blockages, flood rescue etc are covered. The personnel in the department send alerts to all the ward offices regarding any of the aforementioned disaster.

3. Preparedness of the region towards future climate disasters

The Maharashtra State Climate Change Adaptation Action Plan, prepared by TERI for Government of Maharashtra was discussed. While vulnerabilities and future impacts of climate change were discussed, the present situation of the corporation and its preparedness towards such events was also assessed. When asked about the preparedness of the region towards the future vulnerabilities, Mr. Panpatte expressed his concern over the same. According to him, the institutional arrangements like the co-ordination between various departments need to be strengthened. Also he expressed his willingness to undergo training on this very subject of critical importance.

Bhiwandi-Nizampur Municipal Corporation (BNMC)

Discussion date: 11th June 2013

Government attendees

1. Mr. Ramnani, Environmental Officer, Bhiwandi-Nizampur Municipal Corporation.
2. Mr. Godambe, Head, Disaster Management Cell, Bhiwandi-Nizampur Municipal Corporation.

TERI attendees:

1. Ms. Aditi Phansalkar, Research Associate, TERI, Mumbai
2. Ms. Prutha Lanjekar, Research Associate, TERI Mumbai.
3. Mr. Pradeep Desai, Consultant, TERI Mumbai.

Discussion summary

1. **Awareness about climate change**

   The respondents had a fair idea about the changing climate. Mr. Godambe was well versed with the global climate change discourse. The most common source of information on the climate change issues for Mr. Godambe was research papers and news. While he was aware of the natural changes that are taking place in the atmosphere around us, he was also assured of the fact that these changes are human driven. He explained his knowledge on the subject by citing various examples to us.

Picture No. 3: Discussion with Mr. Ramnani, Environmental Officer, BNMC

2. Observations and perceptions

The respondents observed there is an observed increase in the temperatures in the past 6-8 years. Further to this, they also experienced variations in the day and night temperatures. As far as rainfall is concerned, they did not find much change except in the arrival and distribution. Mr. Ramnani also stressed on the probability of increase in the water logging events given the present situation of increase in the urban population in the cities. As mentioned by Mr. Godambe, disaster management plans presently lack the future impacts perspective and require stronger interdepartmental co-ordination. In the purview of the discussion, very interestingly Mr, Godambe addressed a gap in the afforestation programs undertaken. He mentioned about the lack of knowledge regarding the types of plant that are often considered for planting. If they are not native to the region, the species discourage the local biodiversity thus impacting the overall ecosystem balance.

Mr. Godambe believed that if human is responsible for disturbing the balance of nature, he can also repair it with right measure and prudent planning.

3. Mitigation measures and initiatives undertaken.

The corporation seemed a bit passive on the environmental issues. There is a functional disaster management cell for the region. Presently it works for 4 months. The corporation aims to make it work throughout the year.

4. Preparedness of the region towards future climate disasters

The Maharashtra State Climate Change Adaptation Action Plan, prepared by TERI for Government of Maharashtra was discussed. While vulnerabilities and future impacts of climate change were discussed, the present situation of the corporation and its preparedness towards such events was also assessed. Overall the corporation seemed aware about the environmental issues and but did not have the necessary orientation to take appropriate measure to preserve the environment owing to two major aspects. One is that these officers are not technically trained on environmental issues or from a proper educational background of environmental studies and hence lack the orientation. Secondly, tasks such as disaster management, afforestation are additional to their existing/basic tasks; they tend to give last preference to it. The increase in the quantity of waste is the issue to be addressed with immediate effect to averse the negative impacts on health and well as on the environment.

Kalyan Dombivali Municipal Corporation (KDMC)

Discussion date: 11th June 2013

Government attendees

1. Mr. Anil Lad, Deputy Municipal Commissioner, Kalyan Dombivali Municipal Corporation.
2. Mr. Gopal Bhangare, Deputy Engineer, Environment, Kalyan Dombivali Municipal Corporation.

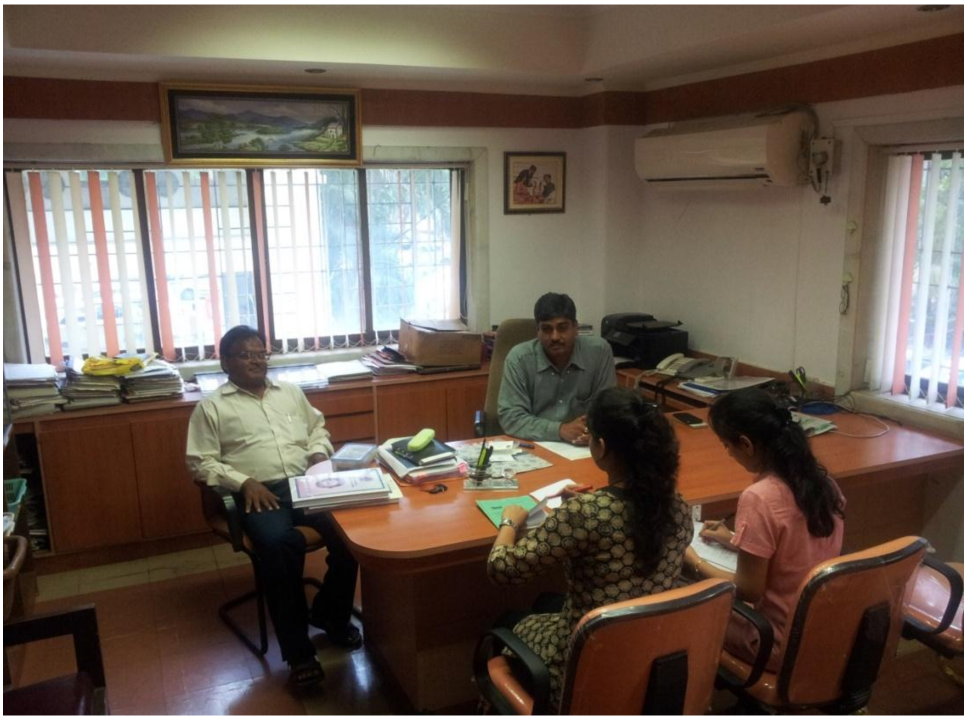
TERI attendees:

1. Ms. Aditi Phansalkar, Research Associate, TERI, Mumbai
2. Ms. Prutha Lanjekar, Research Associate, TERI Mumbai.
3. Mr. Pradeep Desai, Consultant, TERI Mumbai.

Discussion summary

1. **Awareness about climate change**

   Mr. Lad seemed well versed with the global climate change deliberations. His source of information about the climate change and related issues was research papers and scientific journals apart from the local newspapers. Various aspects related to Kyoto protocol, Global Warming, Carbon credits were discussed. Mr. Lad considered climate change to be a global phenomenon impacting local region, while also disturbing the atmospheric balance. He first confronted with this term some 5 years back.



Picture No. 4: Discussion with Mr. Anil Lad, Deputy Municipal Commissioner, KDMC

2. Observations and perceptions

Mr. Lad was affirmative on the fact that climate change is result of unprecedented pumping of CO_2 in the atmosphere and hence largely attributed the impacts to the anthropogenic activities. While mentioning this, he also mentioned about the absence of awareness about such issues, especially in terms of the future catastrophic impacts leads to lack of action in this area. Mr. Lad further mentioned that there have been definite changes in the regular rainfall patterns. Though the annual averages have remained the same, the distribution of rainfall has lost its balance owing to more flood events.

In terms of the increase in the temperatures, he believed that the developed/north countries like, United States and Europe would especially face the brunt of climate change. Further he agreed to the fact that the south Asian countries would be facing more disasters given the changing climate and the increase in the population concentrations in these regions.

3. Mitigation measures and initiatives undertaken.

There exists and early warning system for the region. Alert messages are sent by the corporation to all the district officials and ward officials through wakie talkie. Further this information is disseminated in the wards through a moving vehicle (often an auto rickshaw) and the masses are made aware. The corporation also housed a Disaster Management cell, which looked after various types of disasters.

According to Mr. Lad, excessive flooding can happen in KDMC only when the water from the Barvi dam is released. An engineer deputed by the corporation is under constant communication with the corporation to inform them about such situations and the alerts are released accordingly. While this is done there are disaster management plans which are articulated regularly every year.

A very detailed disaster management plan is prepared by KDMC, based on participatory methods like transect walks and discussions with the communities to mark the vulnerable flood spots.

4. Preparedness of the region towards future climate disasters

The Maharashtra State Climate Change Adaptation Action Plan, prepared by TERI for Government of Maharashtra was discussed. While vulnerabilities and future impacts of climate change were discussed, the present situation of the corporation and its preparedness towards such events was also assessed. Mr. Lad believed that the KDMC is well prepared for any flood or other extreme situation that can occur in the region.

Ulhasnagar Municipal Corporation (UMC)

Discussion date: 11th June 2013

Government attendees

1. Mr. S. G. Pawar, Deputy Municipal Commissioner, Ulhasnagar Municipal Corporation.
2. Mr. Ramesh B. Shirke, Head, Disaster Management Cell, Ulhasnagar Municipal Corporation.

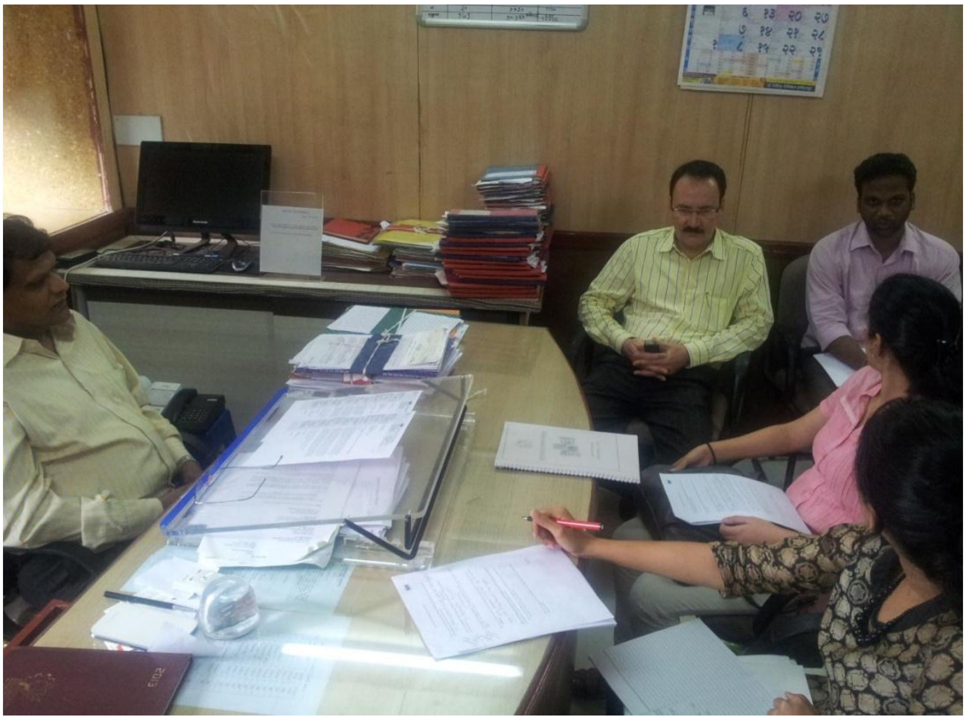
TERI attendees:

1. Ms. Aditi Phansalkar, Research Associate, TERI, Mumbai
2. Ms. Prutha Lanjekar, Research Associate, TERI Mumbai.
3. Mr. Pradeep Desai, Consultant, TERI Mumbai.

