State of Environment Report Bangalore 2008

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Department of Forest, Ecology and Environment, Government of Karnataka

gtz

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Prepared by

Environmental Management & Policy Research Institute

Cover photograph

Tower at Hudson Circle near Corporation

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FOREWORD

Migration of people from villages and towns to cities in search of employment, education, business, and better quality of life is a global phenomenon. Cities located in different climatic conditions have developed over a period of time as a result of urbanisation and they are catering to the needs of original inhabitants as well as migrants depending on the availability of resources in situ. The resources largely include land, water, minerals, vegetation, human resources, infrastructure, electricity, transport, communication and finance. Apart from these the geographical location, climate, knowledge level, socio-political environment and zeal and enthusiasm of inhabitants shape cities.

Bangalore may be ascribed migration of three kinds: Migration of people from within Karnataka, from other states in the country and, to a lesser extent, from out side the country. Migration from different parts of Karnataka has been taking place at a considerable pace since pre-independence as Bangalore is the capital of Karnataka. As there are facilities of higher standard in Bangalore for education, research, technology besides the location of the High Court of Karnataka and Vidhana Soudha the place of governance, it is also inevitable that many citizens residing elsewhere visit Bangalore and some settle down permanently. In recent years, more precisely since the beginning of Common Entrance Test (CET) for the admission of students to professional courses, there is systematic annual migration of students to Bangalore as there are a large number of reputed professional collages and academic institutions. Annual migration of students to Bangalore seeking education in medicine, engineering, law, science and technology is taking place at alarming rate since 15 years. The student community includes students from Karnataka, from other states in India and even from other countries. The annual selection of students from within India has resulted in mushrooming of professional colleges in Bangalore. Supporting academic institutions in nursing, hospitality or business management, have also come into existence side by side in large number.

The migration of students to Bangalore in large scale over a period of more than one and a half decade has resulted in an increase of the number of qualified doctors, dentists, engineers, lawyers, IT professionals, management experts, and scientists. Karnataka is producing the highest number of qualified personnel in many of these fields as compared to other states in India because of the well-established system of selection of students. The availability of qualified professionals in Bangalore has created conducive atmosphere for the growth of speciality hospitals, information technology, biotechnology and manufacturing industries. Attracted by the availability of qualified personnel in large numbers, also multinational companies have exploited the opportunity to their advantage and also to the advantage of qualified personnel and local residents. On the whole, Bangalore has become a hub of activity in several fields leading to multifarious growth and development.

Established after Independence a number of large public sector units such as Bharat Electronics Ltd., Hindustan Aeronautics Ltd. and Hindustan Machine Tools Ltd. continue to be large-scale employers. Growth and economic development has attracted migrants of skilled, semi-skilled and even unskilled workers from northern Karnataka, Tamil Nadu, Andhra Pradesh, Kerala, central and northern India. The growth of Bangalore is visible in various sectors such as construction, hospitality, health, industry, trade & commerce, financial institutions, consultancy, business, tourism, entertainment and aviation. Bangalore's population has increased from 12 lakh in 1970 to 65 lakh today. The vehicle population has grown exponentially in recent years.

The impact of migration, urbanisation, industrialisation and population growth is impinging severely on resources like land, water, electricity and bio-diversity. The rapid growth of industries, technology and commercial activities has resulted in tremendous pressure on the finite resources. The development of infrastructure, transport, communication and affordable housing has not kept pace with the rapid rate of growth unique to Bangalore as compared to perhaps any other city in the world.

The burgeoning population has a pronounced impact on water supply, power supply, the road network, transport and management of waste. Air quality has been affected badly as a result of high level of pollution. Ground water depletion and contamination is being felt in Bangalore Metropolitan Region excluding still, to some extent, the southern part of Bangalore.

This present report gives an overall account of state of the environment prevailing in Bangalore Metropolitan Region. The report has been prepared on the basis of secondary data collected from government organisations, boards, corporations, academic institutions and NGOs. The report has been divided into thirteen chapters in order to group similar issues and to make navigation easier.

I am confident that the efforts made by the subject experts and EMPRI in the preparation of this complex and extensive work have resulted into a document that policy makers, administrators, managers, NGOs as well as academicians will consider as useful. And I hope sincerely that this insightful comprehensive report will lead to informed actions and inspire policy decisions that safeguard better our precious resources while at the same time improving the quality of life of the citizens of this city.

We warmly welcome comments and suggestions on this report.

Bangalore, 31 August 2009

B. Basappa, IFS

Addl. Principal Chief Conservator of Forests
Director General, EMPRI

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To ensure authenticity and good judgement a Review and Monitoring Committee oversaw the development of this report. The committee includes B. Basappa, IFS, Director General, EMPRI, Dr. M.H. Swaminath, IFS, Secretary (Forest), Department of Forest, Ecology & Environment, Government of Karnataka, Shantappa. B. Honnur, Additional Director of Town Planning, BMRDA and Dr. Bakul Rao, Environmental Consultant. The report also benefitted greatly from a large number of constructive comments of GTZ's expert team comprising of Bineesha P., Chief Environmental Advisor, GTZ ASEM and Pravinjith K.P., Managing Director, Paradigm Environmental Strategies Pvt. Ltd. under guidance of Dr. Jürgen Porst, Senior Advisor, GTZ ASEM. Thanks to our editorial team and the keen eye of D.B.N. Murthy wrinkles and remaining inconsistencies were ironed out before the report went into print.

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CONTENTS

EXECUTIVE SUMMARY

The report in a nutshell

This report provides an assessment of environmental issues prevailing in Bangalore Metropolitan Region (BMR). For each issue indicators have been identified and the assessment is, wherever possible, substantiated with data. Apart from expertise, the report draws its conclusions from data whose collection posed a considerable challenge. The process of data acquisition from about 50 major and subsidiary offices of chiefly government agencies stretched well over four months. Not surprisingly, there are variations in data across agencies that need to be understood in order to be interpreted correctly. Some data rightly raised doubts as to its reliability yet a judgement what "good" data is supposed to look like was possible only within certain error margins. Although the authors attempted corrections or bridged gaps with estimates, it was not always possible to prevent that some data discrepancies crept into the report. It is believed that this shortcoming has affected the depth of analysis but not the conclusions drawn for actions needed to mitigate the issues of concern which impact the environment or the inhabitants of BMR. However, more and better data could have facilitated a more insightful and perhaps more conclusive analysis.

Experienced subject experts have prepared each of the chapters. The structure of most chapters begins with an assessment of the current status of the respective subject based on latest information, followed by an analysis of environmental issues, their impact on environment and health and their specific causes. For most key parameters a predication of trends has been attempted to estimate the likely future impact. Thereafter the institutional capacity to respond to issues identified is evaluated. Conclusions for an effective mitigation of environmental issues have, in each chapter, resulted into specific recommendations. Based on these a comprehensive and action oriented "Environmental Management Plan" has been compiled, available at the last chapter.

It is interesting to see how, through each chapter, the perspective on man who is the sole reason for environmental degradation changes. In the chapters on Forest and Wetlands man is primarily an intruder. In chapters Water and Air, man becomes polluter and victim. In Health he becomes a patient, in Transport a passenger, in Industry and entrepreneur, in Waste a polluter, in Energy a consumer. In Socio-Economic Development, Economic Incentives and the Environmental Management Plan man finally emerges as one in all: a citizen of Bangalore Metropolitan Region.

Photographs generally illustrate the environmental issues discussed. There are further photographs however whose discussion did not find room between these pages, sometimes depicting issues that could not be subjected to the scientific rigour the study demands. Taken together, these photos seek not only to illustrate the report, they aim to take the reader on an expedition, a silent journey through Bangalore's environment, educational and sometimes surprising.

Bangalore's rapid and unequal growth

Bangalore, the capital city of Karnataka, has grown from a population of 12 lakh in 1970 to 65 lakh in 2008, and is now bursting at its seams. Urban migration is a phenomenon observed worldwide. India in general and Bangalore in particular are no exception here. Many public sector units, large private enterprises, multi-national companies, banking and financial institutions, and medium and small-scale industries have set up their business in and around Bangalore taking advantage of the climate, incentives, land, business opportunities, availability of technical personnel and skilled labour at affordable prices and a network of good roads and communication. Bangalore has the distinction of being the "Silicon Valley" of India with large private enterprises specialising in IT and related services with an enviable export record. Better livelihood opportunities, affordable quality education, healthcare, transport and communication are attracting people from both within the state and outside with no apparent let up in migration. Such an unprecedented growth has caused serious environmental threats. Gradually concerns about these issues grew as well. Health, sanitation and waste management, energy, transport, water supply, among others, is severely stressed.

Encroachment of wetlands with illegal constructions, the rampant dumping of construction debris and polluted streams in catchment areas resulted in a significant deterioration of BMR's water bodies. It is reported that in 1985, Bangalore had about 51 healthy lakes and tanks, which shrunk to merely 17 in 2008. Air pollution is causing serious concern due to the burgeoning vehicle population and industrial activities. Water availability for its citizens is hampered due to various factors. Quality of water as well as its quantity in certain areas, like slums and far-flung layouts, is not satisfactory. Waste handling and sanitation need to be improved to cater to the ever-increasing population. The higher consumption of electronic goods has resulted in higher amounts of e-waste, which has to be dealt with separately from municipal solid waste. Urban noise is another issue waiting to be solved through proactive measures. Health care is sorely tested with the cost of medical care rising higher and becoming unaffordable, as the government run hospitals are few and far in between. Only citizens of higher economic strata can afford private super-speciality hospitals.

The impact of migration, urbanisation, industrialisation and population growth is impinging severely on energy, land, water, air, forests and biodiversity. The rapid growth of industries, business and commercial activities has resulted in tremendous pressure on the finite resources. The development of roads, transport, communication, affordable housing has not kept pace with the rapid rate of growth unique to Bangalore.

Beyond doubt, climate change ads yet another dimension to the problems. Environmental concern is breaking geographical barriers, as international concern has led to a few hesitant steps worldwide. India, though classified as developing country, has the responsibility of taking proactive measures to mitigate climate change, the effects of which are tangible: unprecedented rains, droughts, change in seasons, cyclones, heavy snow, glaciers melting, epidemics breaking out and so on.

In Karnataka there has been a realisation that the environment needs special care and attention. The "State of the Environmental Report and Action Plan 2003" was the first structured report on the status of the environment in the state. However, Karnataka had an environmental policy even earlier.

Environmental issues

Various factors examined in this report have a noticeable adverse impact on the environment and consequently on the citizens of BMR. This is mainly owing to an ever-growing population with the needs this entails, including the growth in the number of passenger and transport vehicles. This is putting a tremendous burden on the infrastructure, which had earlier catered to a much smaller population. The transformation from a sleepy town to a bustling mega-polis has not happened without its share of growing pains. A few significant observations from each chapter are detailed below in order to give an idea of key issues. A comprehensive analysis is available in each of the corresponding chapters.

Air: Air quality, affected primarily by transport vehicles and industries, is under substantial stress, which has a significant short-term and long-term impact on the health of citizens. The data available however is limited and largely insufficient to draw a conclusive picture of the prevalence of air pollutants.

Energy: Demands on energy are growing exponentially due to lifestyle needs of the rapidly growing population and the growing industry. Electricity supply falls well below demand, leading to seasonal load shedding and continued growth in the number of diesel generator (DG) sets. Though a large share of electricity in Karnataka is generated from hydropower, the combustion fossil fuel produces CO_2 emissions, air pollution and, particularly in the case of DG sets, raises noise levels.

Forest and Biodiversity: Only a few patches of forests are left and the loss of habitat, flora and fauna due to man-made activities is severe. The Structure Plan for the development of BMR has fortunately earmarked reserved zones currently excluded from township development where a conservatory approach is taken with regard to predominantly agro-based livelihoods and the natural environment.

Health: The data shown is indicative of a deterioration of citizens' health, particularly in respect of respiratory and water borne diseases. Consequently, health care needs are on the increase, not only due to pollution related diseases but also as a response of better awareness on the part of the citizens.

Industry: The pace of development of industrial areas does not match the rapid growth of the industry. The absence of common facilities and, in private industrial areas, the absence of in fact most facilities, encourage illegal discharges of effluents and waste. Monitoring and enforcement is impeded by the fact that about 55,000 industries are scattered across BMR, most of which are not registered with Karnataka State Pollution Control Board (KSPCB).

Socio-Economic Development: This dynamics of a burgeoning city and its environs resulted into growing disparities in terms of income levels and the way different areas of the city – inhabited by different economic strata – are taking shape. Functional specialisations such as the concentration of IT industry around the south-east of Bangalore and hospitals near the centre create transportation needs of a magnitude that the city's infrastructure has difficulty coping with.

Transport: The rapid population growth, the quick expansion of the city and a large and growing workforce that can – and does – afford cars have turned Bangalore's roads into a nightmare. The traffic load causes periodic congestions of trunk routes, considerable air pollution and longer travel times. It also entails longer exposure times to polluted air and significant risks for pedestrians, even if merely attempting to cross a road. The forthcoming *Namma Metro,* the first phase of which is scheduled to be commissioned in December 2011, is the first structured approach to mitigating the chaotic traffic.

Urban Planning: A largely unplanned city like Bangalore, which grew from a cluster of a few villages and a British Cantonment, needs better urban planning to improve the connectivity and reduce pollution loads, thus improving the quality of life of its citizens. Efforts in this direction are already tangible but need to be complemented by a more holistic and citizen-centric approaches.

Waste: The city is generating a sizeable quantity of solid, liquid, electronic, hazardous and bio-medical waste. The absence of systematic management for particularly municipal and industrial solid directly affects air, soil and water quality. The establishment of a Treatment, Storage and Disposal Facility (TSDF) for hazardous waste and attempts to shift e-waste recycling increasingly into the organised sectors have begun to help in mitigating severe pressure points.

Water Supply and Sanitation: Bangalore's unquenchable thirst for water has exceeded the surface water supply capacity. The water table has rapidly fallen as a result of the alarming rate of ground water drawings. Citizens are not receiving either the desired quality or quantity of water, compromising the health of particularly economically weaker sections. Poor sanitation, especially in the slums and crowded areas, is a breeding ground of epidemics.

Wetlands: The city and its environs lost most of its water-bodies and their specific biodiversity during the past few decades, owing to relentless expansion, increasing land prices and a largely inadequate response to offer protection to lakes, tanks, and shore areas.

Approaches to impact mitigation

From each chapter evolves a set of specific recommendations. These aim to address inadequacies in current environmental management and are considered capable of mitigating the ill effects of environmental issues. Some of these suggested actions are of a short-term nature while other measures call for long-term planning and actions. Needless to emphasise, the majority of suggestions have strong inter-sectoral linkages, a feature characteristic for environmental issues in general. A few of the mitigation options call for formulation of new or amendment of existing legislation, which is expected to take time. However, broad agreement on the law or rule to be enforced should be reached before its enactment. That would generate a better ground for compliance rather than forcing something perceived unacceptable on to citizens.

Mitigation plans call for capital investment, be it for enhancing institutional capacity, for monitoring programmes, for fuel switch incentives, management tools, subsidies and so on. Other suggestions would need better discipline and control on the part of the stakeholders as well as the citizens and those who use the infrastructure. This also emphasises the paramount importance of enforcing the existing rules and laws in letter and spirit by those charged with the responsibility of safeguarding the environment vis-à-vis the rules and laws in effect. What is important is that concerned stakeholders should have a say in whatever affects them directly and sometimes indirectly. There is a need to build a broad consensus on the major issues and mitigation measures that affect the citizens. For instance, a law against littering could be implemented only with the willing cooperation of every citizen.

An issue emerging from recommendations of many of the report's chapters is the need to address the current data limitations. The call for better data that permits better understanding is particularly urgent in the case of air quality, health and industry. The potential threat to environmental resources is undisputed, yet the data available is often too thin to form a response capable of informing all required decisions. In the case of health, many of the necessary learnings could perhaps be drawn from studies undertaken in other states or even other countries or continents. Pollution related data requires a local monitoring network.

The key recommendations of each chapter have been consolidated into an all-encompassing "Environmental Management Plan". This plan is a single-point referrer for priority actions. It is preferable that each agency concerned with implementation selects a coordinator and, if necessary, a team to liaise with other agencies to improve coordination among governmental departments, a step crucial to the success of many if not most actions proposed. Next steps should involve the definition of specific actions in coordination with other stakeholders, the stipulation of timeframes and an estimation of budgetary requirements.

The importance of continuity in any action-oriented programme should be kept in mind. There has to be a consistent follow up at each stage of the action to keep in check delays and cost overruns. Status reports shared across concerned departments on a periodical basis would be highly desirable. Bottlenecks are likely to be encountered and should be highlighted so that a solution could be found without losing much time. The consultation of experts could be considered as and when the need arises.

Conclusion

This report is an important document that could serve as a guide to improve the state of environment of BMR as well as the quality of life of its citizens in the coming years. It presents an in-depth study of the present status of the environment with a projection for the future and offers recommendations for the mitigation of environmental issues through a structured approach.

The report is not a mere documentation of the existing data but one which, hopefully, would help initiating appropriate actions that would improve the environment battered by a high population of human beings and vehicles. Restoring the environment to some degree of normality needs planned, sincere and concerted actions by one all, involving all stakeholders concerned. It is imperative that actions have to start without much delay and through involvement of the highest decision-makers so that support and the attribution of resources stand on a firm and enduring basis.

The present report is but a small step towards restoring our environment to its glorious pristine past, a sacred duty of everyone as it supports life, as we know it. Its true value, however, can emerge only if acted upon.

Chapter 1

Forest and Biodiversity

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TABLES

FIGURES

1. CLIMATE AND PHYSIOGRAPHY

1.1. BANGALORE URBAN DISTRICT

Bangalore Urban forest division is located on the Deccan Plateau between 12˚14 and 13˚30 north and 77˚3 and 77˚59 east. The topography is almost flat with moderate slopes while only the southern part is undulated and hilly. The elevation varies from 835 to 953 metres. The division has scores of water-tanks spread all over.