Discussion summary

1. **Awareness about climate change**

   The respondents were not very well versed with the challenges the city may face due to climate change impacts. According to the respondents, the climate change is also causing the ozone to deplete and resulting into more intrusion of UV rays on the earth. The most common source of information on these issues was newspaper and news channels. No other source was either known or used. The respondents had heard about climate change first in the year 2000 in a conference and since then continued reading about the subject.



Picture No. 5: Discussion with the Mr. S. G. Pawar, Deputy Commissioner, UMC

2. Observations and perceptions

The respondents observed changes in the rainfall patterns and delayed arrivals of monsoon. While they observed this, they also mentioned about the increased heat and decreased humidity in the region. Being a coastal region, Mr. Lad was surprised to experience heat this year. While he attributed the cases to industrialisation, he said local level negligence with respect to the environment is also major causes of concern. Interestingly he also experienced the coldest winter in last 15 years in Mumbai. However he also accepted the fact that these changes may or may not be due to global atmospheric changes caused by humans, but could be just variations, which are occurring naturally. Prominent intra-seasonal and inter-seasonal variations are observed.

3. Mitigation measures and initiatives undertaken.

There is an active disaster management cell which is responsible for dissemination of the alerts in the city. The alerts are sent through SMS and voice messages through moving vehicles. Disaster management plan, highlighting all the emergency number and persons in charge is prepared. Part from these measures, there are other disasters like fire, landslides, drowning etc. are addressed by the cell.

4. Preparedness of the region towards future climate disasters

The Maharashtra State Climate Change Adaptation Action Plan, prepared by TERI for Government of Maharashtra was discussed. While vulnerabilities and future impacts of climate change were discussed, the present situation of the corporation and its preparedness towards such events was also assessed. Mr. Pawar believed with more efforts and by mainstreaming climate change impacts from the TERI's project, the city could be made well prepared for any flood or other extreme situation that can occur in the region.

Uran Municipal Council:

Discussion Date: May 30th 2013

Government Attendees:

1. Mr. Hitesh, Patry worker.
2. Mr. Bhalchandra Mhatre, Party worker
3. Rajesh Bhagwan Koli, representative of fishermen community (local).
4. Nitil Patil, Chairman, Uran Municipal Council.
5. Z.R Mane, Sub officer, Engineer.
6. Kaushik Shah, BJP representative.
7. Mahesh Loute, Chairman of Water Supply Committee.
8. Prasad Mandelkar, representative of Utsavi NGO

TERI attendees:

1. Ms. Aditi Phansalkar, Research Associate, TERI, Mumbai
2. Ms. Prutha Lanjekar, Research Associate, TERI Mumbai.
3. Mr. Pradeep Desai, Consultant, TERI Mumbai.

Picture No. 6: Discussion with the Uran Municipal Council Authorities

Discussion Summary

- Mr. Mahesh Loute said, he has heard about climate change long back and the most common source of information about this subject is news, journals and social communication.
- He raised his concern over the fact that fisherman communities are more likely to get affected especially in Uran as it has biggest fish catchment area in Asia.
- While climate change is a global phenomenon, he agreed to the fact that the local level activities like, use of air conditioners and carbon emissions due to high usage of vehicles has contributed to climate change.
- Mr. Loute expressed about his need to discuss the expected rainfall not just before onset of monsoon but few weeks before monsoon for the municipal authorities to prepare themselves.
- While discussing with the extreme event situation, Mr Loute shared an experience in which Jambul pool in Uran was flooded. While giving some excerpts on the 26th July flood event, he mentioned about the heavy downpour happening in most of the parts in Mumbai but stressed on the fact that no villages near the shore had any problem but the villages which were within the radius of 20-30 km faced inundation.
- Tree plantation and ban on the plastic is the only strategy initiated under the broader umbrella of environmental conservation
- For disaster management, state collector office section has an emergency cell which has 4 officers they work 24 hours.
-

Mora Koliwada Machchimar Co-op society Ltd, Karanje, Uran

(Video clips of the interview available)

Discussion date: 12th June 2013

Participants from the association

1. Mr. Parshuram Koli, Ex-committee member, Mora Association.
2. Mr. Kiran Koli, Vice Chairman, Mora Association.
3. Mr. Akash Koli, Member, Karanje Society.
4. Mr. Manohar Patil, Member, Mora Association.
5. Mr. Ganesh, Fisherman.
6. Mr. Ajay Koli, Fisherman.

TERI attendees:

1. Mr. Aniruddha Dhamorikar, Research Associate, TERI, Mumbai.
2. Ms. Aditi Phansalkar, Research Associate, TERI, Mumbai.
3. Ms. Prutha Lanjekar, Research Associate, TERI Mumbai.
4. Mr. Pradeep Desai, Consultant, TERI Mumbai.

Discussion summary

Background

The respondents were representatives of Mora Fishermen Association in Uran. Fishing is the backbone of the association's economy. Traditional as well as the modern methods of fishing are used by the fishermen. The various types of fishes found in the sea are Prawns, sharks, crabs, Bombay duck, Pompreft, Gold fish, ribbon fish etc. The fishing activity stalls during the monsoons. Only net fishing is practices if required in these days.

Picture No. 7: Discussions with the Mora Fishermen Association, Uran.

Awareness and perceptions about the changes observed in climate.

1. The community was well-versed with the changes in the climatic parameters like wind and rainfall. The community agreed to the fact that there has been a definite change in the rainfall patterns especially with respect to quantity and distribution of the rainfall in the past 5-7 years.
2. Further, as discussed, they also stressed on the changes in the wind direction. They find the winds to be harsher as compared to few years back.
3. Interestingly the community was affirmative on the increase in the sea level rise in their region. One of the major reasons attributed to the rise in the sea level were the unprecedented reclamations taking place in the region. While this was said, the community also mentioned about the destruction caused to the paddy fields owing to the increasing water logging events. The paddy fields remain inundated in the monsoon resulting in the stalling the agriculture activities in the region.
4. Apart from the local sea level rise, there have been no changes in the sea temperatures, which are equally significant for a good fish catch.

Impacts of the climatic changes on fishing activity.

1. The community mentioned about a decline in fish catch over 5-8 years. Possible reasons could be attributed to the changes in the tidal flows, the winds and the increasing fishing population. Absence of stricter norms and their monitoring for compliance is absent in the region.
2. Further, they mentioned that if rainfall becomes untimely or if the cycle is altered, it directly affects the fish catch. Warmer climate affects the fishes, their breeding and ultimately their fish catch.
3. The fishing community presently has walkie-talkie instruments, on which they receive the information about extreme events, but demanded more detailed and frequent forecasting in this regard for better planning of their activities. At present no forecast or weather advisories reach the communities.
4. Generally the Fishermen community follow the Hindu calendar forecast, which according to them are more reliable and is a part of their traditional methods. One of the key observations made by the community is the warnings given by nature itself prior to any event like cyclone etc. As per the community, there are prominent bubbles which emerge in deep sea, giving an indication of the forthcoming cyclone.

Other developmental issues *(Highlights)*

1. As one of the shocking revelations, the fishermen community mentioned about the chunk of plastic waste found in their fishing nets. In the past 8 years, due to industrialisation activities, in the nearby vicinity, there has been an increased level of plastic waste in the water.
2. The industries washing their oil tanks release the contaminated water in the sea, resulting in the increased pollution levels in the water. The communities foresee the situation getting worse in the coming years if this act is not regulated.
3. The community requested more attention in this regard from the Pollution Control Board.
4. According to the community, there is an urgent need for enforcement of the Coastal Zone Regulation (CRZ) and Maritime Protection Authority (MPA) rules to curtail the degradation of the coastal ecosystems.
5. One of the participants mentioned about the deepening of the sea bed activity undertaken in JNPT area to allow the smooth entrance of large trawler boats. While this is happening, there was scepticism amongst the community about the health and well-being of the fishes in the water, as the chemicals released due to the blasting, ma impact the fishes directly.

Annex 14. Questionnaire guide: Department Officials

Name of the respondent/s and their telephone number:

a. ……………………………………………………………………………………………………

b.

……………………………………………………………………………………………………

Name of the corporation/council:

……………………………………………………………………………………………………

Name of the TERI Interviewer:

……………………………………………………………………………………………………

1. Have you heard about Climate Change? If yes, then what do you know about this?
   ………………………………………………………………………………………
   ………………………………………………………………………………………
   ………………………………………………………………………………………
   ………………………………………………………………………………………
2. When did you first hear about it?
   ………………………………………………………………………………………
   ………………………………………………………………………………………
3. What is the most common medium through which you get the information about this?
   ………………………………………………………………………………………
4. What is your perception about this phenomenon and what do you think could be the possible reasons for the same?
   ………………………………………………………………………………………
   ………………………………………………………………………………………
   ………………………………………………………………………………………
   ………………………………………………………………………………………
5. Do you think there are changes in the following parameters of the climate around you
   a. Rainfall? Yes / No?
      ………………………………………………………………………………
      i. If yes then what change and since when?
         ………………………………………………………………………
         ………………………………………………………………………
   b. Temperature? Yes / No?

………………………………………………………………………………………

i. If yes then what change and since when?