The prevailing rock is granite gneiss, varying in colour, structure and mineral composition. These gneissic masses have been styled as 'Peninsular Gneiss'. Small isolated strings of schists, a dark hornblende granulite, are also found scattered. Among the dyke rocks, a group of dykes of charnockite affinities and some hornblende dykes are found bordering Kanakapura *taluk.*

The soil is good and loamy over most part of the district, especially in the valleys, containing finer particles of decomposed rocks. At higher levels gravelly and reddish soil is found. On the whole the soil is excellent, suitable for growing most of the crops, horticultural plants and vegetables.

April is the hottest month, with temperature rising up to 35 ˚C during day and 21 ˚C at night. December–January is the winter season with a maximum temperature of 26 ˚C and a minimum average temperature of 15 ˚C. January is coldest month but the temperature drops rarely to 10 ˚C. Of late the maximum temperature is found rising as high as 38-39 ˚C during April–May although formerly it did not exceeded 36˚C. In the seventies summer heat frequently resulted in summer rains. The climate has changed much of late as a result of increasing pollution, urbanisation and destruction of vegetation and water bodies.

The mean annual rainfall is around 875 mm spread over 50 days in a year. Over half of the rainfall is received during August–October and cyclonic rains are received in November–December with no rainfall between January–March. The division receives both southwest as well as northeast monsoons, the former in the months of June–July and the latter in the months of August–October, which is more intensive; October being the wettest month.

1.2. BANGALORE RURAL AND RAMANAGAR DISTRICTS

Bangalore Rural and Ramanagar forest divisions lie in the Deccan Plateau between 12˚15 and 13˚35 north and 77˚5 and 78˚0 east.

The central, northern and eastern portions of the district are open countryside made up of vast stretches of undulating plains. Uplands are covered by low scrub jungle and low-lying grounds are dotted with tanks along the streams and are used for agriculture. The terrain is rugged and broken in the west, made up by series of hills and valleys intersected by rocks and rapid streams with sandy beds. In the south, the hills get closer and the land is covered with dense vegetation while the terrain slopes down towards Cauvery river.

A range of hills from Kanakapura in the south to Nijagal in the north, formed of close-grained granite, make a prominent topographic feature. The hills are strewn with boulders and covered with scrub forests. At places the granite hills abruptly rise to form conspicuous landmarks. The valleys between these hills have fertile land with an adequate supply of water. A series of tanks are situated in the low-lying plains. There are no natural lakes in the district. Larger lakes like in Hoskote, Madhure and Doddaballapura store rainwater for a temporary period to be used for agriculture. Among the hills Shivaganga Betta (1380 m), Bilikal Betta, Mudavadi Betta and Narasimhadevara Betta are prominent.

The district is part of the Deccan Plateau. Kanakapura, Devanahalli, Nelamangala, Ramanagar form captivating landscapes. Ramagiri Betta, about 5 km north of Ramanagar is a picturesque hill on the left bank of Arkavathi river. Sivagiri is a large fortified rock near Ramanagar on the right bank of Arkavathi.

The area of this district forms the valley of Arkavathi, which flows southward and enters the district at Doddaballapura *taluk*. It forms several lakes at Doddaballapura and Hesaraghatta and passes through the east of Nelamangala *taluk*. It then flows through Magadi *taluk*, flowing in the east of Sawanadurga. Between Ramagiri and Shivagiri the river passes through Channapatna *taluk* into Kanakapura to join Cauvery river, which also heads southward. The eastern portion includes the upper basin of Pinakini river and the western portion includes a small part of the Shimsa river basin. Pinakini river originates in Nandi Hills like Arkavathi and flows through Devanahalli and Hoskote, where it forms the Hoskote tank. Kanva, Kumadvathi, Vrishabhavathi and Suvarnamukhi are the other minor rivulets of this district. Dams on these have been built at Kanva, Manchanabele and Tippagondanahalli.

The tract borders on Kolar district in the northeast, on Mandya district in the southwest, on Chamrajnagar district in the south and on Salem district of Tamil Nadu in the southeast.

On the western side of the district passing from Kanakapura to Magadi runs the Closepet Granite series. At Thalaghatapura, strings of dark hornblende granulite with pale green pyroxene rock occur. Kaoline mineral is found at Hoskote and Doddaballapura. Near Chikbanavar and Gollahalli graphite is found. The gneissic exposures found in the district are yielding good slabs and size stones.

Soils of Anekal, Bangalore North and Nelamangala are acidic and the rest have normal pH. The soil is loamy over most part of the district, especially in the valleys and at higher elevation, gravelly and reddish soil is found. The soil is best suited for growing most of the horticultural and agricultural crops.

2. FOREST PROFILE

2.1. FORESTS OF BANGALORE URBAN DISTRICT

2.1.1. Forest ratio

The geographical area of Bangalore Urban district is 217,410 ha, out of which the forest area is 4,198 ha including notified and other government lands under the Forest Department's control. The percentage of forest comes to only 1.97% of the geographical area. Forest areas of Bangalore Urban district are spread over 4 Revenue *taluks* and 5 forest ranges covering 17 Reserve Forests, as detailed in Table 1.

2.1.2. Forest types

At the beginning of the last century, most of the forests of this division were of the Tropical Dry Deciduous type under sub-group 5A viz. Southern Dry Mixed Deciduous forest of the Champion and Seth classification. These have now degraded into Dry Deciduous Scrub type and stand classified as DS1.

2.1.3. Dry Deciduous pockets

In some pockets the remnants of earlier forests viz. Dry Deciduous forests are found as at Kaggalipura, Basavanthara and Sulekere.

Figure 1: Bamboo plantation in Marasandra forest

2.1.4. Degradation stages

Most of the forests around Bangalore now stand degraded due to biotic factors and they are classified as Dry Deciduous Scrub type (DS1). These forests are found at Govindapura, Kadugodi, Mandur, B.M. Kaval, Turaligudda, Jarakabande, Jarakabande Sandal Reserve, Marasandra, Kumbaranahalli, Arkavathi, Madappanahalli and Doresanipalya. In most of these places, monoculture plantations of Eucalyptus and Acacia auriculiformes have been raised in the past.

2.1.5. C & D class lands, gomals and district forests

C & D class lands, *gomals* (grazing lands) and district forests in Bangalore Urban district are detailed below.

Table 1: Notified forest areas, C & D class lands, *gomals* and district forests of Bangalore

Range	Number of forest reserves	Total area in ha	Other areas	Total area in ha
Anekal	1	34.1	2	112.0
Bangalore	6	504.3	2	86.7
K.R. Puram	3	395.7		701.5
a) Varthur Hobli	-	-	8	
b) Begur Hobli	-	-	7	
c) Krishnarajapura Hobli	-	-	7	
d) Bidarahlli Hobli	-	-	10	
Kaggalipura	6	1,831.2	4	253.0
Yelahanka	1	380.0	-	-
Total	**17**	**3,145.3**	**40**	**1,153.2**

Notes: Forest area comprises mainly scrub and grasslands with miscellaneous species. Eucalyptus and Acacia auriculiformes are found over most of the area except at Kaggalipura

2.1.6. Characteristic flora of Bangalore Urban district

- Sandalwood (*Santalum album*)
- Jalari (*Shorea roxburghii*)
- Ficus species
- Sanna Ippe / Mohwa tree of South India (*Madhuca longifolia*)

- Exotic species: *Amherstia nobilis* (Splendid Amherstia) and *Brownea grandiceps* (Rose of Venezuela) and *Araucaria columnaries* which give seeds only in Bangalore.

2.2. FORESTS OF BANGALORE RURAL AND RAMANAGAR DISTRICT

The total notified forest areas of Bangalore Rural and Ramanagar districts are 91,722 ha and that of other lands in the custody of Forest Department is 9,394 ha. Forest areas leased to Research wing, Karnataka Forest Development Corporation (KFDC) and other Government Departments are included in the above. An area of 13,710 ha transferred to Cauvery Wildlife and Mandya divisions are not included in this total. An extent of 564.3 ha of forest area from Bettakote, Gangamuthanahalli and Yarthiganahalli of Devanahalli range has been released for Bangalore International Airport.

Table 2: Notified forests of Bangalore Rural district

Range	*Number of forest locations*	*Total area in ha*
Devanahalli	16	2,605.2
Doddaballapura	16	7,703.4
Hoskote	16	3,262.6
Nelamangala	12	3,498.8
Total	**60**	**17,070**

Note: Forests are mainly scrub and grasslands with miscellaneous species. Eucalyptus and Acacia auriculiformes are found over most of the area except at Doddaballapura and Hoskote.

Table 3: C & D class lands, *gomals* and district forests in Bangalore Rural district

Range	*Number of forest locations*	*Total area in ha*
Devanahalli	16	855.0
Doddaballapura	6	957.7
Hoskote	16	3,262.6
Nelamangala	23	990.7
Total	**61**	**6,065**

Note: Mostly scrub and grasslands at places comprising of Eucalyptus, Acacia auriculiformes and other miscellaneous species.

Table 4: Notified forests of Ramanagar district

Range	*Number of forest locations*	*Total area in ha*
Ramanagar	14	8,108.7
Channapatna	25	15,834.7
Kanakapura	25	29,969.0
Sathanur	11	12,853.6
Magadi	18	7,887.0
Total	**93**	**74,653**

Note: Forests are mainly Dry Deciduous and scrub with miscellaneous species. Small plantations of Eucalyptus and Acacia auriculiformes are found at places.

Table 5: C & D class lands, gomals and district forests in Ramanagar district

Range	*Number of forest locations*	*Total area in ha*
Ramanagar	16	745.0
Channapatna	28	2,395.5
Kanakapura	20	1,908.4
Sathanur	15	988.8
Magadi	9	553.5
Total	**88**	**6,591.2**

Note: Mostly scrub and grasslands are found at places along with Eucalyptus, Acacia auriculiformes and other miscellaneous species.

In Bangalore Rural district planting of Eucalyptus and Casuarina started in the early part of last century. Forest areas of Bangalore Rural district are spread over 4 revenue *taluks* covering 60 locations as detailed in Table 2 and Table 3. Forests of Ramanagar district are spread over 5 revenue *taluks* covering 93 locations as detailed in Table 4 and Table 5.

2.2.1. Ratio of forest areas

Geographical area of Bangalore Rural and Ramanagar districts is 5,85,431 ha, out of which the forest areas constitute 1,01,117 ha. 17.2% of the geographical area of the two districts is covered by forest.

Ban on felling of green trees: In 1991 felling of green trees was banned thereby helping the forests to recover to a great extent.

Figure 2: Jarakabande forest

2.2.2. Forest types

As per Champion and Seth classification of forests (1962–63), the forests of Bangalore Rural and Ramanagar divisions fall under the categories varying from Southern Tropical Dry Deciduous to Southern Tropical Thorn Forests.

2.3. FOREST COVER OF BMR

The total forest areas of three districts (i.e., three Forest Divisions) and the Government lands under the control of Forest Department in Bangalore Metropolitan Region (BMR) come to about 1,070 km^2. These are administratively covered under 14 ranges, as given in Table 6.

Table 6: District wise forests under BMR

District	Range	Total area of notified forests in ha	Other Government land in ha	Total tanks extent in ha	Total area under Forest Department in ha
Bangalore Urban	*Anekal*	34.7	112	-	146.7
	Bangalore	504.3	86.7	647.0	1,238.0
	Kaggalipura	1,831.2	253.0	55.0	2,139.18
	K.R. Puram	395.7	701.5	813.9	1,911.0
	Yelahanka	380.0	-	60.3	440.3
	Total	**3,145.34**	**1,153.09**	**1,576**	**5,874.5**
Bangalore Rural	*Devanahalli*	2,605.2	855.0		3,460.2
	Doddaballapura	7,703.4	957.7		8,661.0
	Hoskote	3,262.6	-		3,262.6
	Nelamangala	3,498.8	990.7		4,489.5
	Total	**17,070**	**2,803.3**		**19,873.3**
Ramanagar	*Ramanagar*	8,108.7	745.0		8,853.6
	Channapatna	15,834.7	2,395.5		18,230.3
	Kanakapura	29,969.0	1,908.4		31,877.4
	Sathanur	12,853.6	988.8		13,842.4
	Magadi	7,887.0	553.5		8,440.4
	Total	**74,653**	**6,591.2**		**81,244.0**
Grand total	**14 ranges**	**94,868 (949 km^2)**	**10,547 (106 km^2)**	**1,576 (16 km^2)**	**106,991 (1067 km^2)**

From the above table it is seen that the forest area in Ramanagar district is highest, followed by Bangalore Rural and Bangalore Urban districts. Needless to state that on account of intensive and rapid urbanisation in and around Bangalore, forests have suffered biotic pressure both qualitatively and quantitatively.

2.3.1. Forest ratio in BMR

Total geographical area of the three districts of BMR viz; Bangalore Urban, Bangalore Rural and Ramanagar districts is 8,02,841 ha and the total forest area is 1,06,991.78 ha. Thus, the ratio of the forest area to the geographical area is hardly 13.3%, which is far below the national level of 33% fixed by the Government.

2.3.2. Forest types

At the beginning of the last century most of the forests of Bangalore Urban district were of the tropical dry deciduous type under the sub-group 5A viz. Southern dry mixed deciduous forest of the Champion and Seth classification. These are now degraded into dry deciduous scrub type and stand classified as DS1.

A) Group – 5 Tropical dry deciduous forests

1. *Sub-group 5A Southern tropical dry deciduous forest*
    - C1a Very dry teak
    - C3 Southern dry mixed deciduous forest.
2. *Degradation stages*
    - DS1 Dry deciduous scrub
    - DS2 Dry savannah forest
3. *General edaphic types*
    - E2 Boswellia forest
    - E4 Hardwickia forest
    - E5 Butea forest
    - E8a Phoenix Savannah
    - E9 Dry Bamboo brakes
4. *General Seral types*
    - S1 Dry Tropical riverine forest
    - S1 Secondary dry deciduous forest

B) Group-6 Tropical Thorn forest

1. *Subgroup 6A Southern Tropical Thorn forest*
2. *C1 Southern thorn forest*
3. *DS1 Southern thorn scrub*

2.3.3. Forest classification

Due to various factors like rainfall, edaphic, biotic and management practices the forests of Bangalore Rural and Ramanagar districts can be classified under various categories. It is however, sufficient to broadly classify these forests into the following main categories;

- Dry deciduous type
- Sandal bearing scrub sub-type
- Thorny scrub type
- Riverine sub-type

1. **Dry deciduous type:** The average height of these forest is 10 m. Most of the trees shed foliage in dry season for several months. This type of forest is represented in parts of Sathanur and Kanakapura Ranges and in some pockets of Bangalore Urban District as at Kaggalipura, Basavanthara and Sulekere. The main species in this group are *Tectona grandis, Dalbergia latifolia, Terminalia paniculata and Dalbergia paniculata.*

2. ***Bambusa bambos* sub-type:** Apart from sporadic occurrence of this bamboo in some protected niches and along streams, this sub-type occurs in Sathanur Range at Basavanabetta Reserve Forest in association with Terminalias, Anogeissus species and other deciduous forests.

3. **Sandal bearing scrub sub-type:** Sandal occurs in profusion in relatively drier areas associated with species like Tamarind, Neem, *Memecylon, Canthium, Albizzia, Wrightia, Diospyros montana, Acacia, Feronia, Pongamia, Strychnos potatorum, Cassia, Phyllanthus, Lantana, Dendrocalamus*, etc.

4. **Dendrocalamus strictus sub-type:** This type of forest occurs in varying intensity in elevations between 666 to 1,000 m, noticeably on slopes as found in Bannerghatta National Park.

5. **Thorny scrub type:** This is an open low forest where thorny species dominate where species like Albizzia, Acacia suma, A. catechu, Acacia pinnata, Neem, Canthium didynium, Erythroxylon monogynum, Wrightia tinctoria, Lantana, Randia, Pterolobium, Doddonea, Chloroxylon swietenia, etc, dominate.

6. **Hardwickia and Boswellia type:** These together occur in some niches as at Sathnur, Kanakapura and Ramanagar Ranges.

7. **Riverine sub-type:** This type occurs in narrow strips along larger streams and rivers in some forests which can be differentiated from the general Dry Deciduous type with species like Terminalia arjuna, Pongamia, Eugenia spp, etc.

8. **Phoenix sylvestris:** In some places pure patches of Phoenix sylvestris (Wild Date) occur as at Sulekere Reserve Forest of Bangalore Range, on deposited alluvial soils and waterlogged sites.

Dr. Kadambi, a well-known forester, classifies the forests of Bangalore under 'Dry deciduous type' and recognises two sub-types viz 'Superior scrub type' with *Anogeissus and Albizzia* dominating and 'Inferior scrub type' with species like Acacias, Canthium, Carissa, etc.

2.4. CHARACTERISTIC FLORA OF BMR

1. **Sandalwood *(Santalum album):*** Sandalwood is found growing naturally all over the BMR, more so in Bangalore Urban district. Even a State forest is named after this species viz. Jarakabande Sandal Reserve, as it had thick forest of sandalwood in the past. In Bangalore it is grown widely in private lands, premises of public and Government buildings. Only pity is that it is not allowed to attain maturity by the smugglers. Sandalwood crop is dwindling due to smuggling and spike-disease.

   Sandal regenerates naturally and the birds being the natural propagators of this precious species play an important role in the process of regeneration.

2. **Jalari *(Shorea roxburghii):*** This is another typical tree of the BMR found growing luxuriantly at Kalkere, Bannerghatta, Doresanipalya and Sathnur in some favourable pockets. As per Buchanan's report it was at Ramanagar during 1801-02. This was used as the host tree for lac insect propagation. However, it is not found in abundance in these places now.

Figure 3: Shorea roxburghii (Jalari)

3. **Ficus species:** A few interesting Ficuses are: *F. religiosa* (Aralimara), *F. benghalensis* (Banyan), *F. racemosa* (Country Fig), *F. amplissima* (Bilibasari), *F. arnottiana* (Bettada Arali), *F. drupacea* (Gonimara), *F. microcarpa* (Kirugoli), *F. tsjahela* (Kari-basari), *F. virens* (Basarimara), *F. mollis, F. tinctoria var. parasitica*, etc. Many of these trees are ancient trees deserving to be declared as heritage trees.

The most famous ancient Banyan tree (*Ficus benghalensis*) is a 200 year old 'Dodda Aladamara', off Mysore Road. Villagers near Alanahalli offer special prayers to this tree on auspicious occasions. Reckoned to be a treasure trove of biodiversity, the tree harbours different species of bats, birds and insects within its massive canopy. It covers about 20 guntas area. Additional acreage around this tree is being acquired for its further expansion and growth.