………………………………………………………………………………………
………………………………………………………………………………………

c. Wind speeds and direction? Yes / No?
………………………………………………………………………………………
………………………………………………………………………………………

i. If yes then what change and since when?
………………………………………………………………………………………
………………………………………………………………………………………

6. Have you ever experienced extreme climatic situations like floods, heat waves or cyclones in your lifetime and what was your experience?
………………………………………………………………………………………
………………………………………………………………………………………

7. Has your corporation/ council taken any initiatives in this regard? (Directly or indirectly?) What are those?
………………………………………………………………………………………
………………………………………………………………………………………
………………………………………………………………………………………

8. Is there disaster management cell in your corporation? What are its roles?
………………………………………………………………………………………
………………………………………………………………………………………
………………………………………………………………………………………
………………………………………………………………………………………

9. Are there any response mechanisms like early warning systems devised by your corporation/ MMRDA?
………………………………………………………………………………………
………………………………………………………………………………………
………………………………………………………………………………………
………………………………………………………………………………………

***After this point you may discuss with them the findings of the SAPCC with respect to precipitation and temperature increase in future and build a scenario.*

10. Do you think MMR region is well prepared to face extreme situations like 26 July? If yes what makes you say this? And If **No** then why?
………………………………………………………………………………………
………………………………………………………………………………………

……………………………………………………………………………………………
……………………………………………………………………………………………

11. What do you think are the key challenges for the MMR when we talk about future climate change/variability?

……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………

Questionnaire guide: Agriculture

Date:

Place:

Name of the participants:

1. ---

2. ---

Name of the TERI interviewer:

Q.1: Since when are you practicing agriculture?

Q.2: What is the average land holding size?

Hectares/ acres

Q.3: What are the common crops produce in the area?

Q.4: What is the approximate produce per hectare/ acre?

Q.5. a: Do you think/have observed a change in the rainfall pattern? Yes / No

b. If yes, what changes have you observed?

Q.6. a: Do you think/have observed a change in the temperature pattern? Yes / No

b. If yes, what changes have you observed?

Q. 7: What are the impacts observed, considering the change in rainfall/ temperature?

Q.8: Are there any incidences like Salt Water Intrusion in your area? If yes, how has it affected the produce?

Q.9: Since when are these impacts more prominent?

Q. 10: What initiatives are taken to tackle these impacts at an individual level?

Q.11: What initiatives are taken to tackle these impacts at the council level?

Q. 12: What initiatives/ policies need to be taken to tackle the impacts?

Extra notes

Questionnaire guide: Fisheries

Date:

Place:

Name of the participants:

1.

2.

3.

Name of the TERI interviewer:

Q.1: Since when are you practicing Fishing?

Q.2: What are the various types of practices?

Q.3: Fish types?

Q.4: How much is the approximate catch (Daily/Monthly/Annual)?

Q.5. a: Do you think/have observed a change in the rainfall pattern? Yes / No

b. If yes, what changes have you observed?

Q.6. a: Do you think/have observed a change in the temperature pattern? Yes / No

b. If yes, what changes have you observed?

Q. 7: What are the impacts observed, considering the change in rainfall/ temperature?

Q.8 Any changes observed in Winds (Speed and Direction)/Humidity (reduced / increased)?

Q.9 Do you receive any early warnings w.r.t to cyclone, change in wind directions, thunderstorms etc? Since when & how?

Q.10: Have you observed changes in the sea level? Is there shoreline erosion observed?

Q.12: Has there been any changes in the sea temperatures? If yes, is it affecting fish catch?

Q.11: Which areas in your area flood more? Have they been vulnerable always?

Q.9: Since when are these impacts more prominent?

Q. 10: What initiatives are taken to tackle these impacts at an individual level and council?

Q.11: What initiatives are taken to tackle these impacts at the council level?

Q. 12: What initiatives/ policies need to be taken to tackle the impacts?

Questionnaire with Disaster Management Department of MCGM

Date: **Location:** **Time:**

Name of the officer and Designation:

Contact details:

Q.1: Do you experience any variations in the climate patterns? Any remarks on the trend of these disasters in terms of frequency, intensity, impact?

Q. 2: What initiatives are taken at the corporation level other than formulating the disaster management plan to increase the preparedness of the citizens to disasters induced by CC?

Q.3: Based on the Greater Mumbai Disaster Management Action Plan, are the plans for the listed disasters formulated based on the recent climatic variations? Methodology? Who prepares the action plan?

Q.4: Do you follow the warnings issued by IMD? Yes / No. Why? Since MCGM has its own AWS, does that dept issue any warning? Do these warning help in any way to increase our preparedness or coordinating any SOP activities?

Q.5: Do you think there is any need for special emphasis for disasters such as floods, cyclones and landslides considering the current climatic changes?

Q.6: What constraints do you face while implementing disaster mitigating measures?

Q. 7: Do you think that our city is prepared for higher amplitude disasters? E.g. 26 July

Q. 8: What do you think are the key challenges while mitigating the impacts of disasters at the city level?

Q. 9: What are your recommendations to overcome these challenges?

Any other additional remarks

Questionnaire with Disaster Management Department of NMMC

Date: **Location:** **Time:**

Name of the officer and designation:

Contact details:

Q.1: Do you experience any variations in the climate patterns? Any remarks on the trend of these disasters in terms of frequency, intensity, impact?

Q. 2: What initiatives are taken at the corporation level other than formulating the disaster management plan to increase the preparedness of the citizens to disasters induced by CC?

1. Climate Risk Management Project with GoI and UNDP

Q.3: Based on the Disaster Management Action Plan, are the plans for the listed disasters formulated based on the recent climatic variations? Methodology? Who prepares the action plan?

Q.4: Do you follow the warnings issued by IMD? Yes / No. Why? Since MCGM has its own AWS, does that dept issue any warning? Do these warning help in any way to increase our preparedness or coordinating any SOP activities?

Q.5: Do you think there is any need for special emphasis for disasters such as floods, cyclones and landslides considering the current climatic changes?

Q.6: What constraints do you face while implementing disaster mitigating measures?

Q. 7: Do you think that our city is prepared for higher amplitude disasters? E.g. 26 July

Q. 8: What do you think are the key challenges while mitigating the impacts of disasters at the city level?

Q. 9: What are your recommendations to overcome these challenges?

Any other additional remarks

Annex 15. Details of consultations/meetings held for climate change

Municipal Corporations						
Sr.no	**Organisation/municipal corporation**	**Name**	**Designation**	**Contact**	**Address**	**Date of meeting**
1	Vasai Virar Municipal Corporation (VVMC)	Mrs. Sangeeta Dhaigude	Deputy Municipal Commissioner	8007833322	Vasai Virar Municipal Corporation, Virar (East)	7th June 2013
2	Mira-Bhayendar Municipal Corporation (MBMC)	Mr. Panpatte.	Deputy Municipal Commissioner	7738314777	Mira Bhaindar Municipal Corporation, Bhaindar (West)	7th June 2013
3	Bhiwandi-Nizampur Municipal Corporation (BNMC)	Mr. Ramnani.	Environmental Officer.	9867251922	Bhiwandi Nizampur Municipal corporation, near old jakat naka	11th June 2013
		Mr. Godambe.	Head, Disaster Management Cell,	9850253043		
		Mr. Sanjay Keni.	Environmental Chemist	9921729900		
4	Kalyan Dombivali Municipal Corporation (KDMC)	Mr. Anil Lad.	Deputy Municipal Commissioner,	0251 2203621	Kalyan Dombivli Municipal Corporation Shankarrao Chowk, Kalyan West - 421301	11th June 2013
		Mr. Gopal Bhangare	Deputy Engineer.			
5	Ulhasnagar Municipal Corporation (UMC)	Mr. S. G. Pawar.	Deputy Municipal Commissioner.	9819168035/ 9323819148	Khadegolwadi, Vitthalwadi, Ulhasnagar, Maharashtra 421004	11th June 2013
		Mr. Ramesh B. Shirke	Head, Disaster Management Cell.			

Municipal Corporations						
6	Municipal Corporation of Greater Mumbai (MCGM)	Mr. S.S Shinde	Deputy Municipal Commissioner, Disaster Management Cell	9820702503	MCGM Sabhagruh Rd, Dhobi Talao, Mumbai, Maharashtra 400001	25th July 2013
Municipal Councils						
1	Uran Municipal Council	Mahesh Loute	Chairman of Water Supply Committee.	9975719419	Uran Municipal Council, Uran	30th May 2013
2	Panvel Municipal Council	Mr. S G Patankar	Chief Officer	9322142857	Panvel Municipal Council, Navi Mumbai, Maharashtra 410206	
3	Alibagh Municipal Council	V.S Kamble	Superintendent	02141 222015	Alibagh Municipal Council, Alibagh, Maharashtra	
Please note the detailed minutes of all the aforementioned meetings have been documented with pictures and would be a part of the Final report						

Annex 16. Wind speeds analysis in MMR

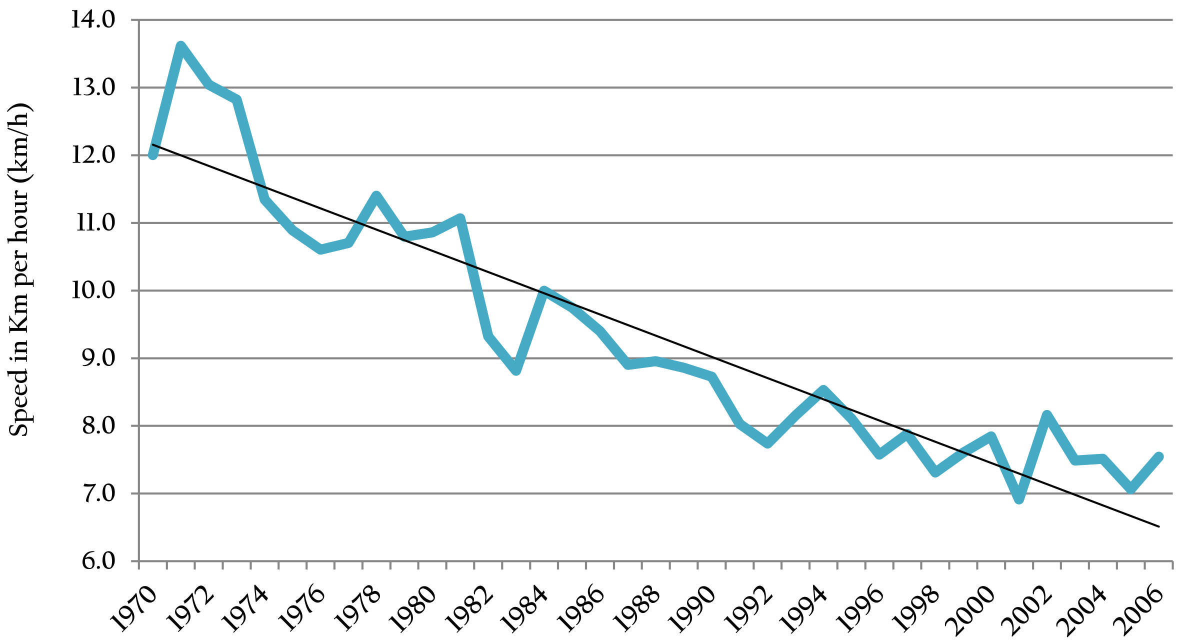


Figure 51: Trends in Wind Speeds in MMR (1970-2012)

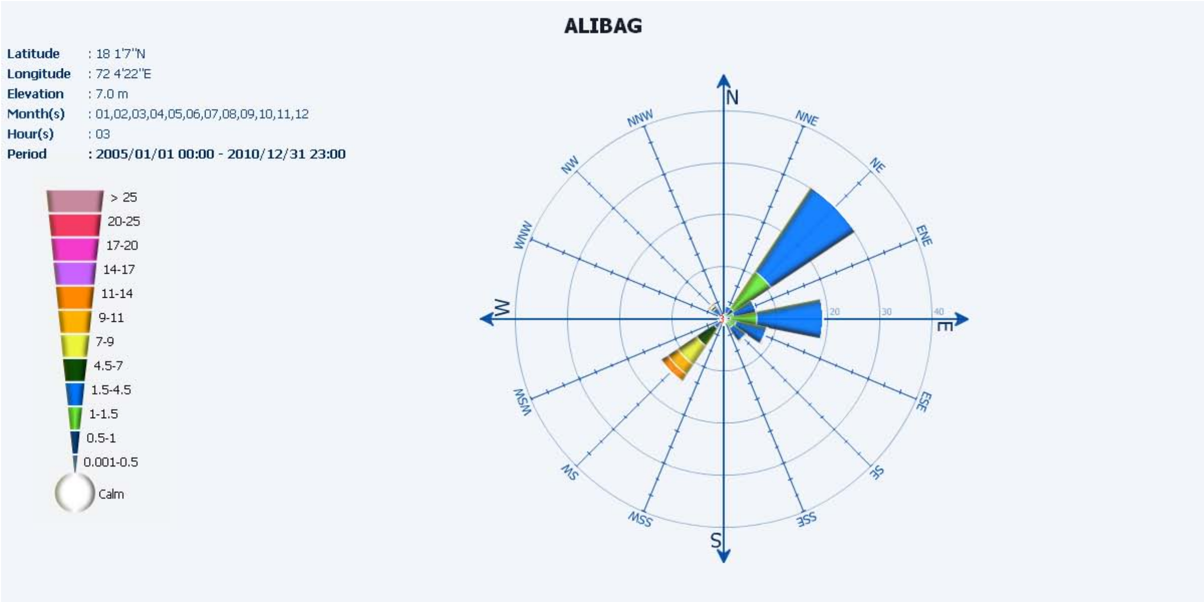


Figure 52: Wind speed and direction at 0830 hrs

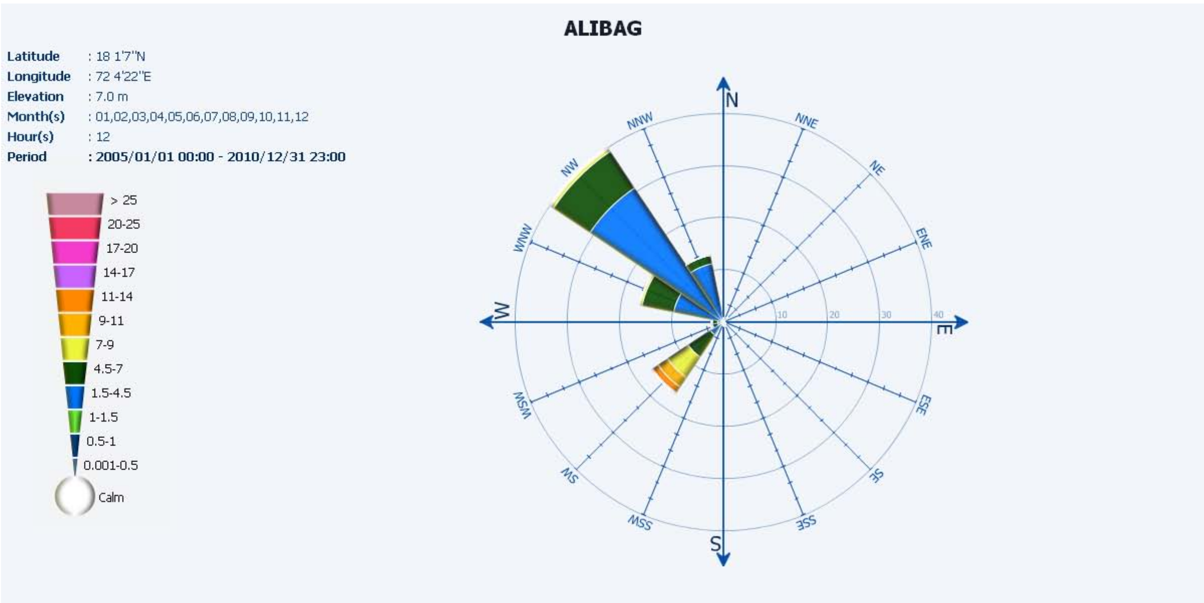


Figure 53: Wind speed and direction at 1730 hrs

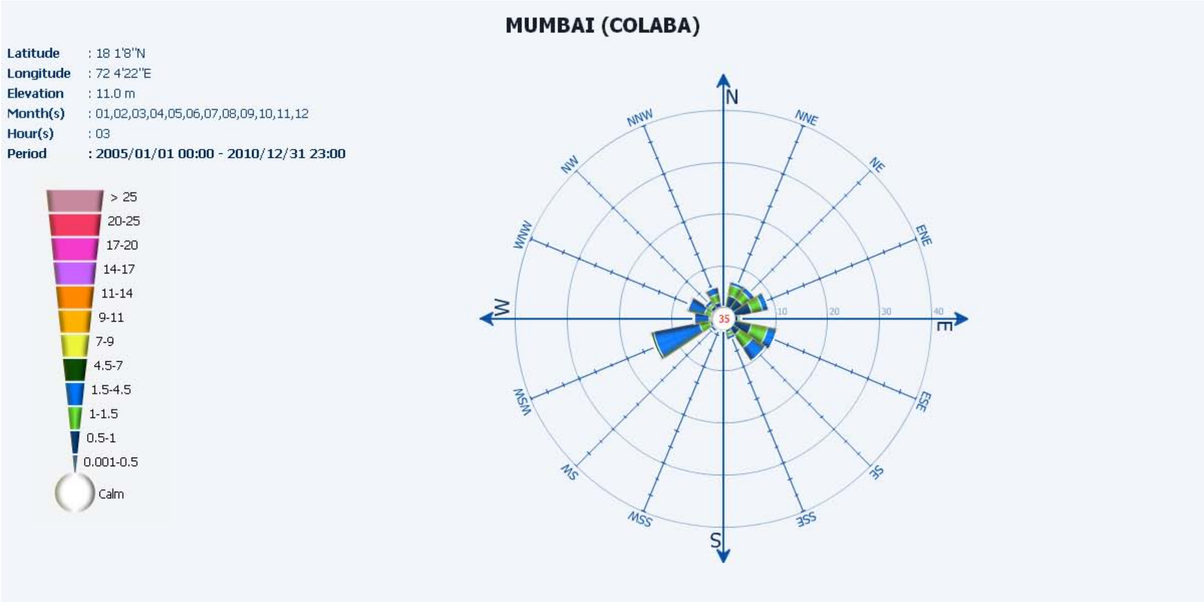


Figure 54: Wind speed and direction at 0830 hrs

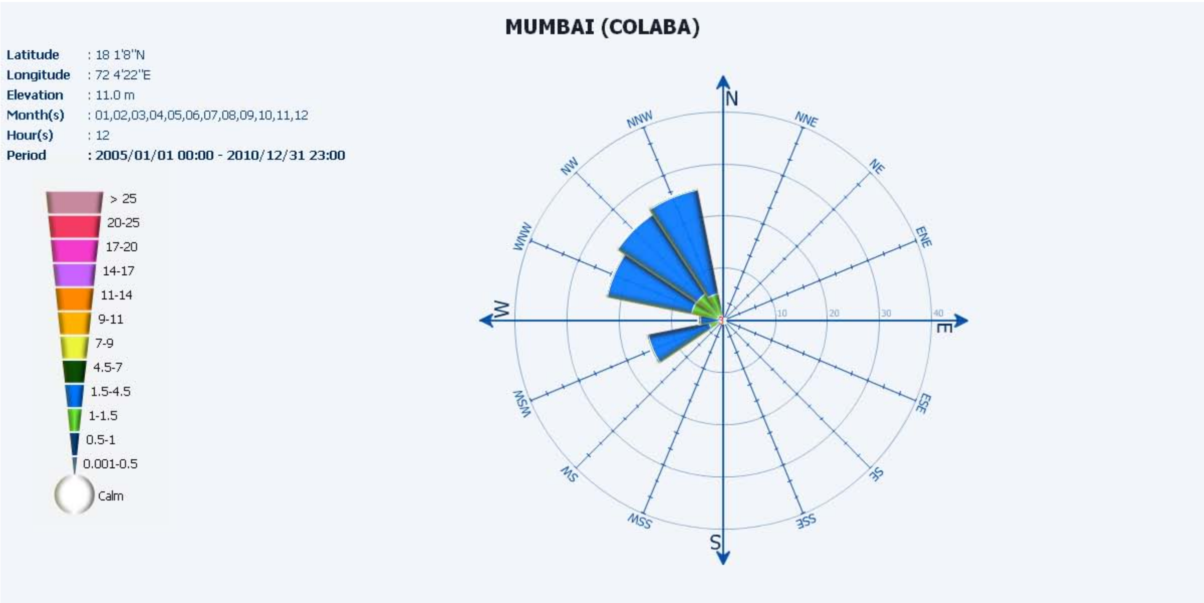


Figure 55: Wind speed and direction at 1730 hrs

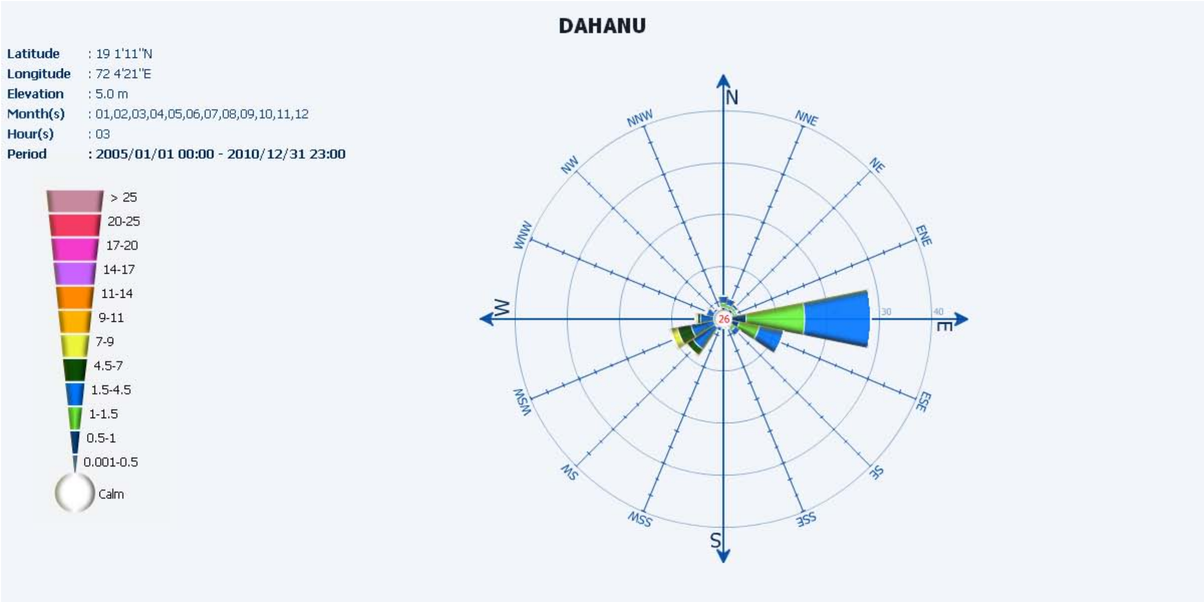


Figure 56: Wind speed and direction at 0830 hrs

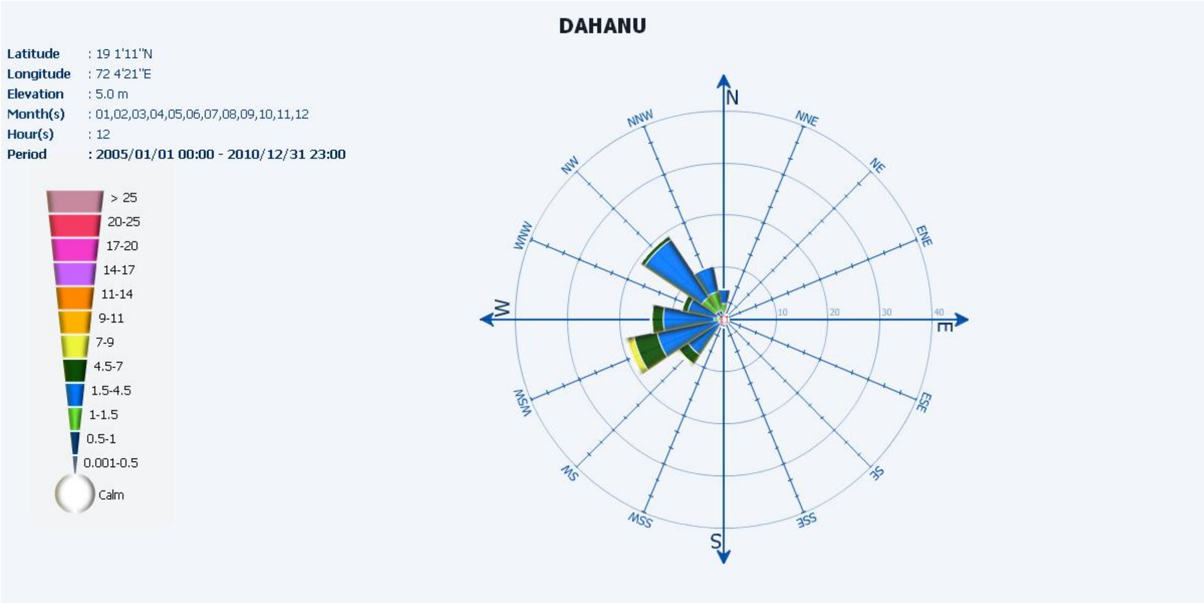


Figure 57: Wind speed and direction at 1730 hrs

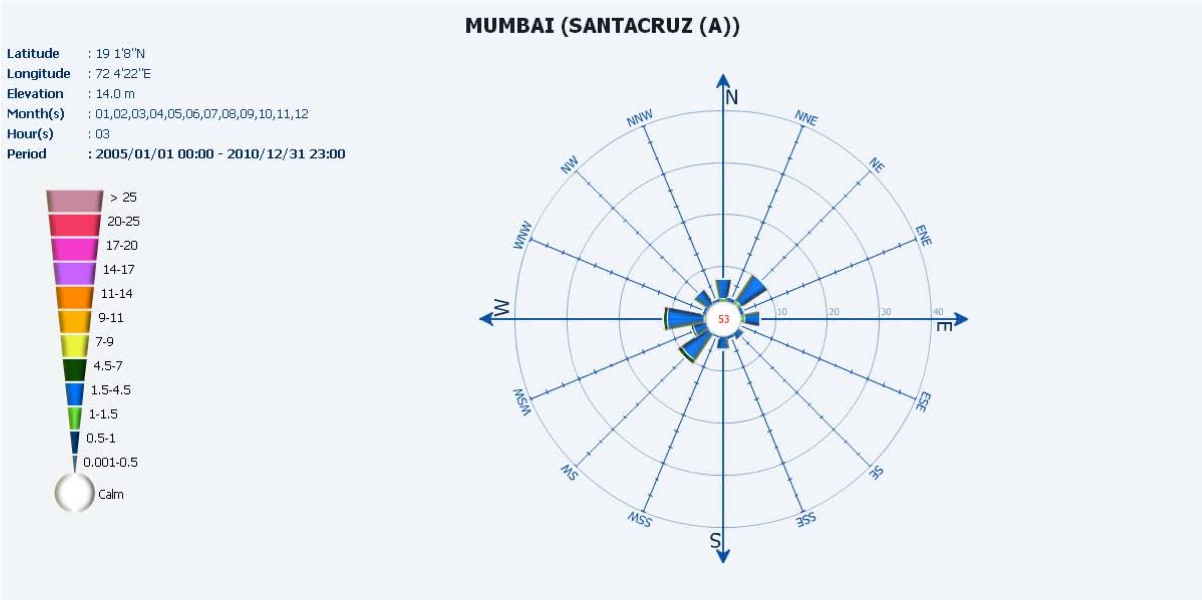


Figure 58: Wind speed and direction at 0830 hrs

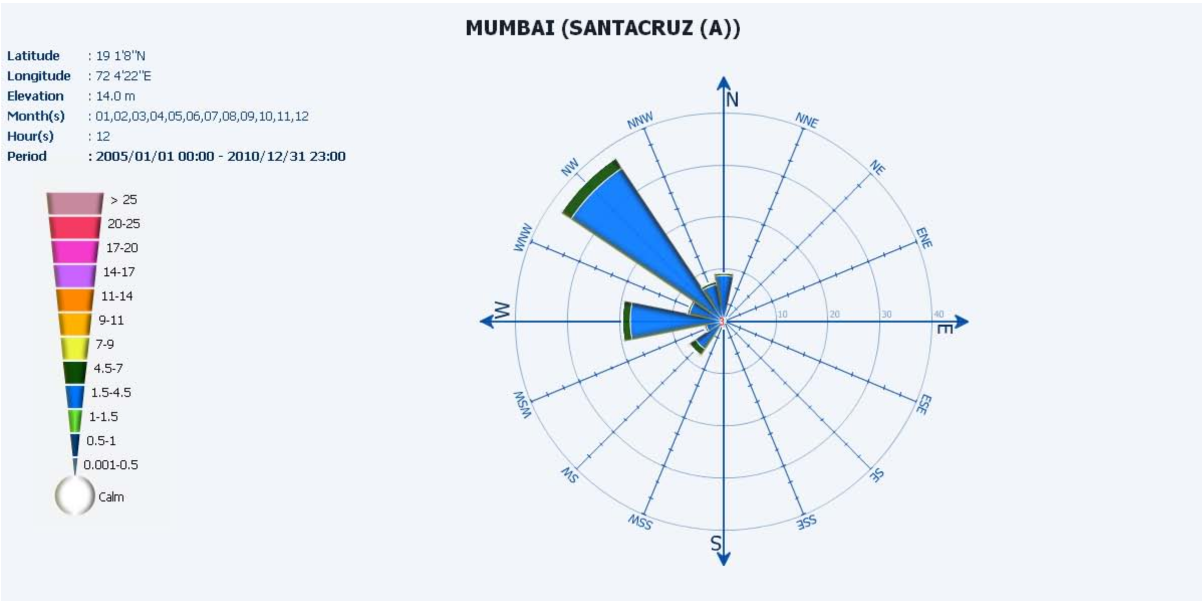


Figure 59: Wind speed and direction at 1730 hrs

Annex 17. List of HCEshaving more than 100 beds in MMR

Region	Hospital Name	Address	Beds
Raigad	Civil Hospital	Near District Post Office, Z.P.Road, Alibag, Raigad	272
	Mahatma Gandhi Mission Hospital	Sector-4E, Kalamboli, Panvel, Raigad.	120
	Mahatma Gandhi Mission Hospital	Sector-18, Kamothe, Panvel, Raigad.	400
	Life Line Hospital, Medical Research Center	Opp. S.T.Stand, Sai Arcade, Panvel, Raigad	250