4. Sanna Ippe/ Mohwa tree of South India (*Madhuca longifolia*): Ancient trees of this species are found planted along the older avenues, highways and places of worship
5. Wrightia tinctoria (Ivory Wood): Wood is eminently suited for turnery, carvings, etc. Superior quality toys are made from its wood at Channapatna in Ramanagar district.
6. *Buchanania axillaris* (Maradi mara): Found growing wildly in patches in the KFDC plantations along the boundary of Bangalore Rural district in Chikkbalapur.

Figure 4: Buchanania axillaris (Mardi)

7. *Memecylon angustifolium* (Belavakan): Grows occasionally along streams.
8. Wild *Mangifera indica*: Varieties like *Hulimavu*, *Gol kai*, *Jirige*, *Pich kai*, *Kari kayi*, *Gunge mavu*, *Sakkare mavu*, *Chit kai*, described by B. L. Rice in 1876 are either rare or have disappeared. Some, however, are found in remote villages.
9. *Butea monosperema var. lutea* (Muttuga) Orange flowered trees described as flame of the forest. Only one specimen is located at Lalbagh.
10. *Firmiana colorata* (Bonfire tree): Found growing wildly at some places.
11. *Cochlospermum religiosum* (Arasinaburga): These are growing at Bannerghatta and Sawanadurga.
12. *Manilkara roxburghiana* (Renja): Found growing wildly in Magadi forests.
13. *Ficus krishnae* (Krishna's Butter cup/ *Makhan Katori*): A variety of Ficus benghalensis having leaves folded at base to form a cup-shaped structure, which was, as per the legend used by Lord Krishna to eat butter. The tree is found in Lalbagh.
14. *Boswellia serrata* (Dhupadamara): The species is found growing in some places of Bangalore Rural and Ramanagar districts.
15. *Hardwickia binata* (Kamara) Grows in drier zones.
16. *Chloroxylon swietenia* (Huragalu/Mashwal): Located in drier zones of Bangalore Rural and Ramanagar districts.
17. *Vitex altissima* (Bharanagi/Nauladi mara): Found in Bannerghatta in abundance.
18. Tamarind (*Tamarindus indica*) trees of Nallur *Gundutopu*: In a 53 acre *Gundutopu* of Nallur near Mallepura of Devanahalli, 35 km from Bangalore, 50 ancient Tamarind trees were found planted. This has been recently declared as Heritage Grove. The Revenue Department is in charge of this land and the Tamarind trees are being looked after by the Forest Department. There is a mother tamarind tree aged about 800 years. This has produced supporting roots and independent plants, a rare botanical phenomenon. It has produced prop roots from its trunk and root-suckdeers from lateral roots. The trees are believed to have been planted during the 12th century when Rajendra Chola reigned. Experts say that the prop-roots and root-suckers are a rare phenomenon. This tree is still producing small roots from callus-like tissue developed from its cambium. Amongst these trees about 50 trees are estimated to be about 800 years in age and other 167 trees are about 300 years old. The biggest tamarind tree here measures nine meters in girth.
19. Jackfruit tree (*Artocarpus heterophyllus*)
   - *500 year-old Jackfruit tree at Dobbspet*: A few ancient Jackfruit trees found growing in the country side also form the characteristic flora of BMR. An ancient Jackfruit tree found growing in a private village property at Dobbspet is estimated to be about 500 years old its fruits are annually taken to Mumbai by its fans.
   - *300 year old Jack fruit tree at Kachahalli in Doddaballapura*: This tree is considered as a heritage tree and is famous for its juicy fruits produced throughout the year, which is a rare and exceptional phenomenon. Its fruits were savoured by the then Maharaja of Mysore, Jayachamarajendra Wadiyar and his famous Dewan M. Visvevaraya. The tree bears 35–40 kg of fruits with some attaining giant size.

The tree bears annually 300 fruits which fetch its private owner INR 20,000 to INR 30,000. The delicious taste of this Jack fruit is unique and the limited cellulose content in this variety makes it easily digestible. This tree is of genetically superior variety according to the experts from Bio-Resource Complex, National Bio-Resource Development Board, University of Agricultural Sciences (UAS).

- *350–400 year old Jack fruit tree at Janagere in Magadi taluk*: Its fruits fetch INR 40,000 to 50,000 annually to its private owner.

2.5. GUNDUTOPUS, DEVARAKADUS AND REVENUE WASTELANDS

2.5.1. Present status

These lands are in charge of Revenue Department governed by Revenue Acts and Rules. The forest lands are governed by the Forest Conservation Act which forbids granting of forest lands for any non-forest activity. But the Revenue Acts do not have any such provisions. These lands are liable to be granted for any purpose. Even *gomal* lands (grazing lands set aside for village cattle) are granted freely for any purpose though there are Government circulars and court orders against the grant of *gomal* lands.

Many of these Revenue Lands have rare and rich flora, fauna and avifauna. They also play an important role in restoring the folk art and culture. Unfortunately, these lands are being released for various developmental works thereby, allowing concrete jungles to occupy the wilderness regions. Therefore, it is proposed that these lands be taken away from the control of Revenue Department and transferred to Forest Department for preservation and rejuvenation before it is too late. In spite of several efforts, the Revenue Department has not furnished information on these lands, for taking up of ecological studies.

These Revenue Wastelands, *Devarakadus* (sacred groves) and *Gundutopu* (village woodlots) lands are required to be preserved as they are ecologically very important, supporting vegetation, fauna and avifauna. Over 2000 *Gundutopus* and *Devarakadus* are estimated to be located in the BMR.

Figure 5: 1000 year old Tamarind *Gundutopu* at Nallur near Devanahalli

Figure 6: *Gunduthopu* at Whitefield used for parking IT vehicles

2.5.2. Assessment

1. *Gundutopus* and *Devarakadus* are important for a healthy rural environment and biodiversity conservation. These are some of the centuries old ancient heritage trees, some of which are historically, culturally and religiously important. These are the only patches of greenery in BMR.
2. Most of the villages in BMR have lost their rural characters and are being rapidly urbanised. These areas support rare and endangered flora and fauna which the villagers have so far protected. After the trees are cut either for developmental work or by encroachment, the biodiversity of rural area would get lost.
3. Many of these *devarakadus* and *gundutopus* are birthplaces of various watercourses and streams maintaining high water levels and upkeep of the sinking underground water levels. These regenerate and support various types of aquifers like wells, streams, etc.
4. Arrests soil erosion, provide organic and green manure for agriculture.
5. The wind fallen branches and dead trees provide small timber, fuel and fodder to the village community.
6. Provide flowers and edible fruits to the people, animals and birds.
7. Serves as community meeting place for rural folk.

2.6. BIODIVERSITY HOTSPOTS

2.6.1. Forest biodiversity hotspots controlled by Forest Department

Forests and other areas coming under the control of Forest Department viz. 1069.9 km^2 located in forest 170 + other lands 189 = 359 locations of BMR should be preserved. These are the last remains of biodiversity hotspots of BMR ecosystem.

- *Forest Department, Dhanavantari Vana at Bangalore University Campus (BUC)*: An area of 37 acres of forest land is planted with rare medicinal and other plants in this *Vana* which is under the control of Forest Department. This forms one of the biodiversity hotspots of BMR. This plot is planted with 414 medicinal plants consisting of 173 species of trees, 82 species of shrubs, 92 species of herbs and 42 species of climbers.
- *Arboratum at Kalkere*: This was established in 1980 where evergreen, semi-evergreen and moist-deciduous local species were planted during the 1980s. These trees have grown taller and big. There are about 80 tree species including 40 species of shrubs and climbers. There are also 17 nitrogen fixing tree species.

> An Anecdote: This area was handed over to the Directorate of Indian Systems of Medicine on 6-1-1970 for cultivation of medicinal plants. But nothing was done till 1985. When I was the Deputy Conservator of Forests of Greenbelt Division, a request came from the Medical Directorate to grant this area for developing a Housing Colony for allotting sites to the staff of the Directorate of Indian Systems of Medicine. I refused the request but suggested that it should be taken back by the Forest Department to plant it with trees. So the grant was refused and was later taken up for tree planting from 29-02-1988. Now it is one of the important biodiversity hotspots of BMR.

- Ficus plot at Kalkere: During August 1989, 24 Ficus species were planted. This plot is a rare collection of Ficus species, having *Ficus religiosa, F. benghalensis, F. tinctoria, F. carica, F. infectoria, F. krishnae, F.hispida, F. asperrima, F. mysorensis, F. glomerata, F. altissima, F.benjamina, F.elastica, F.pandurata, F. microcarpa, F.stulhamani, F. triangularis, F. nerrifolia, F.cyatgistipula, F.nervosa, F.racemosa, F. tomentosa, F. pumila.*
- *Bamboo plot at Doresanipalya*: The following eleven bamboo species brought from Arunachal Pradesh were planted at Doresanipalya in April 1991: *Bambusa balcooa, B. tulda, B. pallida, B. nutans, B. glaucescens, Dendrocalamus hamiltonii, Gigantochloa macrostachya, Oxytenanthera abyssinica, Pseudosasa japonica, Pyllostachys bambusoides, Thyrsostachys oliver.* This plot makes a rare collection of northeast Indian Bamboos.

2.6.2. Hotspots under the control of Revenue Department

Gundutopus and Devarakadus: There are approximately 2,000 Gundutopus and Devarakadus in the BMR which need to be preserved after surveying and removal of encroachment and by listing of flora, fauna and avifauna therein.

2.6.3. Parks under the control of Horticulture Department

Lalbagh: Is a botanical garden of 97 ha established by Hyder Ali and later enriched by Tipu Sultan is now under the control of Horticulture Department. A mango tree planted by Tipu still flourishes in Lalbagh. It is a treasure house of plants comprising of both Indian and exotic plants. There are 1854 species of 673 genera and 890 cultivars of plants. There are many heritage trees here. It has a rare Glass House, a Lalbagh pond and an island. It is one of the main lung spaces of BMR and plays a great role in arresting and absorbing the air pollutants of the city.

Cubbon Park: This was established in the year 1870 by John Meade, the then acting Commissioner of Mysore. The park was initially named as 'Meade's Park' and was subsequently renamed as Cubbon Park. In 1927 it was renamed as 'Sri Chamrajendra Park' to commemorate the Silver Jubilee of Sri Krishnaraj Wodeyar's rule in Mysore State. The park has 6,000 plants belonging to 68 genera and 96 species. Grevellia robusta, Silver oak having the distinction of being the first oaks introduced from Australia, are still found in Cubbon Park adjacent to the Tennis Pavilion. It has an area of 191.2 acres.

There are several beautiful avenue trees viz; Araucaria (Christmas tree), the avenue along Canna beds on either side of the road from Library to Hudson Circle, avenue of Swietenia (Mahogany) in the northern side of the park, the Java Fig avenue along the road leading to Government Museum, the Polyalthia (Mast tree) avenue along the road from the Queen's statue to King Edward's statue and the Chestnut tree avenue from Chamarajendra statue to Siddalingaiah Circle.

2.6.4. Hotspots under the control of Bangalore University and Gandhi Krishi Vignana Kendra

- *Biopark of Bangalore University Campus*: This is under the control of Bangalore University. A patch of about 400 acres is planted with various Western Ghat species with the assistance of Forest Department. The saplings were also brought from Forest

Department nurseries spread over different places. When the trees attain maturity, this bio-park will be one of the unique biodiversity hotspots as it is only 6 years old. BUC has a total area of 800 acres with pockets of wilderness spread over.

- *Gandhi Krishi Vignana Kendra (GKVK)*: This campus has a rich and varied flora comprising of an area of 545 acres. Many birds also visit this place.

2.6.5. Other forests preserved

- *Bannerghatta National Park*: Is situated in the Bangalore Urban district spread over an area of 102 km^2. This has interesting species of Deccan Flora, Fauna and Avifauna. Being within a reach of 22 km from Bangalore, the park has been developed for eco-tourism and is a very popular tourist centre.
- *Pavithra Vana (sacred grove) at Doddamane Gudde*: Established in 1990 is situated near Ramanagar of Ramanagar district in the forest administrative unit of Channapatna Forest Range. This has been developed as a *Nakshatravana* where, there are 39 *Vanas* each of them dedicated to a particular deity. Composition of species is specific to each deity like Vinayaka, Gauri, Ambika, Vishnu, etc. The *Pavithra Vanas* have in all 3,500 trees comprising of shrubs and herbs.
- *Sawanadurga Medicinal Plants Conservation Area (MPCA)*: This was established through the Foundation for Revitalisation of Local Health Traditions (FRLHT) at Sawanadurga of Ramanagar district during 1993. MPCA is situated at the foothill of Bilibetta of Sawanadurga Reserve Forest. Total area of this MPCA is 150 ha with a buffer zone of 800 ha. This plot serves as a permanent conservation plot of the Forest Department. According to Champion and Seth classification, this forest falls under the type dry deciduous scrub, type 5/DS, a type that is found throughout the dry deciduous tracts in the south. Species found are Tamarind, Wood Apple, Neem, *Acacia suma, Anogeissus latifolia, Albizzia lebbeck, Albizia odoratissima, Albizzia amara, Ficus tsiela, Sandfal, Wrightia tinctoria, Zyzyphus sp*, etc.

2.6.6. Other non-forest areas preserved

Quasi government areas: Indian Institute of Science = 416 acres, Raman Research Institute = 22 acres, Veterinary College, Hesarghatta farms of Horticulture, Sports Authority of India are the other quasi government areas that support rich vegetation.

Other non-government areas: Bangalore palace ground has rich and varied vegetative growth in many pockets.

Hotspots under the control of Military: Some of the military establishments spread over the greater Bangalore city have rich flora and vast wilderness areas that may be considered as biodiversity hotspots of BMR. These are Jalahalli Air Force Station, Bharat Electronics Limited (BEL), Hindustan Aeronautics Limited (HAL), Sappers and Miners, Military School, etc.

Figure 7: From branches to scaffoldings – Construction on Bannerghatta Road

2.7. NOTEWORTHY SPECIMENS

2.7.1. Heritage trees

Heritage trees have historical and religious importance, rarity, ancient age of rare size, ecological importance and medicinal values. Some examples of rare species are:

- Mango tree planted at Lalabagh by Tipu
- A giant Saptaparni tree (*Alstonia scholaris*) at Lalbagh
- Lignum vitae/ Tree of life (*Guaiacum officinale*) at Lalbagh
- Orange flowered flame of the forest (*Butea monosperma*) at Lalbagh
- Christmas trees (*Araucaria columnaries*) that flower and fruit only at Bangalore
- Splendid Amherstia (*Amherstia nobilis*) at Lalbagh
- Rose of Venezuela (*Brownea grandiceps*) at Lalbagh

2.7.2. Exotic species

Many of the exotic species are found in the environs of BMR, a few important ones are given below:

- Eucalyptus: Several species of Eucalyptus are found introduced in the region. Out of these, E. hybrid, E. citriodora are commonly found. E. hybrid has earned the name of Mysore Gum. Most of the forests around Bangalore like Jarakabande, Tugli gudda, Marasandra are covered with E. hybrid.
- Silver Oak *(Grevellea robusta):* Silver Oak gets the second place in our environs, as after Eucalyptus this species is found in many places.
- Exotic ornamental trees: Found in Lalbagh and Cubbon Park and along the avenues of Bangalore city. Popular amongst these are Gulmohur, Jacaranda, Badminton Ball, Christmas tree, Mahogany etc. Lalbagh has some rare exotics like Christmas tree, Lignum Vitae, Baobab, several exotic palms, etc.

2.7.3. Endangered flora

The endangered plants of Botanical Survey of India are:

- Crotalaria filipes, a shrub
- Crotalaria hirta
- Crotalaria retusa

Figure 8: Ficus tree at Doddabasti village

Figure 9: Banyan tree at Whitefield

2.8. FAUNA

BMR comprises a rich diversity of fauna such as mammals, reptiles, insects, butterflies, snakes, lizards, spiders, fishes, birds, scorpion, molluscs, slugs, etc. However, it would be beyond the scope of this report to discuss about the faunal components, notwithstanding the fact that many of these groups have not been inventorised.

2.8.1. Reptiles

Over 35 species of reptiles are listed from the region. Some of them are as listed below.

Snakes: Common Indian Monitor (*Varanus bengalensis*), Binocellate/Indian 'Spectacled' Cobra (*Naja naja*), Russell's Viper (*Vipera russelli*), Saw-scaled Viper (*Echis carinatus*), Common Indian Krait (*Bungarus caeruleus*), Common Rat Snake (*Ptyas mucosus*), Indian Python (*Python molurus*), Common Wolf Snake (*Lycodon aulicus*), Common Trinket Snake (*Elaphe helena*), Bronzebacked Tree Snake (*Dendrelaphis tristis*), Green Vine Snake (*Ahaetulla nasutus*), Slender Blind Snake (*Typhlops porrectum*), Boas (*Eryx* spp), Checkered Keelback (*Xenochrophis piscator*), Common Worm or Blind Snake (*Typhlina bramina*), Russell's Earth Boa (*Eryx conicus*), Common Kukri Snake (*Oligodon arnensis*), Buff-striped Keelback (*Amphiesma stolata*), Cat Snake or Indian Gamma (*Boiga trigonata*), Banded Racer (*Argyrogena fasciolatus*) are the snakes found in the region.

Lizards: Indian Chameleon (*Chamaeleon zeylanicus*), Forest Calotes (*Calotes rouxi*), Common Garden Lizard (*Calotes versicolor*), Termite Hill Gecko (*Hemidactylus triedrus*), Bark Gecko (*Hemidactylus leschenaultii*), Peninsular Rock Agama (*Psammophilus dorsalis*), Snake Skink (*Riopa punctata*), Spotted Skink (*Mabuya macularia*), Brahminy Skink (*Mabuya carinata*).

2.8.2. Mammals

Over 40 species of mammals have been recorded several of which are endangered.