SRO-THANE I	Jupiter Lifeline	Eastern Express Highway, Near Cadbury (West) Thane	250
	Civil Hospital	Near jain mandir Thane (West)	336
	E.S.I.S. Hospital	Wagle Estate Road No. 33 Tha	100
	Regional Mental Hospital	Wagle Estate Thane	120
	Bethany Hospital	Pokhram Road No.2, Opp Ma Niketan Thane (W) 400610	125
	Chatrapati Shivaji Maharaj Hospital & Rajiv Ghandhi Medical College	Belapur road Kalwa Thane	500
SRO-Thane II	Umrao Hospital	Asmita Enclave,Mira Road,Thane.	200
	Bhaktivedanta Hospital	Shrishti Complex, Sector 1,Mira Road (E), Dist. Thane	150
	Swami Vivekanand Medical Mission Sanjivani Hospital	Sanjivani Hospital, Near Datta Mandir, Virar West	130
Tarapur II	Sub-District Hospital Dahanu	Tal: Dahanu, Dist:Thane	100
Navi Mumbai	M/s. Reliance Life Sciences Pvt, Ltd,	Thane Belapur Road, MIDC Rabale, TTC Navi Mumbai.	102
Navi Mumbai	M/s. Millenium Hospital,	Plot. No. 19, Sect- 40, Seawood (W),	102
Navi Mumbai	M/s. Watson Pharma Pvt Ltd,	T- 341, T-451-551 & 5TH Foor, Intennational Technology Centere CBD Belapur.	108
Navi Mumbai	M/s. Dr. D.Y Hospital & Research Centre	Nerul (E), Navi Mumbai	750
SROM-I	INHS Asvini Hospital Navy Nagar, Colaba	Navy Nagar, Colaba	825

Region	Hospital Name	Address	Beds
(Mumbai)	M/s.Acworth Municipal Hospital For Leprosy,	Wadala(W), mumbai -31	240
	M/s.B.D.Petit Parsee Genral Hospital	Bomanjee Petit Road,Cumballa Hill Mumbai- 36	219
	M/s. St. Gorge Hospital	P.D.Demello Road., Mumbai-1	467
	M/s. P.D.Hinduja National Hospital and Medical Resarch Centre,	Veer Sawarkar Marg, Mahim Mumbai-16	337
	M/s. Lokmanya Tilak Municipal Hospital & Medical College	Sulochana Shetty Road, Near Bhau Daji Circle,Sion, mumbai- 22	1422
	M/s. Jagivanram Hospital Maratha Mandir Marg.,	Maratha Mandir Marg., Mumbai Center	330
	M/s. Saifee Hospital	15/17, Mahavshi Karve Rd,opp.Charni Road Station Mumbai 04	256
	M/s.Group of T.B. Hospital	Jerhas Wadia Road Sewree mumbai-15	1000
	M/s. B.Y. Nair Charitable Hospital, Medical College	Dr.A.L. Nair Road, mumbai-8	1229
	M/s Gokuldas Tejpal Hospital(G.T.)	L.T.Marg. GPO Mumbai-1	521
	K.J. Somaiya Medical College Hospital and Research Centre	Off.E.E.Highway, Ayurvihar Sion	500
	M/s. M.A. Poddar Auyrvedic Hospital	Dr. Annie Besant Road, Worli, Mumbai, 400018	210
	M/s. Bhatia Hospital	Tukaram Javaji Road , Tardeo Road, Between Nana Chowk and Tardeo, Near Chikhalwadi, Tardeo, Mumbai - 400007	169
	M/s. Bombay Hospital and Medical Reearch Centre	12, New Marine Lines Mumbai- 20	830
	M/s.Tata Memorial Centre	Dr.Borges Marg,Parel Mumbai-12	560
	M/s.Mumbai Port Trust Hospital	Nadkarni Park Wadala Mumbai-37	241
	M/s.St.Elizabeth's Hospital	J.Meheta Road, Malbar Hill, Mumbai-06	100
	M/s. Grant Medical College Sir J.J.Hospital,	Byculla Mumbai-8	1352
	M/s. Saboo Siddique Maternity and General	Imamwada Road, opp. Mugal Masjid Hospital Mumbai-9	100

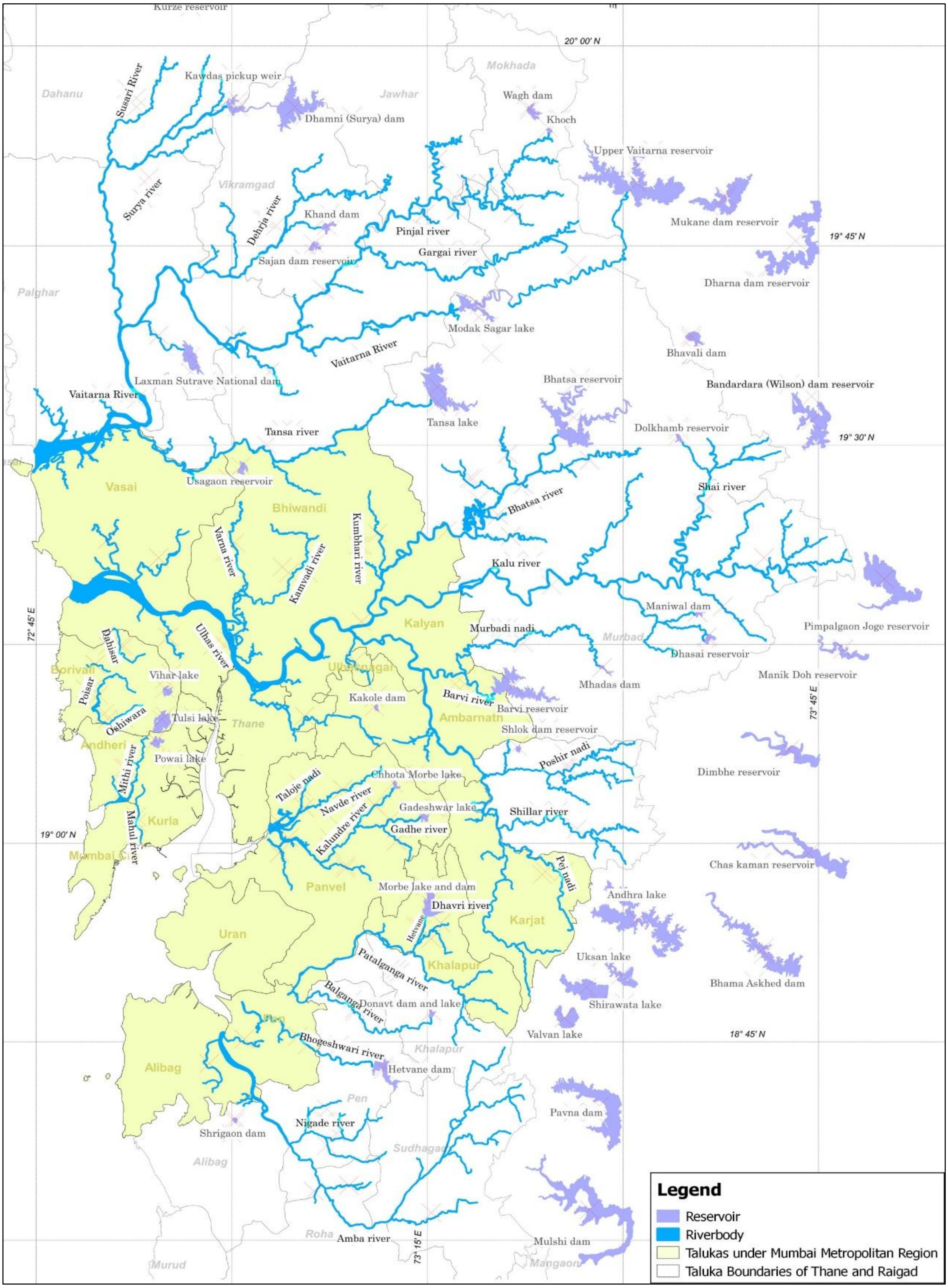
Region	Hospital Name	Address	Beds
	Hospital		
	M/s. Radhaibai Watumull Global Hospital	120, Veer Savarkar Marg., Mahim M-16	128
	M/s. Nowrsjee Wadia Maternity Hospital	Acharya Dhonde Mag, Parel M-12	305
	M/s. Shushrusha itizens Co op Hospital ltd	698,-B, Ranade road,Dadar Mumbai28	140
	M/s.Kamaladevi Guaurdutta Mittal Ayurdic Hospital	Netaji Subhash Road Mumbai- 2	152
	M/s.Sir Hurkisandas Narrotumdas Hospital and Research Centre	Rajaram Mohan Roy Road, Prarthana Samaj, Girgaon M- 04	259
	M/s.Masina Hospital	Sant Savata marg byculla, mumbai-27	318
	M/s. ESIS Hospital	Ganpat Kadam Marg, Worli Naka Mumbai-18	150
	M/s.Prince Ali Khan Hospital	Aga Hall Nesbit Road Mazagaon Mumbai-10	160
	M/s. The Mahatma Gandi Hospital	Dr.S.S.Road Parel	250
	M/s.Kasturba Hospital	Sane Guruji Marg Mumbai-11	515
	M/s.Jaslok Hospital and Research Centre	15, Dr. G.Deshmukh marg, mumbai- 26	363
	M/s. Conwest Jain Clinic Group of Hospitals	8/10, S.V. Sonani Peth, Khadilkar Road	100
	M/s. Raheja Hospital	Raheja Rugnalaya Marg Mahim mumbai - 16	188
	M/s.Breach Candy Hospital	60 A, Bhulabhai Dsai Road Mumbai 26	162
	M/s.Dr.Babasaheb Ambedkar Memorial	opp. Rani baug Byculla Mumbai-27	366
	Seth G.S.medical collage King Edward Memorial Hospital	Parel Mumbai-12	1800
	Cama and Albless Hospi	Mahapalika Marg,mumbai1	505
	Balaji Heart Hospital	Victoria Road, Cross Lane III Byculla (E) M-27	100
SROM-II	Dr. R.N Cooper, Municipal General Hospital	Johu, VilePare-(W),Mumbai-56.	390