Table 7: Mammals found in BMR

Common name	Scientific name
Leopard	*Panthera pardus*
Jungle cat	*Felis chaus*
Rusty spotted Cat	*Felis rubiginosa*
Wild dog	*Cuon alpinus*
Common Indian Mongoose	*Herpestes edwardsi*
Ruddy Mongoose	*Herpestes smithi*
Jackal	*Canis aureus*
Elephant	*Elephas maximus*
Gaur	*Bos gaurus*
Blackbuck	*Antilope cervicarpa*
Sambar	*Cervus unicolor*
Spotted deer	*Axis axis*
Barking deer	*Muntiacus muntjak*
Mouse deer	*Tragulus meminna*
Indian wild boar	*Sus scrofa*
Small Indian civet	*Viverricula indica*
Common Palm Civet	*Paradoxurus hermaphroditus*
Sloth bear	*Melursus ursinus*
Bonnet macaque	*Macaca radiata*
Common langur	*Presbytis entellus*
Pangolin	*Manis crassicaudata*
Indian porcupine	*Hystrix indica*
Indian hare	*Lepus nigricollis*
Slender Loris	*Loris tardigradus.*
Flying fox	*Pteropus giganteus*
Shortnosed Fruit Bat	*Cynopterus sphinx*
Grey Musk Shrew	*Suncus murinus*
Three-striped Palm Squirrel	*Funambulus palmarum*
Gerbille	*Tatera indica*
Whitetailed Wood Rat	*Rattus blanfordi*
Longtailed Tree Mouse	*Vandeleuria oleracea*

2.8.3. Tortoises, Terrapins and Turtles

Star Tortoise (*Geochelone elegans*), the rare and charming land tortoise, is found along the eastern borders in semi-arid regions. Indian Pond Terrapin (*Melanochelys trijuga*), a fresh-water form, is commonly found in most of the waters. Deccan Soft-shell Turtle (*Trionyx leithi*), a mud turtle of shallow waters is found in the Cauvery river system.

2.8.4. Insects

A comprehensive study of the insects of BMR has not been done. This area is very likely to support a fairly large diversity of insects. However, several experts who have specialised in particular groups have documented only insects of the group that interests them. For example Grasshoppers of the region have been studied; ants of the area have been documented and are in excess of 100 species. A new species of ant was discovered recently. Similarly, select groups have been documented while no effort has been made to collate all this information and also to fill in the gaps. This should be a very important task that should be taken up at the earliest.

Table 8: Examples of insects found in the BMR

▪ Six-Spotted Carabid Beetle	▪ Painted Grasshopper
▪ Hooded Grass Hopper	▪ Tortoiseshell Beetle
▪ Bush Cricket	▪ Long Horned Grasshopper
▪ Cicada	▪ Damselflies
▪ Ant Lion	▪ Owl fly
▪ Hones Bee	▪ Dragonfly
▪ Stick Insect	▪ Praying Mantis
▪ Tiger Beetle	▪ Cantharids or Scarab Beetle
▪ Moths	▪ Spotted Scutellarid Bug
▪ Cotton Bug	▪ Jewel Insect
▪ Dung Beetle	▪ Termites

2.8.5. Butterflies

Butterflies are an important component of biodiversity in a given ecosystem and they add to the aesthetics of any place. They perform the vital role of pollination in nature. They help in pollinating flowers, their eggs and larvae serve as food for a host of organisms. Butterflies are also associated in an intricate and interesting relationship with plants and other organisms.

The current list of butterflies of Bangalore is in excess of 150 species which is 10% of the number of species that is known to occur in the country [Karthikeyan, S (1999): The vertebrates and Butterflies of Bangalore: A Checklist. WWF-India, Karnataka State Office, Bangalore Pp. 48]. As should be expected, some are rare and endangered. The Southern Birdwing the largest Indian butterfly and the Grass Jewel the smallest Indian butterfly occur in Bangalore; the former being the rare species of the two.

If this rich butterfly fauna is to survive, it is imperative that diversity of flora that the region enjoys be fostered. With the rapid changes that the city and its surrounding landscape are experiencing, it would be interesting to study the effect on butterflies. This will also provide for suitable conservation plan to retain this charismatic group of insects.

Table 9: Some butterflies found in the BMR

▪ Common Mormon	▪ Common Wanderer
▪ Common Rose	▪ Plain Tiger
▪ Crimson Rose	▪ Striped Tiger
▪ Lime Butterfly	▪ Blue Tiger
▪ Blue Mormon	▪ Common Crow
▪ Common Banded Peacock	▪ Crimson Tip
▪ Common Emigrant	▪ White Orange Tip
▪ Mottled Emigrant	▪ Yellow Orange Tip
▪ Southern Birdwing	▪ Plain Orange Tip
▪ Common Blue Bottle	▪ Peacock Pansy
▪ Common Nawab	▪ Blue Pansy
▪ Tailed Jay	▪ Lemon Pansy
▪ Common Gull	▪ Yellow Pansy
▪ Pioneer	▪ Psyche
▪ Common Jezebel	▪ Danaid Eggfly

2.8.6. Spiders

There has been no concerted effort to document the spiders of the area under consideration. Though they are a very important group of Invertebrates, not much attention has been given to them. Studies of spiders of the areas have been almost non-existent. Some of the interesting spiders include the tarantulas, the giant wood spiders, several species of jumping spiders, wolf spiders and social spiders

Table 10: Some spiders found in the BMR

▪ Garden Spider	▪ Green Lynx Spider
▪ Giant Wood Spider	▪ Social Spider
▪ Brown Lynx Spider	▪ Tarantula

2.8.7. Fishes

Fish species exceeding 40 have been recorded from the region. These represent 3 orders and 14 families. As recently as 1999 *Salmastoma belachi* a new species of fish was described from the region. This only goes to show that our water bodies still have in store some surprises. This also means that the development plans for the lakes of the area have to be planned only after conducting careful study of these aquatic ecosystems.

Table 11: Different families of fishes present in the lake systems of BMR

Family		
▪ Cyprinidae	▪ Poecilidae	▪ Heteropheustidae
▪ Cobitidae	▪ Ambassidae	▪ Cichidae
▪ Balitoridae	▪ Gobiidae	▪ Channidae
▪ Bagridae	▪ Belontiidae	▪ Siluridae
▪ Mastacembelidae	▪ Claridae	

2.8.8. Unique fauna

Some of the unique wild animals found in the BMR are:

Table 12: Unique animals found in the BMR

Common name	Scientific name
▪ Rustyspotted Cat	*Felis rubiginosa*
▪ Ruddy Mongoose	*Herpestes smithi*
▪ Indian Elephant	*Elephas maximus*
▪ Blackbuck	*Antilope cervicarpa*
▪ Sloth bear	*Melursus ursinus*
▪ Common Langur	*Presbytis entellus*
▪ Slender Loris	*Loris tardigradus.*

2.8.9. Avifauna

BMR is quite rich in birdlife, with more than 330 birds listed in the region *(Appendix 2)*. Yellow Throated Bulbul, Yellow Throated Sparrow, House Sparrow, Spotbilled Pelican are unique to the region. The following are some birds recorded in the region.

Table 13: Birds found in the BMR

Common name	Scientific name
▪ Spotbilled Pelican	*Pelecanus philippensis*
▪ Honey Buzzard	*Pernis ptilorhynchos*
▪ Shikra	*Accipiter badius*
▪ Crested Hawk Eagle	*Spizaetus cirrhatus*
▪ Bonelli's Eagle	*Hieraaetus fasciatus*
▪ Longbilled Vulture	*Gyps indicus*
▪ Whitebacked Vulture	*Gyps benghalensis*
▪ Short-toed Eagle	*Circaetus gallicus*
▪ Crested Serpent Eagle	*Spilornis cheela*
▪ Red Spurfowl	*Galloperdix spadicea*
▪ Grey Junglefowl	*Gallus sonneratii*
▪ Green Pigeon	*Treron phoenicopetera*
▪ Blossomheaded Parakeet	*Psittacula cyanocephala*
▪ Koel	*Eudynamys scolopacea*
▪ Small Greenbilled Malkoha	*Rhopodytes viridirostris*
▪ Great Horned Owl	*Bubo bubo*
▪ Brown Fish owl	*Bubo zeylonensis*
▪ Alpine Swift	*Apus melba*
▪ Storkbilled Kingfisher	*Pelargopsis capensis*
▪ Small Green Barbet	*Megalaima viridis*
▪ Rufous Woodpecker	*Micropternus brachyurus*
▪ Little Scalybellied Green Woodpecker	*Picus myrmecophoneus*
▪ Pigmy woodpecker	*Picoides nanus*
▪ Indian Pitta	*Pitta brachyuran*
▪ Golden Oriole	*Oriolus oriolus*
▪ Whitebellied Tree Pie	*Dendrocitta leucogastra*
▪ Tickell's Blue Flycatcher	*Muscicapa tickelliae*
▪ Paradise Flycatcher	*Terpsiphone paradise*
▪ Orphean Warbler	*Sylvia hortensis*
▪ Blueheaded rock Thrush	*Monticola cinclorhynchus*
▪ Purple Sunbird	*Nectarinia asiatica*
▪ Yellowthroated Sparrow	*Petronia xanthocollis*
▪ House Sparrow	*Passer domesticus*
Rare winter visitor	
▪ White Stork	*Ciconiaciconia*
▪ Greater Flamingo	*Phoeniconaias*
▪ Barheaded Geese	*Anser indicus*
▪ Brahminy Duck	*Tadorna ferruginia*
Endemic	
▪ Yellowthroated Bulbul	*Pycnonotus xantholaemus*

2.9. RECOMMENDATIONS

2.9.1. Gundutopus, devarakadu and Revenue Wastelands

- Should be cleared of encroachment.
- Should be surveyed and stone-walled or fenced.
- Should not be allotted for any other purpose.
- Should be replanted with useful and fruit-yielding local tree species, wherever older trees have died or fallen.
- Trees existing in these patches should be listed and entered in a register.
- Heritage and ancient trees standing in these patches should be identified and listed.
- A list of such lands (Revenue, *Devarakadus* and *Gundutopus*) should be prepared and a separate document should be maintained by the *Gram Panchayats* and concerned departments.
- Historical and biodiversity study of these areas should be under taken.

2.9.2. Biodiversity hotspots

- Demarcation of boundary and fencing of the area to prevent encroachment
- Strict enforcement of vigilance and protection by the staff in charge duly taking care of the needs of staff such as arms, ammunitions, vehicles, communication system, etc.
- Extensive studies in the biodiversity of these units should be taken up by employing experts in various fields.

2.9.3. Heritage, exotic, endangered and unique flora and fauna

Habitat of heritage trees, exotic species, endangered species, unique flora and fauna existing in government and non-government lands of BMR should be protected and preserved duly taking care of the census aspect periodically.

Figure 10: Ruddy Mongoose

Figure 11: Spot-billed Pelican

Figure 12: Yellow Throated Sparrow

3. ENVIRONMENTAL VALUE OF FORESTS

Forest areas play an important role in controlling pollution and providing other benefits. They absorb noise, dust and solar radiation. Under forest cover the atmospheric temperature is lesser by at least 2 ^{0}C as compared to the open surrounding areas. Noise pollution is also reduced by 40–60% of CO_2 emitted by the vehicles is also absorbed. They recharge aquifers; keep the rivers and streams flowing and arrest silting up of reservoirs. Most of them are watershed areas of the river systems.

3.1. AIR POLLUTION

Urban citizens are subjected to dangerous levels of highly toxic gases including volatile organic compounds and sulphur gases through the air they breathe. A report documents at least 45 chemicals, including 13 chemicals that were found in 21 air samples taken from 13 locations around the country between 2004–06. Twenty-eight compounds were found at levels up to 32,000 times higher than levels considered safe in residential air by the United States Environmental Protection Agency.

The chemicals are found to target virtually every system in the human body such as eyes, central nervous system, skin and respiratory system, liver, kidneys, cardio vascular system, blood and reproductive system.

Figure 13: Vehicular pollution

Air washing: Forests reduce air pollutants through the process of air washing. Airborne particulate matter such as dust, sand, fly ash, pollen and smoke are either removed or arrested by the trees in the forests by air washing. These get settled on the leaves, branches, boles, etc., of the trees on account of humidity created by the transpiration of plants and get washed down to earth during rains. This phenomenon is especially seen around quarries, mining areas, etc. where the vegetation is seen covered with particulate matter in summer and get washed down during the rainy season.

Forests absorb and disburse air pollution: Plants produce oxygen during the photosynthetic process. Thus, they perform an important role in pumping extra oxygen into the air, which is very important for our survival. They also dilute the polluted air by mixing it with fresh air. Studies from the United States of America have shown that an air mass having 160 parts per million (ppm) of ozone will be absorbed of its ozone by about 80%, if this air mass were to stand over a forest-cover for eight hours. Studies in Russia have shown that a green-belt of plants of 500 m around factories reduce sulphur dioxide content to the extent of 70% and nitric oxide by 67%. The potential of forest areas to actively reduce pollution is a real yet barely known fact.

Dust pollution: Forests collect the urban dust and other particulates on their foliage and reduce dust pollution.

Sound pollution: Sound pollution adversely affects human health and comfort. It could also be controlled by vegetation. Noise produced by automobiles, trains, industries, mining, factories, highway-traffic could be reduced by at least 50% by the forests if situated nearby.

3.2. CONTROL OF TEMPERATURE AND HUMIDITY

- Tree cover of the forests intercepts solar radiation to the extent of 90% in summer.
- Trees in the forests intercept, reflect, deflect and absorb solar radiation: Urban temperature is reduced by 1.5–2.5 °C if the urban areas are surrounded by the forests.
- Glare and reflection pollution: Forests reduce and control the pollution of glare and reflection near cities and even villages. So in rural areas these pollutions are markedly found absent.
- Trees and other vegetation in the forests intercept precipitation and retard its flow to the soil. This activity enhances infiltration and decreases run off and soil erosion. Trees also minimise evaporation of soil moisture. Daily transpiration rate of an average sized shade tree is reported to be 400 litres of water which means it can match work of five average air-conditioners of 2,500 kcal/hr capacity each kept running for 20 hours/day.

3.3. OTHER MERITS

- *Windbreaks and shelterbelts*: Forests serve as windbreaks and shelterbelts in arresting high winds causing damage to agricultural crops and property. Forests lessen the wind velocity around open areas.
- *Store-houses of biodiversity*: The forest is inhabited by varieties of animals of varying size like insects and birds, which support the plant diversity by means of their living habit.

- *Soil erosion*: Forests control and prevent soil erosion caused either by rains or winds.
- *Wastewater filtration*: Trees in the urban area help in managing the wastewater. They serve as 'Living filter systems', by evaporating the wastewater.
- *Recreation and wildlife amusement centres*: Forests like Bannerghatta National Park can be developed as wildlife, parks for recreation and education of public.

4. CONFLICTS

4.1. LOSS OF GREEN COVER

4.1.1. Vegetation and water bodies

Satellite images show a comparison of the green cover of BMR in 1973 and 2006. The green cover has been encroached by the buildings. The study conducted by the IISc scientist Prof. T.V. Ramachandra has highlighted the loss of city's green cover by 32% between 1973 and 1992 and by 38% till 2002. About 25% of our vegetation over the last 5 years from 2002 to 2007 has been lost. The study shows that there has been 466% growth in the city's sprawl over the last 35 years from 1973 to 2007. Loss of vegetation and water bodies and rise in anthropogenic pressure are the prime factors behind the rise in temperature of the city by alarming 3 ^{0}C in the past decade alone. The study was conducted by the study of Land Surface Temperature (LST) using modern tools like remote sensing data and Normalised Difference in Vegetation Index (NDVI) and the study was carried out by conducting field survey of the city. Water and vegetation play a significant role in determining the LST.

4.1.2. Recommendations

- Fool proof and punitive measures should be adopted to check forest encroachments.
- Introduction of exotic species amidst natural vegetation should be banned. Instead, indigenous species should be preferred.
- Joint Forest Planning and Management should be encouraged in forest areas having 0.25 and less density of vegetation.
- Laying of overhead cables, pipes and formation of roads in forest areas as well as trees in urban areas should be avoided.

Figure 14: Severe pruning jeopardising stability – Champa tree in J. P. Nagar

- Sand mining and quarrying in forest areas should be banned through suitable legislation.
- The Revenue wastelands, *gomals*, *gundutopus* and *devarakadus* should be transferred from Revenue Department to Forest Department in order to conserve and protect the existing vegetation and land.

4.2. QUARRYING AND MINING IN FOREST AREAS

- Forests contain and sustain a rich source of biodiversity. In addition, many of the rivers and streams originate in the forest regions. These water courses are maintained and sustained by the forests which absorb and hold water to feed the water bodies. Quarrying and mining in forest areas do immense damage to the forests, water sources and the biodiversity contained therein.
- Forests contain rich vegetation like trees, shrubs, herbs and climbers. These will be destroyed by mining and quarrying. Through mining and quarrying activities great stretches of forests are cleared of its vegetation and surface soil, which in turn results in the destruction of vegetation.
- Forests are the storehouse of biodiversity. They provide habitat for wild mammals, reptiles, insects,

birds, etc. Species like the Yellow-throated Bulbul *Pycnonotus xantholaemus,* which is both an endemic and an endangered species, are affected by mining and quarrying. This species thrives in hills that have boulders scattered all over and support some sparse vegetation. It is exactly these hills that are under serious threat from quarrying. Therefore, quarrying should be carried out with caution and after reviewing the flora and fauna that would be affected.

- Quarrying and mining activities add to air pollution like dust, smoke, noise, etc.
- Of late sand mining is causing considerable damage to rivers, streams and reservoirs. By this activity the water levels of these water courses are reduced to a great extent. At some places the streams and rivulets are disappearing as a result of siltation of riverbed.

4.3. MANAGEMENT ISSUES

4.3.1. Problems in hazard management

- Poaching of animals and smuggling of plants
- Encroachment of forest areas
- Deforestation and shrinkage of habitat
- Digging of tunnels, laying of tubes, cables, overhead high voltage power transmission lines, etc.
- Mining, including sand mining
- Introduction of exotics
- Lack of modern weapons with the staff for protection
- Shrinkage of water bodies due to reduced inflow

4.3.2. Protection of aquatic flora and fauna

Measures to be taken in protecting the aquatic flora and fauna of water bodies:

- Over fishing to be controlled.
- Introduction of exotic fish like African Carp fish which eats away all the local fish should be banned.
- Siltation of tanks to be checked.
- Poaching of water birds to be stopped.
- Encroachment of foreshores and tank bed for cultivation and building construction to be checked.
- Pollution of water bodies with urban waste, sewage water and industrial effluent to be checked.
- Ancient tanks need extensive repairs.
- Erection of brick kilns in or near water bodies to be prohibited.
- Sand mining in tank beds, which is one of the dangerous activities of late should be stopped
- Tanks being released for layouts, industrial units and other developmental work should be stopped.
- Clogged or destroyed feeder channels of water bodies to be declogged and maintained.
- Boating to be prevented in water bodies as it destroys aquatic flora and fauna.
- Recreation and entertainment activities involving hotels, eateries, kiosks, boating clubs and leasing foreshores (or near about areas) for any such purposes should be prohibited.

5. TREE PLANTING

5.1. ASSOCIATED DEPARTMENTS

5.1.1. Forest Department

A. Tree planting in Bangalore City was done from 1983 to 2002 by Forest Department.

Table 14: Tree planting by Forest Department from 1983 to 2002

Planting areas	*Number of seedlings planted*	*Number of parks planted*
Road side planting	10,44,234	120
School planting	1,78,476	
Parks and other institutions	2,06,281	
I Block plantation in Government lands	20,56,939	
Total	**34,85,930**	**120**

Source: Forest Department

Figure 15: Forest nursery at Puttenahalli

B. Tree planting done in Bangalore City from 2002 to 2007 by Forest Department.

Table 15: Tree planting by Forest Department from 2002-07

Year	Number of seedlings planted
2002–03	1,58,000
2003–04	48,900
2004–05	84,300
2005–06	5,160
2006–07	2,74,600
Total	**4,28,760**

Source: Forest Department

Total tree planting done by the Forest Department: A+B = *39,14,690 saplings + 120 parks*.

5.1.1. Bangalore Mahanagara Palike

Table 16: Tree planting in Bangalore city by BMP

Year	Number of seedlings planted
2006–2007	3,000
2007–2008	19,500
Total	**22,500**

Source: BMP

5.1.2. Bangalore Development Authority

Table 17: Tree planting in Bangalore City by BDA from 1997 to 2007

Year		Number of seedlings planted	Number of parks raised
1.	1997–98	3,400	
2.	1998–99	10,000	
3.	1999–2000	7,500	
4.	2000–01	9,000	
5.	2001–02	7,500	12
6.	2002–03	4,000	
7.	2003–04	2,800	
8.	2004–05	4,000	
9.	2005–06	1,000	
10.	2006– 07	6,200	
Total		**55,400**	**12**

Source: BDA

5.2. ASSESSMENT

- Tree planting is being done by 3 agencies in the city viz. Forest Department, BDA and BMP.
- Tree planting and post planting operations are not being done properly resulting in heavy casualty of plants
- Small seedlings of less than 1 m in height should not be planted.
- Planting of a particular species for particular site-situation is not being done. Tall growing species are planted under cables etc. and species having large canopy are planted on narrow roads. This practice should be checked.
- Selection of species taken up for planting is not always right and species having longer span of life are not being planted which needs to be discouraged.
- Public are not involved in planting of saplings. It has been largely a departmental and contractors show.
- There is no control over illicit or unauthorised cutting of trees in the city. Many unauthorised cutting of trees go without being booked for offence under the Tree Act.
- While widening or digging of road, the trees that could be saved are not being saved. Trees can be saved by maintaining tree-medians and widening of roads on either side.
- Regular crown-pruning and tree-surgery is not being done.

Figure 16: Often the price of development - Tree cemetery, old Airport Road flyover

Figure 17: Are trees losing appeal? – Cut trees at a residence

5.3. RECOMMENDATIONS

- Public, students, tree wardens, tree police, etc., along with government and quasi-government agencies should be involved in tree planting and protection of saplings.
- Assessment of survival percent of seedlings should be taken up every year by an independent agency.
- Recoveries should be ordered for loss and unsuccessful planting from the contractors.
- Payments may be made for only those plants that survive after one or two years.
- Large trees lasting for longer years to be planted for reducing urban pollution like dust, sound, solar radiation and for absorbing air pollutants on broader roads.
- While widening the roads, as many older trees should be saved as possible. This could be done by keeping tree medians and by acquiring government land on either side of the road, if available.
- Heritage trees should be preserved.

ANNEXURE 1: FLORA OF BMR

	Botanical name	Local name	Family	Remarks
1	*Aagyei citneata*	Kallanamele	Convolvulaceae	
2	*Abrus precatorius*	Gurugunji	Fabaceae	Medicinal plant
3	*Abuiilon indicum*	Shinnudhre Gida	Malvaceae	Medicinal plant
4	*Acacia auriculiformis*			
5	*Acacia catechu*	Cachu (Khadira)	Malvaceae	Medicinal plant
6	*Acacia chundra*			
7	*Acacia concinna*	pachali, Belaga	Mimosaceae	
8	*Acacia ferruglinea*	Banni	Mimosaceae	Medicinal plant
9	*Acacia intsia*	Kaduseege	Mimosaceae	
10	*Acacia leucophloea*	Biliiai, NCiibela	Mimosaceae	
11	*Acacia nilotica*	Gobli, Karijali	Mimosaceae	
12	*Acacia polycantha*			
13	*Achras zapota*			
14	*Achyranthus aspera*	Uthrane	Amarantaceae	Medicinal plant
15	*Adathoda vasica*			
16	*Adenanthera pavonina*	Aadusoge	Acanthaceae	Medicinal plant
17	*Adina cordifolia*	Aadusoge	Acanthaceae	Medicinal plant
18	*Aegle marmelos*	Bilpathre	Rutaceae	Medicinal plant
19	*Aeschynomene indica*			
20	*Agave sisalana*		Amaryllidacea	
21	*Ailanthus excelsa*	Hiremara	Simarudaceae	Medicinal plant
22	*Alangium lamarckii*	Ankola	Alangiaceae	Medicinal plant
23	*Albizzia amara*	Sujjalu / tuggali	Mimosaceae	Medicinal plant
24	*Albizzia lebbek*	Bage	Mimosaceae	Medicinal plant
25	*Albizzia odoratissima*	Bilwara	Mimosaceae	Medicinal plant
26	*Albizzia procera*	Bellati	Mimosaceae	
27	*Albuitilon Indicum*	Thumbegida	Malvaceae	
28	*Alloteropsis cimicina*			
29	*Anacardium occidentale*	Geru	Anacardiaceae	
30	*Anona squamosa*	Seethaphala	Annonaceae	Medicinal plant
31	*Anogeissus latifolia*	Dindiga, Dindlu	Combretaceae	Medicinal plant
32		Arasina	Zingiberaceae	
33	*Aristolochia indica*	Iswaree beru balli	Aristolochiaceae	Medicinal plant
34	*Artocarpus integrifolia*	Halasu	Moraceae	
35	*Azadirachta indica*	Bevu	Meliaceae	Medicinal plant
36	*Azima tetracantha*	Uppagachi	Salvadoraceae	
37	*Bambusa arundinaceae*	Bidhiru	Poaceae	Medicinal plant
38		Barbehullu		
39	*Bauhinia purpurea*	Kaadu mandhara	Caesalpinaceae	Medicinal plant
40	*Bauhinia racemosa*	Kenchuvala, Achiga	Caesalpiniaceae	
41	*Bauhinia vahlii*	Arise	Caesalpinaceae	Medicinal plant
42	*Bombax malabaricum*	Buruga	Bombacaceae	Medicinal plant
43		Bombu, Hebbidiru	Poaceae	
44	*Boswellia serrato*	Bilidhupa, Maddi	Burseraceae	Medicinal plant

	Botanical name	Local name	Family	Remarks
45	*Bridelia retusa*	Mullu honne	Euphorbiaceae	
46	*Buchanania angustifolia*	Maradi	Anacardiaceae	Medicinal plant
47	*Buchanania lanzan*		Anacardiaceae	Medicinal plant
48	*Butea monosperma*	Muthuga	Fabaceae	
49	*Caesalpinia bonduc*	Gajjika	Caesalpiniaceae	
50	*Caesalpinia mimosoides*	Keniaga	Caesalpiniaceae	
51	*Caesearia tomentosa*	Hesara	Semydaceae	
52	*Calotropis gigantean*	Ekka	Asclepiadaceae	Medicinal plant
53	*Calotropis procera*	Ekka	Asclapiadaceae	
54	*Canthium parviflorum*	Kare	Rubiaceae	
55	*Canthium sp*	Heddarare	Rubiaceae	
56	*Capparis horrida*	Kathrihambu	Capparaceae	
57	*Capparis stylosa*	Hunsadlimullu	Capparidaceae	
58	*Cardiospermum halicacabum*	Agniballi	Sapindaceae	Medicitial plant
59	*Careya arborea*	Kaulu	Mvrtaceae	Medicinal plant
60	*Carissa carandas*			
61	*Caryota urens*	Bagani	Caryophvlaceae	
62	*Cassia auriculata*	Avarike, Thangadi	Caesalpiniaceae	Medicinal plant
63	*Cassia fistula*	Kakke	Caesalpiniaceae	Medicinal plant
64	*Cassia hirsute*			
65	*Cassia mimosoides*			
66	*Cassia siamea*	Seemathangadi	Mimosaceae	
67	*Cassia tora*	Chagache	Caesalpiniaceae	
68	*Casuarina equisetifolia*	Survey	Casuarinaceae	
69	*Celastrus montana*	Kadugandha	Celastraceae	
70	*Celastrus paniculata*	Gengungeballi	Celastraceae	
71	*Ceropegia tuberosa*	Bachachamanda Bithrige	Asclepiadaceae	
72	*Chloroxylon swietenia*	Hurugalu, Birligida	Meliaceae	
73	*Cipadessa baccifera*	Chittunde	Meliaceae	
74	*Cissus quadrangularis*			
75	*Clematis gouriana*	Arakanambu	Ranunculaceae	
76	*Cochlospermum gossypium*	Bettadavare	Malvaceae	
77	*Cordia macleodii*	Hadage	Boraginaceae	
78	*Cordia myxa*	Challe	Boraginaceae	
79	*Crotalaria filipes*			
80	*Crotalaria hirta*			
81	*Crotalaria retusa*	Dhingala	Fabaceae	Medicinal plant
82	*Croton bonplandianus*			
83	*Cryptolepias buchanani*	Halubatti	Periplocaceae	
84	*Curculigo orchioides*	Nela Thaale	Amaryllidaceae	Medicinal plant
85	*Cymbopogon citrates*	Lemon grass	Zingiberaceae	
86	*Cynodon dactylon*	Garike hullu	Poaceae	Medicinal plant
87	*Cynoglossum denticulatum*			
88	*Daemia extensa*	Kuntigena gida	Asclepidaceae	Medicinal plant
89	Dalbergia latifolia	Beete	Legminosae	
90	*Dalbergia paniculata*	Pachali, Belaga	Fabaceae	
91	*Dalbergia sissodes*	Sissoo	Fabaceae	

	Botanical name	Local name	Family	Remarks
92	*Datura metel*	Dhathuri gida	Solanaceae	Medicinal plant
93	*Delonix regia*	Gulmohar		
94	*Dendrocalamus strictus*	Kiribidiru	Poaceae	
95	*Desmodium heterocarpon*			
96	*Desmodum pulchellum*	Kaadulthi	Fabaceae	Medicinal plant
97	*Desmodium velutinum*			
98	*Desnidium motorium*			
99	*Digitaria longiflora*			
100	*Dioscorea pentaphylla*		Dioscoreaceae	Medicinal plant
101	*Diospyros melanoxylon*	Tupra, Bidiele	Ebenaceae	Medicinal plant
102	*Diospyros montana*	Jaalaganti	Ebenaceae	Medicinal plant
103	*Dodonea viscosa*	Kanagalu	Sapindaceae	Medicinal plant
104	*Dregea volubilis*	Akeseppu	Asclepiadaceae	
105		Eachalu	Palmaceae	
106	*Elaeodendron glaucum*	Mukarthi	Celastracease	
107	*Eleocharis retroflexa*			
108	*Elephant grass*		Poaceae	
109	*Embelia ribes*			
110	*Embelia tsjeriam-cottom*	Amti, Choladhanga	Myrsinaceae	Medicinal plant
111	*Emblica officinalis*	Nelli	Euphorbiaceae	Medicinal plant
112	*Emblica sonchifolia*		Asteraceae	Medicinal plant
113	*Entada scandens*	Ganapeballi	Mimosaceae	
114	*Erythroxylon monogynum*	Devadari	Linaceae	
115	*Erythrina stricta*			
116	*Eucalyptus hybrid*	Neelagiri	Mytaceae	Medicinal plant
117	*Eucalyptus torticormis*			
118	*Euphorbia antiquorum*			
119	*Euphorbia hirta*			
120	*Euphorbia tirukalli*	Kalli	Euphorbiaceae	
121	*Evolvulus alsinoides*	Vishnukranthi	Convolvulaceae	Medicinal plant
122	*Feronia elephantum*	Bela	Rutaceae	
123	*Ficus bengalensis*	Ala	Moraceae	Medicinal plant
124	*Ficus benjamina*			
125	*Ficus glomerata*	Atti	Moraceae	
126 .	*Ficus hispida.*			
127	*Ficus infectoria*	Basari (Kappu)	Moraceae	
128	*Ficus lacor*	Karl Basari	Moraceae	
129	*Ficus mysorensis*	Goni	Moraceae	
130	*Ficus racemosa*			
131	*Ficus religosa*	Arali	Moraceae	
132	*Ficus iomentosa*			
133	*Ficus tsjahela*			
134	*Fimbristylis dichotoma*			
135	*Flacourtia indica*			
136	*Flacourtia ramontchi*	Sannagejjalikey	Flacourtiaceae	
137	*Flacourtia sepiaria*	Bilehuli	Flacourtiaceae	
138	*Flemingia strobilifera*		Fabateae	

	Botanical name	Local name	Family	Remarks
139	*Fluggea leucopyrus*	Bilitooli	Euphorbiaceae	
140	*Fluggea microcarpa*	Haggajalikey	Euphorbiaceae	
141	*Gardenia gummifera*	Bikke	Rubiaceae	
142	*Gardenia latifolia*	Rebbikke	Rubiaceae	
143	*Girardinia zeylanica*	Thurike gida	Urticaceae	
144	*Givotia rottleriformis*	Bhotale	Euphorbieceae	
145	*Gloriosa Superba*	Gouri gadde, Koli juttu	Liliaceae	
146	*Glossocardia bosvallea*			
147	*Glycosmis pentaphylla*			
148	*Glyricidia maculata*			
149	*Gmelina asiatica*	Roboli, Hela	Verbenaccae	
150	*Grevillea robusta*	Sliveroak	Proteaceae	
151	*Grewia arborea*	Sivanae	Verbenaceae	
152	Grewia *hirsute*			
153	Grewia *retuse*	Jane	Tilliaceae	
154	Grewia tiliifolia	Sanna dippe	Tilliaceae	
155	Gymnema *sylvestre*	Madhu naashini	Asclepiadaceae	
156	Gymnosporia *montana*	Thandarasi	Celastraceae	
157	Habenaria *roxburghii*			
158	Hard*wickia binata*	Kamara,Karachi	Fabaceae	
159	Hard*wickia pinnata*	Yennemara	Caesalpiniaceae	Medicinal plant
160	H*elicteres isora*Kow	Edamuri,Balmuri	Sterculiaceae	Medicinal plant
161	H*emidesmus indicus*	Seadeberu	Asclepiadaceae	Medicinal plant
162	Hib*iscus furcatus*	Bettadha bende	Malvaceae	Medicinal plant
163	Hib*iscus rosa sinensis*	Dhasavala	Malvaceae	Medicinal plant
164	Hib*iscus vitifolius*			
165	Ho*larrhena antidysenterica*	Kodachia	Apocynaceae	Medicinal plant
166	Ho*loptelea interwifolia*	Thapasi	Moraceae	Medicinal plant
167	Hy*menodictvon excelsum*	Doddathoppe	Rubiaceae	
168	Ic*hnocarpus wightiana*	Narihambu	Asclepiadaceae	
169	*Ichnocarpus frutescen*			
170	In*digiofera pulchella*	Neeli	Fabaceae	
171	I*ndigofera tinctoria*	Nellisoppu	Fabaceae	Medicinal plant
172	Indigofera wightii			
173	I*sachne lisboae*			
174	I*schaemum indicum*			
175	*Ixora nigricans*			
176	*Ixora parviflora*	Goravi	Rubiaceae	
177	*Jacaranda mimosaefolia*			
178	*Jasminum arborescens*	Mallige	Oleaceae	
179	*Jasminum pubescens*	Kaadu Malli	Oleaceae	Medicinal plant
180	*Jasminum sambac*			
181	*Jatropha curcas*	Turkkuharalu	Euphorbiaceae	Medicinal plant
182	*Jatropha gossipyfolia*			
183	*Justicia betonica*			
184	*Justicia simplex*			
185		Kiribidiru	Poaceae	