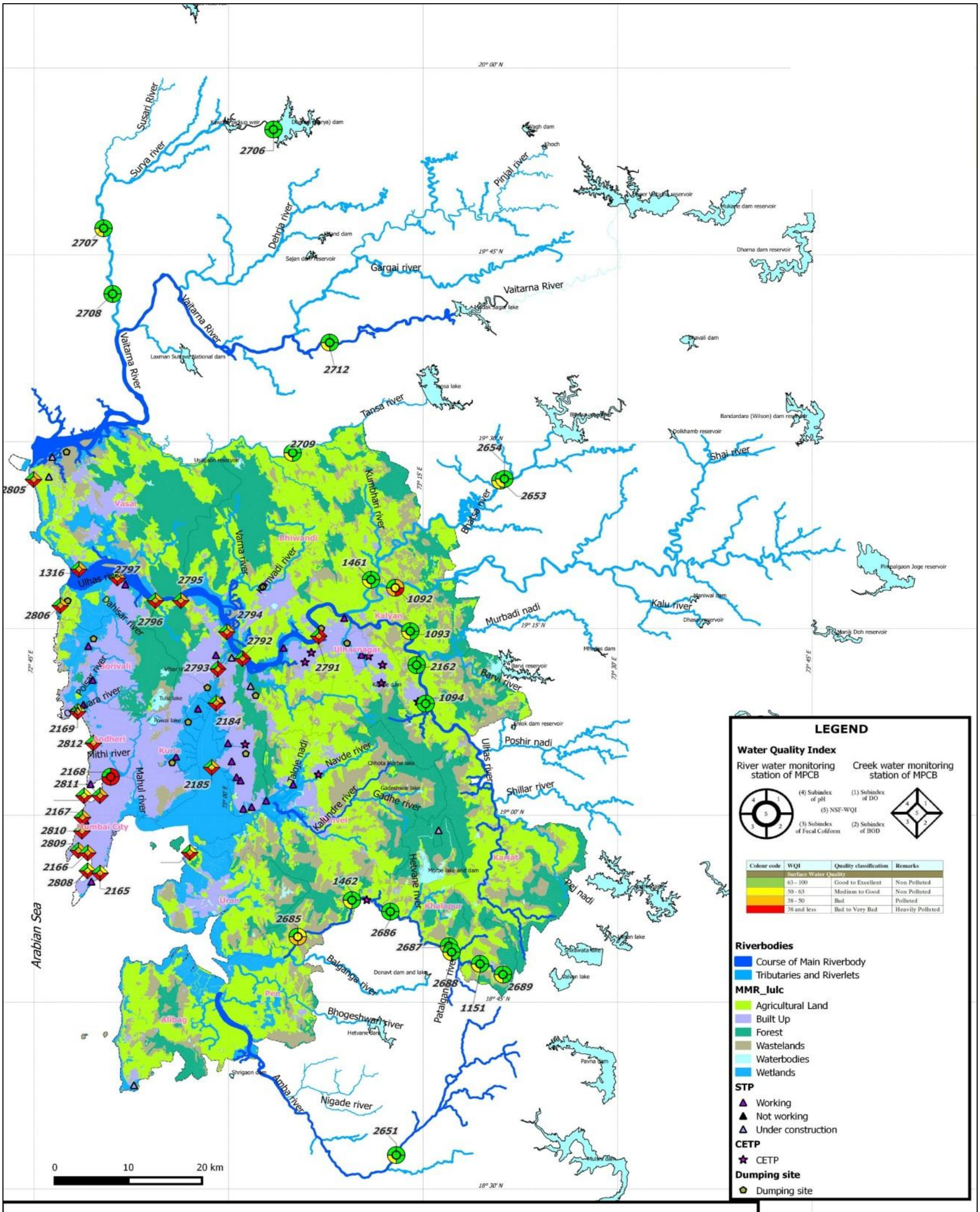
Region	Hospital Name	Address	Beds
	Bandra Holy Family Hospital Society	St. Andrew Rd, Bandra-(W), Mumbai-60	232
	M/s. Lilavati Hospital & Research Centre,	A- 791,Bandra.(W). Mumbai 50	320
	M/s. Asian Heart Hospital,	G/N Block Bandra Kurla Complex, Bandhra- (E),Mumbai-51	230
	M/s. Medical Supt.Hospital V.N.Desai, Municipal General Hospital,	Santazaru-(E), Mumbai-55.	254
	M/s Guru hospital	S-341 Gandhi nagar Bandra (E) Mumbai-400051	120
	BCJ Hospital and Asha parkeh Research Centre	Santacruz Residents association , S.V. Road Sanatacruz (W) Mumbai- 400054	110
	Hinduja Healthcare Private limited	Plot No- 724 11th road Near Khar Telephone Excahnge , Khar (W) Mumbai- 400052	100
	Sevenhills Healthcare Pvt. Ltd	Marol Marishi Road, Near Marol Maroshi Bus Depot, Marol, Andheri (E), Mumbai- 400059	1500
	Oshiwara Municipal Maternity Home MCGM Hospital	Ajit Glass Lane, S.V. Road, Jogeshwari (W), Mumbai -400 102	134
	ESIC Model Hospital Cum ODC	MIDC Andheri (E) MUmbai-93	300
	Kokilaben Dhirubai Ambani Hospital and Medical Research institute	(A unit of Mandke Foundation), Raosaheb Achutrao Patvardhan Marg, 4 Banglows, Andheri (W), Mumbai 53	691
	Criticare Multispeciality Hospital and research Center	Plot No-38/39 Gulmohar, Main Raod J.V.P.D. Scheme Andheri (W) Mumbai-400049	100
	Siddharth Municipal General Hospital	Opp. Motilal nagar post office, Motilal Nagar, Goregaon (W), Mumbai 400104	167
	Anjuman I Islams Kalsekar Hospital	60, Fisheries University road, Yari road, Versova, Andheri, (W), Mumbai 61	100
	Balabhai Nanavati	Swami Vivekanand Road, Vile	343

Region	Hospital Name	Address	Beds
	Hospital	Parle (West),	
	Holy Spirit Hospital, Andheri	Mahakali Caves Road Andheri, (E) Mumbai	300
	Khan Bahadur Bhabha Hospital (municipal general hospital Kurla Bhabha Hospital)	Old Agra Rd, Kurla (W), Mumbai- 400 070	306
	K.B. Bhabha Muncipal General Hospital, Bandra	R.K. Patkar Marg Bandra (W) Mumbai	436
Mumbai -III	Forties Hospital Ltd	Mulund -Goregaon Link Rd Bhandup	264
	Godrej Memorial Hospita	Phirozshah Vikhroli E Mumbai 79	111
	Bhabha Atomic Research Centre	Anushakti Nagar Mumbai -94	390
	Krantiveer MJPhule Gen. Mun.	Kannamwar Nagar Vikhroli, Mumbai-83	130
	LH Hiranandani Hospital	Hillside Avenue Hiramaw Garden Powai	188
	Joy Hospital PL	423 AB 10th Rd Chembur Mumbai-71	106
	H.T. Doshi Ghatkopar Hindu Sabha	Shradhanand Rd Near Railway Stn. Ghatkopar	128
	Seth V.C. Gandhi & M.A. Vora Mun. Gen. Rajawadi Hospital	Rajawadi Hospital Rajawadi Ghatkopar (E)	580
	Centenery Mun.Gen.Hospital (Shatabai Hospital)	W.T.Patil May Govandi Mumbai-81	210
SROM-IV	E.S.I.S. Hospital,	LBS Marg, Mulund (W),	400
	Shri. Hiralal Bhagawanti Municipal General Hospital,	S.V.P. Road, 10th road,Borivali (W), Mumbai –400 103	373
	Smt. M.T. Agarwal Municipal General hospital,	Dr. Rajendra Prasad road, Mulund (W), Mumbai – 400 080	225
	Karuna Hospital,	Borivali (W), Mumbai – 400 103	156
	Municipal Century Hospital	in the premises of Municipal Maternity Home, Kasutrba cross road no. 2, Borivali (E), Mumbai – 400 066	120
	Hira Mongi Navneet Hos	Junction of Valji Ladha road, Ganesh Gawde road, Mulund (W), Mumbai – 400 080	120

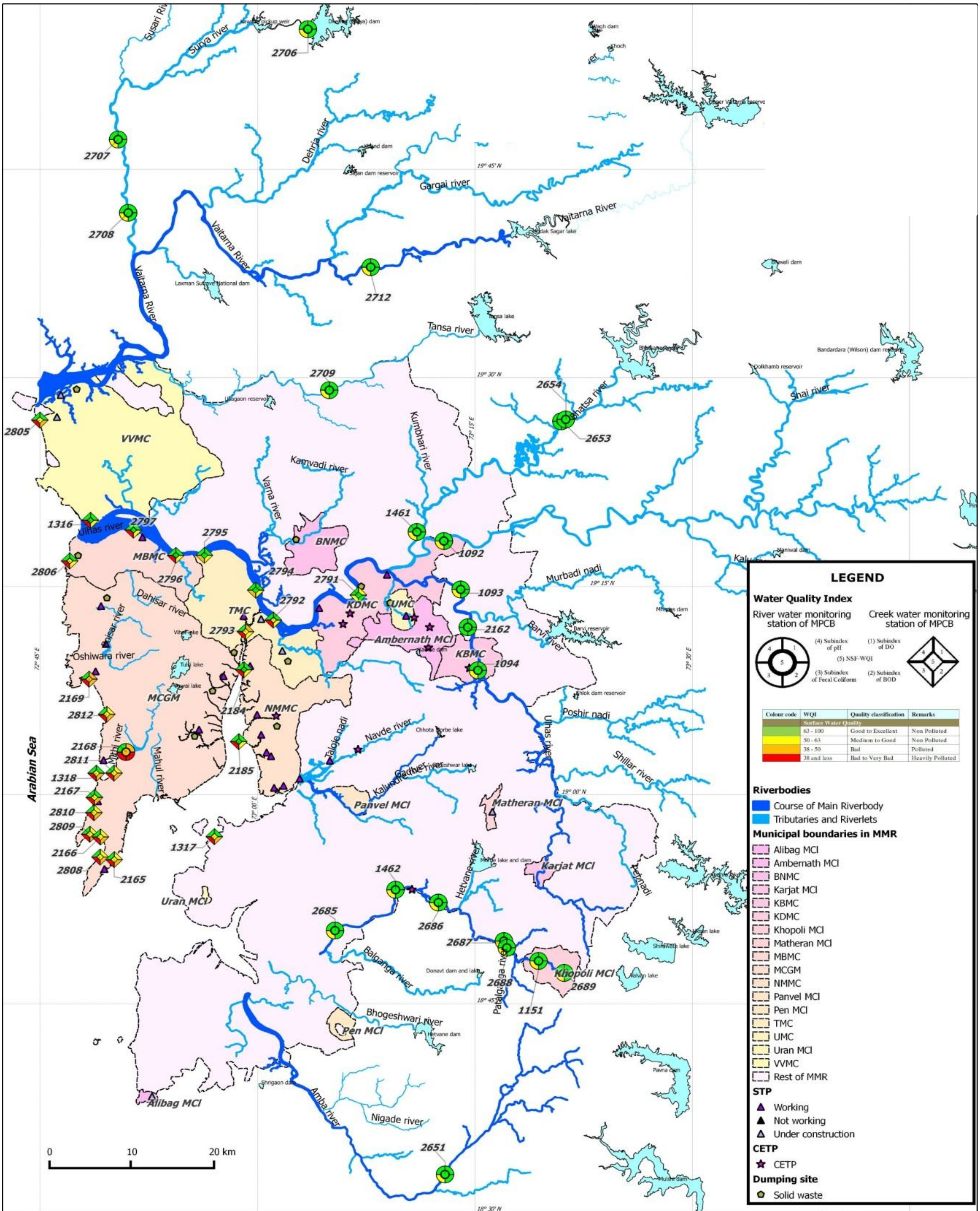
Region	Hospital Name	Address	Beds
SROK-I	Shivam Nursing Home,	Shrenik CHS Ltd., Plot No. 106, Sector-II, Charkop, Kandivali (W), Mumbai – 400 067	100
	Vertex Hospital	23/9, Veena nagar, Phase-II, Near Tulsi Pipe line road, Mulund (W), Mumbai – 400 080	100
	Rukminibai Hospital	Kalyan-Dombivali Muncipal Corporation, Kalyan, Dist- Thane.	120
	Asian Institute of Medical Sciences	Plot no. P-72, Milap Nagar, MIDC, Dombivali (E), Dist- Thane.	100
	Shastri Nagar Hospital	Kopaer, Dombivali, Dist-Thane.	120
	Central Railway Hospital	Tal-Kalyan, Dist-Thane.	120
SROK-II	Central Hospital	Opp.Seva Sadan Bed College, ,Ulhasnagar 3	202
	ESIS Hospital	Camp No.3 Ulhasnagar 3	100
SROK-III	Sub-District Hospital	Tal-Shahapur, Dist-Thane.	100