	Botanical name	Local name	Family	Remarks
186	*Lagasca mollis*			
187	*Lagerstroemia flosreginae*	Holedasavala	Lythraceae	
188	*Lagerstroemia lanceolata*	Nandi	Lythraceae	
189	*Lagerstroemia microcarpa*			
190	*Lagerstroemia parviflora*	Channangi	Lythraceae	
191	*Lagerstroemia reginae*			
192	*Lantana camara*	Lantana	Verbenaceae	
193	*Lemon grass*		Zingiberaceae	
194	*Leucas aspera.*	Thumbe	Lamiaceae	
195	*Leucas linifolia*	Thumbe	Lamiaceae	
196	*Leucas montana*			
197	*Limonia crenulata*			
198	*Limonia acidissima*	Naibela	Rutaceae	
199	*Linnophila indica*			
200	*Loranthus falcatus*			
201	*Loranthus indica*	Badanike	Loranthaceae	
202	*Ludwigia parviflora*			
203	*Madhuca indica*	Ippe,Helippe	Sapotaceae	Medicinal plant
204	*Madhuca longifolia*	Kadippe	Sapotaceae	
205	*Majjigegida*		Liliaceae	
206	*Mallotus philippensis*	Kumkumadha mara	Euphorbiaceae	Medicinal plant
207	*Mangifera indica*	Maw	Anacardiaceae	Medicinal plant
208	*Martynia diandra*		Pedaliaceae	Medicinal plant
209	*Melia composita*	Maddi	Meliaceae	
210	*Millingtonia hortensis*	Akash Mallige		
211	*Mimosa pudica*	Naachie mullu ida	Mimosaceae	Medicinal plant
212	*Mitragyna parviflora*	Kadambolu		
213	*Moringa oleifera*	Nue	Moringaceae	Medicinal plant
214	*Morinda sanctum*	Sritulasi	Labiatae	
215	*Morinda tomentosa*	Maddi mam	Rubiceae	Medicinal plant
216	*Mucuna pruriens*			
217	*Mundulea sericea*			
218	*Murdannia nudiflora*			
219	*Nerium oleander*			
220	*Ochna obtusaia*			
221	*Ocimum canum*			
222	*Ocimum sanctum*	Thulasi	Lamiaceae	Medicinal plant
223	*Ocimum wodiar*	Arenalli	Anacardiace	
224	*Odina wodier*	Arenalli	Anacardiaceae	
225	*Oldenlandia corymbosa*			
226	*Olea dioica*			
227	*Oplismenus compositus*			
228	*Opuntia dillenii*	Papaskalli	Cactaceae	
229	*Oxalis corniculata*	HuH soppu	Oxalidaceae	Medicinal plant
230	*Parthenium hysterophorus*			
231	*Passiflora foetida*	Kukkiballi	Passifloraceae	Medicinal plant
232	*Pavetta indica*	Pavatte	Rubiaceae	

	Botanical name	Local name	Family	Remarks
233	*Pavonia zeylanica*	Shivana kadle	Malvaceae	Medicinal plant
234	*Peltophenium hysterophorus*			
235	*Peltophorum pterocarpum*			
236	*Pennisetum pedicellatum*			
237	*Peristrophe bicalyculata*	Chibira Jdda	Acanthaceae	Medicinal plant
238	*Perotis indicus*			
239	*Phoenix humilis*	Kirichalu	Arecaceae	
240	*Phoenix xylvestre*			
241	*Phyllanthus amarus*	kirunelli	Euphorbiaceae	Medicinal plant
242	*Phyllanthus maderaspatensis*			
243	*Phyllanthus simplex*		Euphorbiaceae	Medicinal plant
244	*Phvllanthus virgatus'*			
245	*Plumbago zeylanica*	Bili chitramoola	Plumbainaceae	Medicinal plant
246	*Plumeria alba*	Kaadu sampige	Apocynaceae	Medicinal plant
247	*Polyalthia longifolia*			
248	*Polygala elongata*		Polygalaceae	Medicinal plant
249	*Polygala longifolia*			
250	*Pongamia pinnata*	Honge	Fabaceae	
251	*Premna tomentosa*	Lie	Verbenaceae	
252	*Prosopis juliflora*	Bellary Jali	Fabaceae	
253	*Prosopis spicigera*	Banki	Fabaceae	
254	*Protium caudatum*	Kondamaavu	Burseraceae	
255	*Psidium guajava*			
256	*Pterocarpus marsupium*	Honne	Fabaceae	
257	*Pterolobium hexapetalum*			
258	*Randia dumetorum*	Kaare	Rubiaceae	Medicinal plant
259	*Rhinacanthus communis*	Naagamallige	Acanthaceae	Medicinal plant
260	*Ricinus communis*	Harle	Euphorbiaceae	Medicinal plant
261	*Ruellia prostrate*			
262	*Rungia repens*			
263	*Samanea saman*			
264	*Santalum album*	Sandal, Gandha	Santalaceae	Medicinal plant
265	*Sapindus laurifolius*			
266	*Schleichera trijuga*	Sagade, Kendala	Sapindaceae	
267	*Schreberas swietenoidies*	Gante	Oleaceae	
268	*Scilla hyacinthine*			
269	*Scutia indica*	Kurudi	Rhamnaceae	
270	*Semecarpus anacardium*	Geru, Marking nut	Anacardiaceae	Medicinal plant
271	*Sesabania bispinosa*			
272	*Shorea roxburhii*			
273	*Shorea talura*	Jalari	Dipterocarpaceae	
274	*Sida acuta*			
275	*Sida cordifolia*			
276	*Sida glutinosa*			
277	*Sida veronicifolia*			
278	*Smilax zeylanica*			
279	*Smithia conferta*			

	Botanical name	Local name	Family	Remarks
280	*Smithia bigemina*			
281	*Solanum erianthum*			
282	*Solanum ferox*	Gullabane	Solanaceae	Medicinal plant
283	*Solanum indicum*	Sonde	Solanaceae	Medicinal plant
284	*Solanum torvum*			
285	*Solanum xanthocarpum*			
286	*Sophubia delphinifolia*			
287	*Soymida febrifuga*	Same	Meliaceae	
288	*Spondias mangifera*			
289	*Stachytarpheta indica*			
290	*Sterculia urens*			
291	*Stereospermum chelonoides*			
292	*Stereospermum suaveolens*	kaladri,Padri,hanse	Bignoniaceae	
293	*Streblus asper*	Mitli	Urticaceae	
294	*Striga asiatica*			
295	*Strychnos potatorum*	Chilla	Fabaceae	
296	*Syzigium jambos*			
297	*Syzygium cumini*	Neralu	Myrtaceae	
298	*Tabebuia argentia*			
299	*Tabebuia pallid*			
300	*Tagetas erecta*			
301	*Tamarindus indica*	Hunse	Fabaceae	
302	*Tecoma stans*			
303	*Tectona grandis*	Sagavani, Tega	Verbenaceae	
304	*Tephrosia pulcherrima*			
305	*Tephrosia purpurea*			
306	*Tephrosia villosa*			
307	*Terminalia arjuna*	Tora Matti, Belinatti	Combretaceae	Medicinal plant
308	*Terminalia bellirica*	Shanti Tree, Tare	Combretaceae	Medicinal plant
309	*Terminalia chebula*	Alale	Combretaceae	Medicinal plant
310	*Terminalia coriacea*		Combretaceae	
311	*Terminalia paniculata*	Kulude, Karwa	Combretaceae	
312	*Terminalia tomentosa*	Matti	Combretaceae	
313	*Terminalia tremula*			
314	*Thespesia populnea*			
315	*Thevetia nerifolia*			
316	*Tinospora cordifolia*			
317	*Toddalia aculeate*			
318	*Tragia involucrate*			
319	*Tragus roxburghii*			
320	*Trebulus terestris*			
321	*Trema orientalis*			
322	*Triumfetta rhomboidea*			
323	*Triumfetta pilosa*			
324	*Tylophora asthmatica*			
325	*Ventilago madraspatana*	Poppichakke	Rhamnaceae	
326	*Vernonia anthelmintica*			

	Botanical name	Local name	Family	Remarks
327	*Vernonia cineria*			
328	*Viscum monoicum*			
329	*Vitex altissima*			
330	*Vitex negundo*	Lakki	Verbenaceae	Medicinal plant
331	*Wendlandia exserta*			
332	*Withania somnifera*			
333	*Wrightia tinctoria*	Ale	Apocynaceae	
334	*Wrightia tomentosa*			
335	*Xanthium strumarium*			
336	*Zizyphus jujube*	Bore, Yelachi	Rhamanacea	
337	*Zizyphus oenoplia*	Soorimullu	Rhamnacea	
338	*Zizyphus rugosa*			
339	*Zizyphus xylopyrus*			
340	*Zizyphus glabrata*	Karukuttemara	Rhamnacea	
341	*Zornia diphylla*			
Monocotidous plants found in the BMR				
	AndropoJion serratus			
	Asparagus racemosus	Hebbidiru		
	Bambusa arundinacea			
	Curcuma longa			
	Cymbopogon citrates			
	Dendrocalomus strictus	Kirubidiru		
	Imperata arundinacea			
	Phoenix sylvestris	Eachalu		

ANNEXURE 2: BIRDS OF BMR

Podicipedidae
1. Podiceps ruficollis, Little Grebe
Pelecanidae
2. Pelecanus phifippensis, Grey Pelica
Phalacrocoracidae
3. Phalacrocorax carbo, Large Cormorant
4. Phalacrocorax fuscicollis, Indian Shag
5. Phalacrocorax niger, Little Cormorant
6. Anhinga rufa, Darter
Ardeidae
7. Ardea cinerea, Grey Heron
8. Ardea purpurea, Purple Heron
9. Ardeola grayii, Pond Heron
10. Ardea alba, Large Egret
11. Ardeola striatus, Little Green Heron
12. Bubulcus ibis, Cattle Egret
13. Botaurus stellaris, The Bittern
14. Egretta intermedia, Smaller Egret
15. Egretta garzetta, Little Egret
16. Egretta gularis, Indian Reef Heron
17. Nycticorax nycticorax, Night Heron
18. Ixobrychus minutus, Little Bittern
19. Ixobrychus cinnamomeus, Chesnut Bittern
Ciconiidae
20. Mycteria leucocephala, Painted Stork
21. Anastomus oscitans, Openbill Stork
22. Ciconia episcopus, Whitenecked Stork
23. Ciconia ciconia, White Stork
Threskiornithidae
24. Threskiornis aethioplcs, White Ibis
25. Pseudibis papillosa, Black Ibis
26. Plegadis talcinellus, Glossy Ibis
27. Platalea leucorodia, Spoonbill
Phoenicopteridae
28. Phoeniconaias major, Greater Flamingo
Anatidae
29. Anser indicus, Barheaded Goose
30. Dendrocygna javanica. Lesser Whistling Teal
31. Tadorna ferruginea, Brahminy Duck
32. Anas acuta, Pintail
33. Anas crecca, Common Teal
34. Anas poecilorhyncha, Spotbill Duck
35. Anas strepera, Gadwall
36. Anas Penelope, Wigeon
37. Anas querquedula, Garganey
38. Anas clypeata, Shoveller
39. Aythya ferina, Common Pochard
40. Nettapus coromandelianus, Cotton Teal
41. Sarkidiornis melanotus, Comb Duck

Accipitridae
42. Elanus caeruleus, Blackwinged Kite
43. Pernis ptilorhynchos, Honey Buzzard
44. Milvus migrans govinda, Pariah Kite
45. Milvus migrans lineatus, Blackeared Kite
46. Haliastur Indus, Brahminy Kite
47. Accipiter gentiles, Goshawk
48. Accipiter badius, Shikra
49. Accipiter nisus, Sparrow-Hawk
50. Buteo rufinus, Longlegged Buzzard
51. Butastur teesa, White-eyed Buzzard
52. Spizaetus cirrhatus, Crested Hawk-Eagle
53. Hieraaetus fasciatus, Bonelli's Eagle
54. Hieraaetus pennatus, Booted Hawk-Eagle
55. Aquila rapax, Tawny Eagle
56. Aquila clanga, Greater Spotted Eagle
57. Ictinaetus malayensis, Black Eagle
58. Sarcogyps calvus, Black Vulture
59. Gyps benghalensis, Indian Whitebacked Vulture
60. Neophron percnopterus, Scavenger Vulture
61. Circus cyaneus, Hen Harrier
62. Circus macrourus, Pale Harrier
63. Circus pygargus, Montagu's Harrier
64. Circus melanoleucos, Pied Harrier
65. Circus aeruginosus, Marsh Harrier
66. Circaetus gallicus, Short-toed Eagle
67. Spilornis cheela, Crested Serpent Eagle
68. Pandion haliaetus, Osprey
Falconidae
69. Falco biarmicus jugger, Laggar Falcon
70. Falco peregrinus japonensis, Peregrine Falcon
71. Falco peregrinus peregrinator, Shaheen Falcon
72. Falco subbuteo, Hobby
73. Falco chicquera, Readheaded Merlin
74. Falco tinnunculus, Kestrel
Phasianidae
75. Francolinus pondicerianus, Grey Partridge
76. Coturnix coturnix, Common Quail
77. Coturnix coromandelica, Rain Quail
78. Coturnix chinensis, Bluebreasted Quail
79. Perdicula asiatica.,Jungle Bush Quail
80. Perdicula erythrorhyncha, Painted Bush Quail
81. Galloperdix spadicea, Red Spurfowl
82. Galloperdix lunulata, Painted Spurfowl
83. Gallus sonneratii, Grey Junglefowl
84. Pavo cristatus, Common Peafowl
Turnicidae
85. Turnix tanki, Yellowlegged Button Quail
86. Turnix suscitator, Common Bustard Quail

Gruidae
87. Anthropoides virgo, Demoiselle Crane
Rallidae
88. Rallus striatus, Bluebreasted Banded Rail
89. Porzana pucilla, Baillon's Crake
90. Porzana fusca, Ruddy Crake
91. Amaurornis akool, Brown Crake
92. Amaurornis phoenicurus, Whitebreasted Waterhen
93. Gallicrex cinerea, Kora
94. Gallinula chloropus, Moorhen
95. Porphyrio porphyrio, Purple Moorhen
96. Fulica atra, Coot
Jacanidae
97. Hydrophasianus chirurgus, Pheasant-tailed Jacana
98. Metopidius indicus, Bronzewinged Jacana
Rostratulldae
99. Rostratula benghalensis, Painted Snipe
Recurvirostridae
100. Himantopus himantopus, Blackwinged Stilt
101. Recurvirostra avocetta, Avocet
Burhinidae
102. Burhinus oedicnemus, Stone Curlew
103. Esacus magnirostris, Great Stone Plover
Glariolidae
104. Cursorius coromandelicus. Indian Courser
105. Glareola lactea. Small Indian Pratincole
Charadriidae: Charadriinae
106. Vanellus cinereus. Greyheaded Lapwing
107. Vanellus indicus. Redwattled Lapwing
108. Vanellus malabaricus. Yellow-wattled Lapwing
109. Pluvialis squatarola. Grey Plover
110. Pluvialis dominica. Eastern Golden Plover
111. Charadrius dubius. Little Ringed Plover
112. Charadrius alexandrinus. Kentish Plover
Charadriidae: Scolopacinae
113. Numenius arquata. Curlew
114. Limosa limosa. Blacktailed Godwit
115. Tringa erythropus. Spotted Redshank
116. Tringa tetanus Common Redshank
117. Tringa stagnatilis. Marsh Sandpiper
118. Tringa nebularia. Greenshank
119. Tringa ochropus. Green Sandpiper
120. Tringa glareola. Wood Sandpiper
121. Tringa terek. Terek Sandpiper
122. Tringa hypoleucos. Common Sandpiper
123. Gallinago nemoricola. Wood Snipe
124. Gallinago stenura. Pintail Snipe
125. Gallinago media. Great Snipe
126. Gallinago gallinago. Fantail Snipe
127. Gallinago minima. Jack Snipe
128. Scolopax rusticola. Woodcock
129. Calidris minuta. Little Stint
130. Calidris temminckii. Temminck's Stint

131. Calidris testacea. Curlew-Sandpiper
132. Philomachus pugnax. Ruff and Reeve
Charadriidae: Phalaropinae
133. Phalaropus lobatus. Rednecked Phalarope
Laridae
134. Larus brunnicephalus. Brownheaded Gull
135. Larus ridibundus. Blackheaded Gull
136. Chlidonias hybrida Whiskered Tern
137. Sterna aurantia. Indian River Tern
138. Sterna acuticauda. Blackbellied Tern
Columbidae
139. Treron phoenicoptera. Green Pigeon
140. Columba livia, Blue Rock Pigeon
141. Columba elphinstonii. Nilgiri Wood Pigeon
142. Streptopelia orientalis. Rufous Turtle Dove
143. Streptopelia decoacto. Indian Ring Dove
144. Streptopelia tranquebarica. Red Turtle Dove
145. Streptopelia chinensis. Spotted Dove
146. Streptopelia senegalensis. Little Brown Dove
Psittacidae
147. Psittacula eupatria. Alexandrine Parakeet
148. Psittacula krameri. Roseringed Parakeet
149. Psittacula alexandri. Redbreasted Parakeet
150. Psittacula cyanocephala. Blossomheaded Parakeet
151. Psittacula columboides. Bluewinged Parakeet
Cuculidae
152. Clamator coromandus. Redwinged Crested Cuckoo
153. Clamator jacobinus. Pied Crested Cuckoo
154. Cuculus varius. Common Hawk-Cuckoo
155. Cuculus micropterus. Indian Cuckoo
156. Cuculus canorus. Cuckoo
157. Cacomantis sonneratii. Indian Baybanded Cuckoo
158. Cacomantis passerinus. Indian Plaintive Cuckoo
159. Surniculus lugubris. Drongo-Cuckoo
160. Eudynamys scolopacea. Koel
161. Rhopodytes viridirostris. Small Greenbilled Malkol
162. Taccocua leschenaultii. Sirkeer Cuckoo
163. Centropus sinensis. Crow-Pheasant
Strigidae: Tytoninae
164. Tyto alba. Barn Owl
Strigidae: Striginae
165. Otus scops. Scops Owl
166. Otus bakkamoena. Collared Scops Owl
167. Bubo bubo. Great Horned Owl
168. Bubo zeylonensis. Brown Fish Owl
169. Glaucidium radiatum. Barred Jungle Owlet
170. Athene brama. Spotted Owlet
171. Strix ocellata. Mottled Wood Owl
Caprimulgidae
172. Caprimulgus indicus. Indian Jungle Nightjar
173. Caprimulgus mahrattensis. Sykes's Nightjar
174. Caprimulgus macrurus. Longtailed Nightjar
175. Caprimulgus asiaticus. Common Indian Nightjar

176. Caprimulgus affinis. Franklin's (Allied) Nightjar
Apodidae: Apodinae
177. Chaetura gigantea. Brownthroated Spinetail Swift
178. Apus melba. Alpine Swift
179. Apus pacificus. Large Whiterumped Swift
180. Apus affinis. House Swift
181. Cypsiurus parvus. Palm Swift
Apodidae: Hemiprocninae
182. Hemiprocne longipennis. Crested Tree Swift
Alcedinidae
183. Ceryle rudis. Lesser Pied Kingfisher
184. Alcedo atthis. Small Blue Kingfisher
185. Pelargopsis capensis. Storkbilled Kingfisher
186. Halcyon smyrnensis. Whitebreasted Kingfisher
187. Halcyon pileata. Blackcapped Kingfisher
Meropidae
188. Merops leschenaulti. Chesnutheaded Bee-eater
189. Merops philippinus. Bluetailed Bee-eater
190. Merops orientalis. Small Green Bee-eater
191. Nyctyornis athertoni. Bluebearded Bee-eater
Coraciidae
192. Coracias benghalensis. Indian Roller
Upupidae
193. Upupa epops. Hoopoe
Bucerotidae
194. Tockus birostris. Grey Hornbill
Capitonidae
195. Megalaima zeylanica. Large Green Barbel
196. Megalaima viridis. Small Green Barbet
197. Megalaima haemacephala. Crimsonbreasted Barbet
Picidae
198. Micropternus brachyurus. Rufous Woodpecker
199. Picus myrmecophoneus. Little Scalybellied Gree Woodpecker
200. Dinopium benghalense. Lesser Goldenbacked Woodpecker
201. Picoides mahrattensis. Yellowfronted Pied Woodpecker
202. Picoides nanus. Pygmy Woodpecker
203. Chrysocolaptes festivus. Blackbackcd Woodpecker
Pittidae
204. Pitta brachyura. Indian Pitta
Alaudidae
205. Mirafra javanica. Singing Bush Lark
206. Mirafra assamica. Rufouswinged Bush Lark
207. Mirafra erythroptera. Redwinged Bush Lark
208. Eremopterix grisea. Ashycrowned Finch-Lark
209. Ammomanes phoenicurus. Rufoustailed Finch-Lark
210. Alauda gulgula. Eastern Skylark
211. Riparia riparia. Collared Sand Martin
212. Hirundo concalor. Dusky Crag Martin
213. Hirundo rustica. Common (Barn) Swallow
214. Hirundo smithii. Wiretailed Swallow
215. Hirundo fluvicola. Indian Cliff Swallow

216. Hirundo daurica. Redrumped (Striated) Swallow
Laniidae
217. Lanius excubitor. Grey Shrike
218. Lanius vittatus. Baybacked Strike
219. Lanius schach. Rufousbacked Shrike
220. Lanius cristatus. Brown Shrike
Oriolidae
221. Oriolus oriolus. Golden Oriole
222. Oriolus xanthornus. Blackheaded Oriole
Dicruridae
223. Dicrurus adsimilis. Black Orongo
224. Dicrurus leucophaeus. Grey Orongo
225. Dicrurus caerulescens. Whitebellied Orongo
226. Dicrurus hottentottus. Haircrested Orongo
Artamidae
227. Artamus fuscus. Ashy Swallow-Shrike
Sturnidae
228. Sturnus malabaricus malabaricus. Greyheaded Myna
229. Sturnus malabaricus blythii. Whiteheaded Myna
230. Sturnus pagodarum. Blackheaded Myna
231. Sturnus roseus. Rosy Pastor
232. Sturnus vulgaris. Starling
233. Acridotheres tristis. Indian Myna
234. Acridotheres fuscus. Jungle Myna
Corvidae
235. Dendrocitta vagabunda. Indian Tree Pie
236. Dendrocitta leucogastra. Whitebellied Tree Pie
237. Corvus splendens. House Crow
238. Corvus macrorhynchos. Jungle Crow
Campephagidae
239. Tephrodornis pondicerianus. Common Wood Shrike
240. Coracina novaehollandiae. Large Cuckoo-shrike
241. Coracina melaschistos. Smaller Grey Cuckoo-shrike
242. Coracina melanoptera. Blackheaded Cuckoo-shrike
243. Pericrocotus flammeus Scarlet (Orange) Minivet
244. Pericrocotus cinnamomeus. Small Minivet
Irenidae
245. Aegithina tiphia. Common lora
246. Chloropsis aurifrons. Goldfronted Chloropsis
Pycnonotidae
247. Pycnonotus jocosus. Redwhiskered Bulbul
248. Pycnonotus leucogenys. Whitecheeked Bulbul
249. Pycnonotus cafer. Redvented Bulbul
250. Pycnonotus xantholaemus. Yellowthroated Bulbul
251. Pycnonotus luteolus. Whitebrowed Bulbul
Muscicapidae: Timaliinae
252. Pellorneum ruficeps. Spotted Babbler
253. Pomatorhinus horsfieldii. Slaty headed Scimitar Babbler
254. Dumetia hyperythra. White throated Babbler
255. Chrysomma sinense. Yellow eyed Babbler
256. Turdoides caudatus. Common Babbler

257. Turdoides malcolmi. Large Grey Babbler
258. Turdoides striatus. Jungle Babbler
259. Turdoides affinis. Whiteheaded Babbler
Muscicapidae: Muscicapinae
260. Muscicapa latirostris. Brown Flycatcher
261. Muscicapa parva. Redbreasted Flycatcher
262. Muscicapa superciliaris. Whitebrowed Blue Flycatcher
263. Muscicapa nigrorufa. Black and Orange Flycatcher
264. Muscicapa rubeculoides. Bluethroated Flycatcher
265. Muscicapa tickelliae. Tickell's Blue Flycatcher
266. Muscicapa thalassina. Verditer Flycatcher
267. Muscicapa albicaudata. Nilgiri Flycatcher
268. Culicicapa ceylonensis. Greyheaded Flycatcher
Muscicapidae: Rhipidurinae
269. Rhipidura aureola. Whitebrowed Fantail Flycatcher
270. Rhipidura albicollis. Whitethroated Fantail Flycatcher
Muscicapidae: Monarchinae
271. Terpsiphone paradisi. Paradise Flycatcher
272. Monarcha azurea. Blacknaped Flycatcher
Muscicapidae: Sylviinae
273. Cisticola juncidis. Streaked Fantail Warbler
274. Prinia hodgsonii. Franklin's Wren- (Longtail) Warbler
275. Prinia subflava. Plain Wren- (Longtail) Warbler
276. Prinia socialis. Ashy Wren- (Longtail) Warbler
277. Prinia sylvatica. Jungle Wren- (Longtail) Warbler
278. Orthotomus sutorius. Tailor Bird
279. Acrocephalus aedon. Thickbilled Warbler
280. Acrocephalus stentoreus. Indian Great Reed Warble
281. Acrocephalus dumetorum. Blyth's Reed Warbler
282. Acrocephalus agricola. Paddyfield Warbler
283. Hippolais caligata. Booted Tree Warbler
284. Sylvia hortensis. Orphean Warbler
285. Sylvia curruca. Lesser White throat
286. Phylloscopus affinis. Tickell's Leaf Warbler
287. Phylloscopus magnirostris. Largebilled Leaf Warbler
288. Phylloscopus trochiloides. Greenish Leaf Warbler
289. Phylloscopus occipitalis. Large Crowned Leaf Warbler
Muscicapidae: Turdinae
290. Erithacus svecicus. Bluethroat
291. Erithacus brunneus. Bluechat
292. Copsychus saularis. Magpie-Robin
293. Phoenicurus ochruros. Black Redstart
294. Saxicola torquata. Stone Chat
295. Saxicola caprata. Pied Bush Chat
296. Saxicoloides fulicata. Indian Robin
297. Monticola cinclorhynchus. Blueheaded Rock Thrush
298. Monticola solitarius. Blue Rock Thrush

299. Zoothera wardii. Pied Ground Thrush
300. Zoothera citrina. Whitethroated Ground Thrush
301. Turdus merula. Blackbird
Paridae: Parinae
302. Parus major. Grey Tit
303. Parus nuchalis. Whitewinged Black Tit
304. Parus xanthogenys. Yellowcheeked Tit
Motacillidae
305. Anthus hodgsonii. Indian Tree Pipit
306. Anthus trivialis. Tree Pipit
307. Anthus novaeseelandiae. Paddyfield Pipit
308. Motacilla indica. Forest Wagtail
309. Motacilla flava thunbergi. Greyheaded Yellow Wagtail
310. Motacilla flava bheema. Blueheaded Yellow Wagtail
311. Motacilla flava melanogrisea Blackheaded Yellow Wagtail
312. Motacilla cinerea. Grey Wagtail
313. Motacilla alba. White Wagtail
314. Motacilla maderaspatensis. Large Pied Wagtail
Dicaeidae
315. Dicaeum agile. Thickbilled Flowerpecker
316. Dicaeum erythrorhynchos. Tickell's Flowerpecker
Nectariniidae
317. Nectarinia zeylonica. Purplerumped Sunbird
318. Nectarinia lotenia. Loten's Sunbird
319. Nectarlnia asiatica. Purple Sunbird
Zosteropidae
320. Zosterops palpebrosa. White-eye
Ploceidae: Passerinae
321. Passer domesticus. House Sparrow
322. Petronia xanthocollis. Yellowthroated Sparrow
Ploceidae: Ploceinae
323. Ploceus philippinus. Baya Weaver Bird
324. Ploceus manyar. Streaked Weaver Bird
Ploceidae: Estrildinae
325. Estrilda amandava. Red Munia
326. Lonchura malabarica. Whitethroated Munia
327. Lonchura striata. Whitebacked Munia
328. Lonchura punctufata. Spotted Munia
329. Lonchura malacca. Blackheaded Munia
Fringillidae: Carduelinae
330. Carpodacus erythrinus. Common Rosefinch
Emberizidae
331. Emberiza melanocephala. Blackheaded Bunting
332. Emberiza brunniceps. Redheaded Bunting

Chapter 2

Wetlands

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FIGURES

1. PROFILE OF WETLANDS IN BMR

1.1. CURRENT STATUS

Wetlands have played a very important role in the life of living beings since time immemorial. Wetlands are characterised by their fragile ecosystems that are susceptible to changes. They are productive and biologically rich but endangered ecosystems acting as interface between land and water systems. They filter the sediments and nutrients from the surface water and support all life forms through extensive food webs and biodiversity.

Wetlands function in varieties of ways including decay of organic matter, release of nitrogen, sulphur and carbon into the atmosphere, removal of nutrients, sediment action of organic matter and growth and development of all the wetland aquatic organisms. Wetlands also act as components of products such as fish, recreation, flood control system, ground water recharge and balancing of storm water.

The status of wetlands located in Bangalore Metropolitan Region (BMR) in course of time would be critical and challenging due to uncontrolled expansion and conversion of lakes for industrial development, commercial development, construction high-rise apartments and formation of new layouts resulting in,

- Encroachment
- Sewage pollution
- Discharge of industrial effluents
- Sand mining and quarrying
- Deforestation, denudation of wetlands
- Use of chemical fertilisers and pesticides
- Mining of ground water aquifers
- Demand for rising irrigation water volumes

Figure 1: Waste dumps on Karihobanahalli tank bed, Peenya

Since 1973, more than 70% of wetlands in the BMR have been lost as a result of conversion of these wetlands for infrastructure development and formation of residential areas. In 1985, there were 51 healthy wetlands in Bangalore city alone but at present only 17 water bodies have been identified around the city. Similarly, most of the wetlands in the entire BMR are undergoing several changes exacerbated by the physical growth of the region, loss of green belts, the revised master plan that paves way for allocation of new plots for industrial, commercial and residential purposes. Worst, since there are no guidelines on what constitutes a wetland buffer zone, there have been several levels of interpretations on actual buffer zones, even in the context of wetland restoration and management.

Figure 2: Construction on Peenya's Shivapura tank bed

The environmental ethics of wetland conservation must first be differentiated from the concept of a "tank" system. While the primary purpose of a "tank" is for irrigation and water supply, a wetland constitutes a holistic system of environmental and biodiversity conservation including flora, fauna, landscape, as well as ecological and economical services.

1.1.1. Distribution of water bodies

Satellite images taken in 2003 shows that BMR has approximately 2,789 identified water bodies. These are in several stages of decay mainly due to anthropogenic activities and erratic monsoon rainfall. The total water spread area is 18,620 ha. These water bodies are grouped into five major groups based on their water spread area categorisation (see Table 1). More than 1,260 water bodies are less than 2 ha in area and therefore, classified as minor lakes while 847 are between 2–8 ha classified as small lakes. 469 lakes are under the category of medium lakes and they vary between 8–25 ha while 117 lakes are classified as large lakes with water spread area ranging between 25 ha to 50 ha. About 96 lakes are considered as very large lakes and range from more than 50 ha. (see Chapter 3 "WATER SUPPLY AND SANITATION", section 5.4.1).

Table 1: Distribution of water bodies in Bangalore region

Type of lakes (in ha)	*Bangalore Development Authority*		*Bangalore Metropolitan Region*	
	Number of lakes	*Water spread area (ha)*	*Number of lakes*	*Water spread area (ha)*
Minor (less than 2)	285	194.0	1,260	864.8
Small (between 2 and 8)	185	833.1	847	2,809.3
Medium (between 8 and 25)	94	1,220.0	469	4,258.0
Large (between 25 and 50)	29	1,003.4	117	2,742.1
Very large (more than 50)	15	1,322.3	96	7,586.0
Total	***608***	***4,572.8***	***2,789***	***18,260.2***

Source: Lake Development Authority:2003

1.1.2. Socio-economic aspects of wetlands

People in Bangalore use wetlands for domestic and economic reasons. But, many consider these wetlands as primary resources with which they can sustain their daily livelihoods with food and as a means of income. Mostly, the wetlands are used as irrigation tanks for various small scale and large scale agricultural activities. Ground water extraction from the wetlands recharged aquifers is increasingly becoming a huge environmental pressure, threatening hydrological balance of a wetland. Livestock grazing is another major economic resource dependent on wetland vegetation.

Figure 4: Lakes as source of income

Figure 3: Lakes of desirable recreational spaces

Fisheries is another important aspect of wetland use where a huge variety of exotic fish species are introduced, reared and harvested for domestic and commercial purposes. Other activities include laundry/washing services, sand mining, brick making, aesthetic and spiritual activities which sometimes include cremation of dead bodies. With the rising population in the region more people are now moving into wetland boundaries for real estate and other major economic services.

1.2. BIODIVERSITY OF BANGALORE WETLANDS

1.2.1. Phytoplankton

A variety of micro-diverse species have been documented in several studies. Chakrapani (1989) has documented many varieties of planktons in the wetlands of Bangalore as given in the table below:

Table 2: Phytoplankton diversity

Mycophyceae	Chlorophyceae
Microcystis spp. *Oscillatoria spp.* *Rivularia spp.* *Merismopedia spp.* *Spirulina spp.* *Coclosphaerium spp.* *Nostoc spp.* *Gloeocapsa spp.*	*Volvox spp.* *Eudorina spp.* *Pandorina spp.* *Euglena spp.* *Zygnema spp.* *Ulothrix spp p.* *Cladophora spp.* *Spirogyra spp.* *Pediastrum spp* *Coelanastrum spp.*
Bacillariophyceae	**Dinophyceae**
Finnularia spp. *Navicula spp.* *Synedra spp.* *Asterionella spp.*	*Ceratium*

Source: Chakrapani:1989

1.2.2. Protozoans and Rotifers

Table 3: Zooplankton diversity

Protozoans	Rotifers	
▪ *Difflugia lobostoma* ▪ *Diffugia carinata* ▪ *Arcella sp.* ▪ *Notholea sp.* ▪ *Centropyrus sp.* ▪ *Polymorphs sp.* ▪ *Pelomyna sp.* ▪ *Paramecium sp.* ▪ *Euglypha sp.* ▪ *Nebola sp.*	▪ *Toichocerca sp.* ▪ *Brachionus calicyflorus* ▪ *B. angularis* ▪ *B. fortucula* ▪ *B. falcatus* ▪ *B. caudatus* ▪ *B.gidenstata* ▪ *Lecane sp.* ▪ *Monostyla bulla* ▪ *Keratella sp.* ▪ *K.tropica* ▪ *K. procurva* ▪ *Platia sp.*	▪ *Scaridium sp.* ▪ *Asplanchna sp.* ▪ *Rotatoria sp.* ▪ *Filinea longiseta* ▪ *Filinia sp.* ▪ *Euclamis sp.* ▪ *Testudinella sp.* ▪ *Phillodina sp.* ▪ *Hexarthra sp.* ▪ *Polyarthra sp.* ▪ *Horacella sp.* ▪ *Conocilus sp.* ▪ *Ascomorpha sp.*

1.2.3. Crustaceans, insects and butterflies

Table 4: Crustaceans documented in Bangalore wetlands

Family	Species
Cladocera	*Moina sp.* *Bosmina sp.* *Daphnia sp.*
Copepoda	*Mesocyclops leukarti* *Heliodiaptomus sp.* *Paradiaptomous sp.*
Ostracoda	*Cypris sp.* *Heterocypris sp.* *Stenocypris sp.*

Source: Chakrapani:1989

The biodiversity status of planktons in wetlands of BMR has altered as the city's streams that used to replenish the lakes with rain water have been turned into storm water drains carrying untreated sewage and industrial effluents. The ecological importance of wetlands in supporting a series of biosynthetic steps from plankton community to molluscs, insects, fish and birds is at risk and further studies confirm the change in phytoplankton composition due to sewage pollution. Also, the alteration in rainfall pattern and interference of anthropogenic activities has been a change in algal dominance of Spirulina from Microcystis.

Some of the insects recorded in Bangalore wetlands include *Culex* sp. *Larvae; Chironomid* sp.*; Chaoborus* sp.*; Cyprisniadeae;* Water spiders; Dragonflies, Water Beetle; Emerald Beetle; Xyclopa Bee; Termites; etc. A study conducted by Bangalore University to record the butterfly diversity in the vicinity of surrounding wetlands of the campus within the Vrishabhavathi valley in 2007 has documented 5 main families of butterflies as given in Table 5.