Annex 18. A3 size prints of significant maps from the report



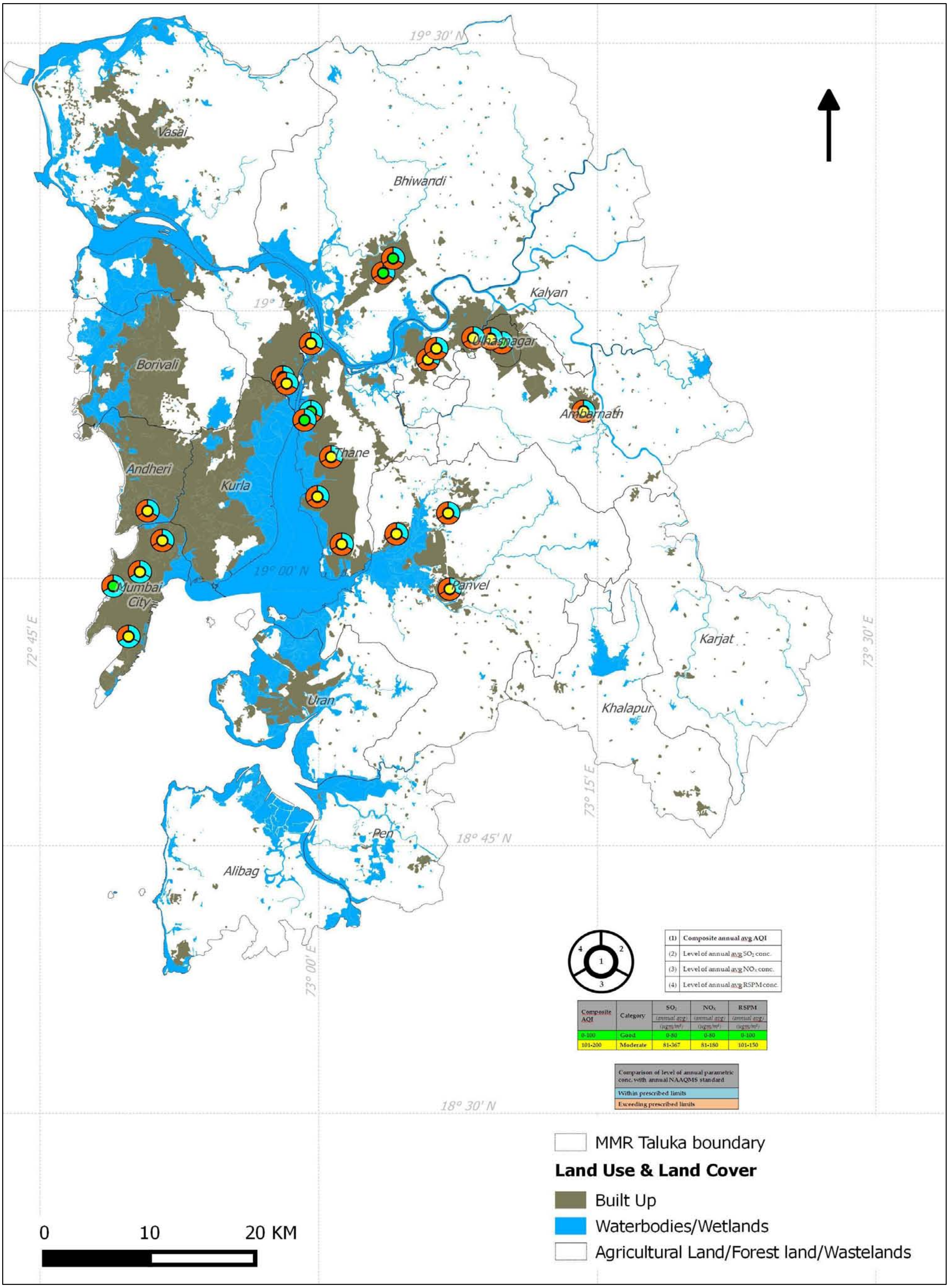


River water monitoring location of MPCB and its NSF-WQI (National Sanitation Foundation - Water Quality Index) for Pre Monsoon period from Dec12 - May13

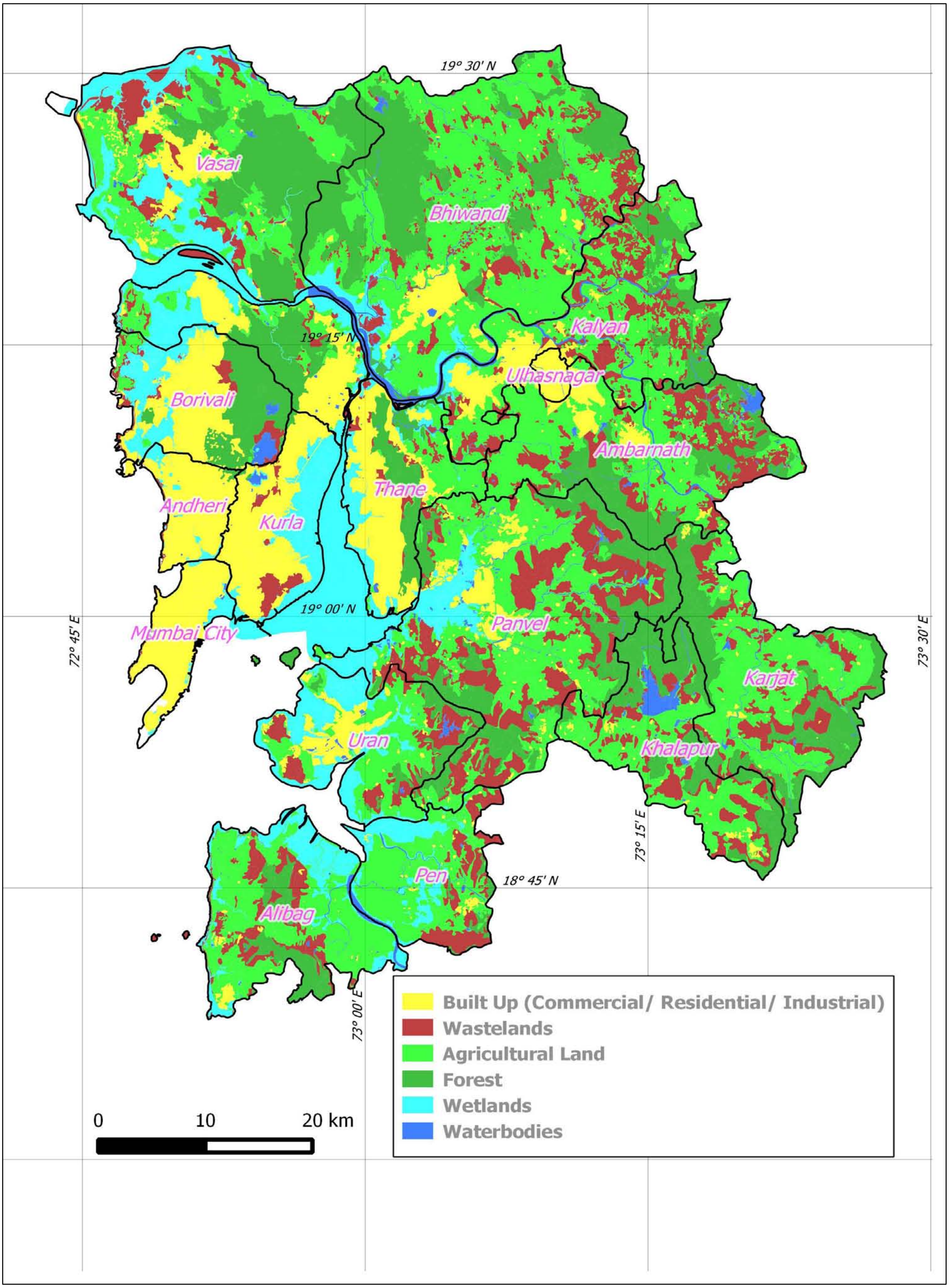


N

River monitoring station of MPCB and National Sanitation Foundation-Water Quality Index (NSF-WQI) for Post Monsoon period from Jun12 - Nov12



19° 30' N
Vasai
Bhiwandi
Kalyan
19°
Ulhasnagar
Borivali
Ambarnath
Thane
Andheri
Kurla
19° 00' N
Panvel
Mumbai City
72° 45' E
73° 30' E
Karjat
Uran
Khalapur
73° 15' E
Pen
18° 45' N
Alibag
73° 00' E
1
2
3
4
(1) Composite annual avg AQI
(2) Level of annual avg SO2 conc.
(3) Level of annual avg NOx conc.
(4) Level of annual avg RSPM conc.
Composite AQI
Category
SO2 (annual avg) (µgm/m³)
NOx (annual avg) (µgm/m³)
RSPM (annual avg) (µgm/m³)
0-100 Good 0-80 0-80 0-100
101-200 Moderate 81-367 81-180 101-150
Comparison of level of annual parametric conc. with annual NAAQMS standard
Within prescribed limits
Exceeding prescribed limits
18° 30' N
MMR Taluka boundary
Land Use & Land Cover
Built Up
Waterbodies/Wetlands
Agricultural Land/Forest land/Wastelands
0
10
20 KM


19° 30' N
19° 15' N
19° 00' N
18° 45' N
72° 45' E
73° 00' E
73° 15' E
73° 30' E
Vasai
Bhiwandi
Kalyan
Ulhasnagar
Borivali
Ambarnath
Thane
Andheri
Kurla
Mumbai City
Panvel
Karjat
Uran
Khalapur
Pen
Alibag
Built Up (Commercial/ Residential/ Industrial)
Wastelands
Agricultural Land
Forest
Wetlands
Waterbodies
0
10
20 km

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