Table 5: Butterfly diversity in Bangalore wetlands

Family	Species
Lycaenidae	*Leptotes plinius* (Zebra Blue) *Castaluis rosimon. F* (Common Pierrot) *Spindasis vulcanus* (Common Silverline) *Lampides boeticus L* (Pea Blue) *Jamides celeno* (Common Cerulean) *Euchrysops cnejus.F* (Gram Blue) *Zizula hylax* (Grass Jewel)
Pappillionidae	*Papilio polytes.L* (Common mormon) *Pachliopta aristolochiae* (Common Rose) *Pachliopta hector.L* (Crimson Rose) *Graphium sorpedon* (Blue Bottle) *Graphium doson* (Common Jay) *Graphium agamemnon* (Tailed Jay) *Papillio demoleus* (Lime Butterfly)
Nymphalidae	*Neptis hylas M* (Sailer) *Hypolimnas bolina.L* (Great Eggfly) *Junonia hierta.F* (Yellow Pansy) *Junonia almanac* (Peacock Pansy) *Junonia lemonius* (Lemon Pansy) *Junonia orithya* (Blue Pansy) *Precis iphita.C* (Chocolate Pansy) *Moduza procris* (Commander) *Danaus chrysippus.L* (Plain Tiger) *Danaus genutia.C* (Striped Tiger) *Tirumala liminiaceae* (Blue Tiger) *Tirumala septentmonis.B* (Dark Blue Tiger) *Euthalia nais. F* (Baronet) *Mycalesis perseus* (Common Bushbrown) *Acraea violae* (Tawny Costor) *Ariadne merione* (Common castor)
Pieridae	*Cepora nerissa* (Common Gull) *Pareronia valeria* (Common Wanderer) *Delias eucharis* (Jezebel) *Hebomoia glaucippe.L* (Greatest Orange Tip) *Colotis danae* (Crimson Tip) *Ixias pyrene* (Yellow Orange Tip) *Catopsilia pyranthe* (Mottled Emigrant) *Eurema hecabae.L* (Grass Yellow) *Leptosia nina* (Psyche)
Hesperiidae	*Spialia galba.F* (The Indian Skipper) *Hasora chromus* (Common Banded Awl)

Source: Bangalore University Field Study:2008

1.2.4. Fish species

Introduction of exotic fish species is detrimental to the native diversity of fish species in Bangalore. Given that many of the introductions are aggressively colonising species such as the African catfish, most of the local native species have disappeared and the local biota is almost eliminated.

Table 6: Fish diversity documented in Bangalore Wetlands

Family	Species
Cyprinidae	▪ *Catla catla* (Catla – Catla) ▪ *Labeo rohita* (Rohu) ▪ *Labeo fimbriatus* (Fimbriatus – Kemmeenu) ▪ *Cirrhinus mrigal* (Mrigal, Bangaloi) ▪ *Cyprinus carpio* (Common Carp – Samanya Gende) ▪ *Cyprinus carpio Specularis Lacepede* (Mirror Carp –Kannadi menu); *Ctenopharyngodon iddellus* (Grass Carp – Hullugande) ▪ *Ambly pharyngodonmola* Mola Carpet) Pakke Menu) ▪ *Danio aequipinnatus* (Giant Danio – Sasalu) ▪ *Labeo Boggut* (Boggut – Gubbali) ▪ *Esomusdanricus* (Flying barb – Meese pakke) ▪ *Salmostoma belachi* (Rajor Belly – Belachi) ▪ *Puntius dorsalis* (Long Snout Barb – Sanna-gende) ▪ *Puntius Sarana* (Oliver barb – Gende) ▪ *Puntius Sophore* (Sport fin – Gud Pakke) ▪ *Rasboro daniconius* (Black line Rasboro – Sasalu kol kane) ▪ *Barilius bendelisis* (Hamilton's Baril – Bilichi) ▪ *Gara gotyla gotyla* (Nilagiris Garra – Kalluko-rava)
Cobitidae	▪ *Lepidocephalus themolis* (Malabor Loach) ▪ *Nemachielus deninsoni*
Siluridae	▪ *Ompok bimaculatus* (Goan Cat fish – Godle)
Bagridae	▪ *Mistus vacassius* (Gangetic Mystus – Mee-sigirlu) ▪ *Vistus Vittatus* (Striped dwarf cat-fish – Gir-lu)

Note: Other families of fish diversity in Bangalore include Sacchobranchidae, Channidae, Mastacebelidae and Cichlidae

Source: Lake Development Authority:2003

According to the Society for Advancement of Aquaculture (2002), the Department of Fisheries has introduced the culture of fast growing Indian major carps like *Catla catla, Labeo rohita, Cirrhinus mrigala, Cyprinus carpio, Hypothalmychthys molitrix and Ctenpharyngodon idella*. These exotic species have adapted well in various types of biotopes in Bangalore region. It is said that *Cyprinus carpio* (Common carp) and *Oreochromis mossambica* (Tilapia) have dominated the inland water bodies as they breed and multiply very fast in a short span of time. However, these exotic species have caused a population decline of indigenous fish species in several water bodies of BMR. This decline may be due to adverse effects caused to their habitats due to indiscriminate fishing, industrial pollution, weed infestation and siltation. Different taxa of fishes present in the lake systems of BMR and three orders of Mastacembeliformes, Cypriniformes, Ophiocephaliformes, have been documented.

1.2.5. Diversity of Snakes

The biodiversity of water snakes in Bangalore city with a case study on water snakes of Palace Lake (Ataaz and Moolemath:2007) indicates the presence of different species of water snakes including *Macropistodon plumbicolor* (Green Keelback); *Xenochropis piscator* (Checkered Keelback); *Atretium schistosum* (Olive Keelback Water Snake) and *Amphiesma stolata* (Striped Keelback). These snakes are excellent bioindicators to assess the health status of the urban lakes of Bangalore. The young ones of Olive Keelback are known to feed on mosquito larvae.

Ataaz and Moolemath (2007) have also described a connection on survivability of these important lake side species with important factors such as percentage loss of water habitat, degree of fragmentation, siltation load, alteration of natural flow and reclamation activities associated with the lake's catchments. Other common snakes found in the wetlands of BMR have been given in Table 7.

Table 7: Snakes documented within Bangalore wetlands

Scientific name	Common name
▪ *Macropistodon plumbicolor*	Green Keelback
▪ *Xenochropis piscator*	Checkered Keelback
▪ *Atretium schistosum*	Olive Keelback
▪ *Amphiesma stolata*	Striped Keelback
▪ *Ptyas mucosus*	Rat Snake
▪ *Naja naja*	Cobra
▪ *Eryx conicus*	Common Sand Boa
▪ *Eryx johnii*	Red Sand Boa
▪ *Lycodon aulicus*	Wolf Snake

1.2.6. Wetlands flora

According to the study carried out in 2007 on Rejuvenation of Lakes in Bruhat Bangalore Mahanagara Palike (BBMP) in respect of 17 different lakes of Bangalore representing the three main drainage basins, the identification of flora was carried out in the periphery and in the tank bed of these selected lakes. The study has helped in identification of major and common species found in various other wetlands of Bangalore. These wetlands contain the species planted earlier by Department of Forests and those growing naturally.

Table 8: Floral diversity

Scientific name and common name of floral diversity of BMR		
Acacia nilotica (Indian gum) *Acacia sp.* (Banni) *Achyranthes aspera* (Uththaraani) *Ageratum conyzoides* *Alternanthera pungens* (Mullu honagone) *Alternanthera sessilis* (Honogea soppu) *Amarantus spp.* (Mullu kere soppu) *Annona squamosa* (Custard apple) *Anthocephalus chinensis* (Kadamba) *Argemone mexicana* *Argyreia sp.* *Artocapus heterophyllus* (Jackfruit) *Azadirachta indica* (Neem) *Bambusa arundinacea* (Hebbiduru) *Bixa orellana* (Arnatto) *Calotropis gigantean* (Kari aegada gida) *Calotropis procera* (Billi aikada gida) *Cassia siamea* (Seemethengdi) *Cassia auriculata* (Tanner's cassia) *Cassia occidentalis* (Dodda thagase) *Cassia tora* (Gandhu tagase) *Cinnamomum verum* (Dalchini) *Cocos nucifera* (Coconut) *Colocasia esculenta* (Kesave dantu) *Couropuita guianensis* (Nagalinga) *Cucurbita Pepo* *Cynodon dactylon* *Cyperus sp.* *Dalbergia sisso* (Dalbergia) *Datura alba* *Datura metel (*Kari ummathi gida)	*Delonix regia* (Gul mohar) *Dodonaea viscosa* (Andara baralu) *Eucalyptus globules* Eclipta *alba* *Eichornia crassipes* (Water hyacinth) *Eupatorium divergens* *Ficus bengalensis* (Baniyan) *Ficus benjamina* *Ficus racemosa* (Atti) *Ficus religiosa* (Arali) *Grevillea robusta* (Silver Oak) *Hibiscus sp.* *Ipomea carnea* *Ipomea sp.* *Jatropha glandulifera* *Lagerstroemia flos reginiae* *Lantana indica* *Law sonia internus* (Mehandi) *Madhuca longifolia* (Illipe) *Malachra capitata* *Mangifera indica* (Mango) *Melia dubia* (Hebbevu) *Michelia chimpaca* (Sampige mara) *Mimusops elengi* (Pagade mara) *Mimosa pudica* (Sensitive plant) *Nymphea nelumbo* *Opuntia diilenii* (Prickly pear) *Parthenium hysterophorus* (Congress grass) *Paspalum compactum* *Passiflora foetida Peltophorum pterocarpum (*Copper Red*)*	*Phoenix sylvestris (Eachala mara* – Wild Date Palm*)* *Pithecellobium dulce* (seeme junse) *Polygonum glabrum* *Pongamia pinnata* (Honge mara – Indian beeches) *Pridium guajava* (Guava) *Prosopis chilensis* (Bellary Jalli) *Prunus cerasus* (Common Cherry) *Pterocarpus marsupium* (Hone mara) *Ricinus communis* (Castor) *Salvia spp.* *Samanea saman* (Rain Tree) *Santalum album* (Sandal) *Sida acuta* (Bheemana kadi – Sickle leaf) *Solanum torvum (* Kadu Badne) *solanum indicum* *Syzygium cumini* (Nerale) *Tamarindus indica* (Hunse mara) *Tecoma stans* *Tectona grandis* (Teak) *Terminalia arjuna* (Thoremathi) *Terminalia catappa* (Indian almond) *Typha angustata* (Aanejondu) *Typha sp.* *Vitis amurensis* (Vineyards) *Wrightia tinctoria* (Aale; Dyes Oleander) *Water Lilly* *Ziziphus jujube* (Jujube Tree)

Source: STEM Report for Rejuvenation of Lakes under BBMP,2007

1.2.7. Diversity of Birds

Around 120 bird species are found in various lakes of Bangalore spread over 19 families. They account for over 40% of the total bird population of 330 species recorded in Bangalore. They vary in size from a small sparrow-sized bird to large birds which stand up to 1.2 m. They make use of a variety of conditions from dry ground and meadows bordering the lakes to the water spread area itself. Depending upon their size, the availability of food and suitable conditions for foraging, different bird groups can be seen occupying different regions of the lake.

Birds are classified according to the wetland habitats they occupy. They include open water birds (ducks, geese, grebes, cormorants, kingfishers, terns, gulls, pelicans); Wader and shoreline birds (Stilt, Greenshank, sandpipers, storks, Ibises, Spoonbill, herons, egrets and storks); Aerial, meadow and grassland birds (wagtails, lapwings, plovers, pratincoles and swallows) and birds of the reedbeds and other vegetation (rails, bitterns, coot, jacans, moorhens, snipe, painted snipe, etc).

Figure 5: Wetland Birds in Ullal lake

Table 9: Bird diversity

Acrocephalus aedon (Thickbilled Warbler) *Acrocephalus agricola* (Paddyfield Warbler) *Acrocephalus dumetorum* *Alcedo atthis* (Small Blue Kingfisher) *Amaurornis akool* (Brown Crake) *Amaurornis phoenicurus)* *Anas acuta* (Pintail) *Anus clypeata* (Shoveller) *Anas crecca* (Common teal) *Anas Penelope* (Wigeon) *Anas poecilorhyncha* (Spotbill duck) *Anas querquedula* (Garganey) *Anas strepera* (Gadwall) *Anastomus oscitans* (Openbill stork) *Anhinga rufa* (Darter) *Anser indicus* (Barheaded Goose) *Ardea alba* (Large Egret) *Ardea cinerea* (Grey Heron) *Ardea purpurea* (Purple Heron) *Ardeola grayii* (Pond Heron) *Ardeola striatus* (Little Green Heron) *Aythya ferina* (Common Pochard) *Aythya fuligla* (White-eyed Pochard) *Botaurus stellaris* (Bittern) *Bubo zeylonensis* (Brown Fish Owl) *Bubulcus ibis* (Cattle Egret) *Calidris minuta* (Little Stint) *Calidris teminckii* (Teminck's Stint) *Calidris testacea* (Curlew Sandpiper) *Caryle rudis* (Lesser Pied Kingfisher) *Charadrius alexandrinus* (Kentish Plover) *Charadrius dubius* (Little Ringed Plover) *Ciconia ciconia* (White Stork) *Ciconia episcopus* (White necked stork) *Circus aeruginosus* (Marsh Harrier) *Circus melanoleucos* (Pied Harrier) *Circus pygargus* (Montague's Harrier) *Cisticola juncidis* (Streaked Fantail Warbler) *Dendrocygna javanica* *Egretta garzetta* (Little Egret) *Egretta gularis* (Indian Reef Heron)	*Esacus magnirostris* (Great Stone Plover) *Egretta intermedia* (Smaller Egret) *Flaco tinnunculus (*Kestrel) *Fulica atra* (Coot) *Galicrex cinerea* (Kora Watercock) *Gallinago gallinago* (Fantail Snipe) *Gallinago media* (Great Snipe) *Gallinago minima* (Jack Snipe) *Gallinago nemoricola* (Wood Snipe) *Gallinago stenura* (Pintail Snipe) *Gallinula Chloropus* (Moorhen) *Glareola lacteal* (Small Indian Pranticole) *Halcyon pilleata* (Blackcapped Kingfisher) *Halcyon smirnensis* *Haliastur Indus* (Brahminy Kite) *Himantopus himantopus* (Black-Winged Stilt) *Hirundo daurica* (Striated Swallow) *Hirundo Rustica* (Barn/Common Swallow) *Hirundo Smithii* (Wiretailed Swallow) *Larus ridibundus* (Blackheaded gull) *Limosa limosa* (Blacktailed Godwit) *Lonchura malabarica* (White-throated Munia) *Lonchura Malacca* (Blacheaded Munia) *Lonchura striata* (White backed munia) *Merops leschenaultia* *Merops crientalis* (Small Green Bee Eater) *Merops philippinus* (Blue tailed bee eater) *Metopidius indicus* (Bronze winged Jacana) *Milvus migrans govinda* (Pariah kite) *Motacilla alba* (White wagtail) *Motaciila cinerea* (Greay Wagtail) *Motacilla flava bheema* (Blue Headed Yellow Wagtail) *Motacilla flava melnogrisea* (Black-headed Yellow Wagtail) *Motacilla flava thunbergi* (Grey Headed Yellow Wagtail) *Motacilla maderaspantensis* *Mycteria leucocephala* (Painted Stork) *Nettapus coromandelianaus* *Numenius arquata* (Curlew)	*Nycticorax nycticorax* (Night Heron) *Pandion haliatus* (Osprey) *Pelargopsis carpensis* *Pelecanus philippensis* (Grey Pelican) *Phalacrocorax carbo* (Large Comorant) *Phalacrocorax fuscicollis* (Indian Shag) *Phalacrocorax niger* (Little Cormorant) *Phalaropus lobatus* (Rodnecked Phalarope) *Philomachua pugnax* (Ruf and Reve) *Phoenicopterus minor* (Lesser Flamingo) *Phoenicopterus roseus* *Platalea eucorodia* (Spoonbill) *Plegadia falcinellus* (Glossy Ibis) *Ploceus manyar* (Streaked Weaver Bird) *Ploceus philippinus* (Baya Weaver Bird) *Pluvialis dominica* (Easter Golden Plover) *Pluvialis squataola* (Grey Plover) *Podiceps ruficollis* (Little Grebe) *Porphyrio porphyrio* (Purple Moorhen) *Porzana fusca* (Ruddy Crake) *Porzana pusila* (Baillon's crake) *Pseudibis papillosa* (Black ibis) *Rallus striatus* (Blue Breasted Blended Rail) *Recurvirostra avocetta* (Avocet) *Rostratula bhengalensis* (Painted Snipe) *Sarkidiornis melanotus* (Comb duck) *Scolopax rusticola* (Woodcock) *Sterna acuticauda* (Blackbellied Tern) *Sterna aurantia* (Indian River Tern) *Tadorna ferruginea* (Brahminy Duck) *Threskiornis aethiopica* (White Ibis) *Tringa erythropus* (Spotted Red Shank) *Tringa glareola* (Wood Sandpiper) *Tringa hypoleucos* (Common sandpiper) *Tringa nebularia* (Green shank) *Tringa ochropus* (Green Sandpiper) *Tringa stegnatilis* (Marsh Sandpiper) *Tringa terek* (Terek Sandpiper*)* *Tringa totonus* (Common Redshank) *Vanellus cinereus* (Greyheaded apwing) *Vanellus indicus* (Red wattled Lapwing) *Vanellus malabaricus* (Yellow Wattled Lapwing)

Source: Krishna et al:1996

1.3. WATER QUALITY MONITORING

In 2001, the Research and Development Wing of the Karnataka State Pollution Control Board (KSPCB) published a comprehensive report on the monitoring of lakes and tanks in and around BMA to assess the state of water quality. This was an interesting report giving information on the water bodies carried out after the first phase of the city's lake restoration process. KSPCB's report as a result of water quality monitoring on 44 selected lakes (including all but 2 in the NLCP list) revealed that most of the lakes still remained highly polluted.

Untreated sewage coming out of the missing sewage links from the new layouts had begun to reach the watershed lines of lake systems and cumulatively causing pollution of water bodies. It was also revealed in the report that the city was undergoing sewage management crisis. The missing links were the information of bypasses and such bypasses of effluents generated from within the catchment area were not reaching the sewage treatment plants. The Bangalore Water Supply and Sewerage Board (BWSSB) was burdened with development of water supply network for the layouts which were formed for without proper planning of drainage system.

The report on the water quality of 44 lakes revealed that while the pH remained between 7.5 and 8, most lakes had the dissolved oxygen (DO) of less than 2 mg/l. The biochemical oxygen demand (BOD) was 58 mg/l exceeding even the discharge standards set for inland surface water (30 mg/l). Total coliforms were at 1265 MPN/100 ml (Most probable number) and fecal coliforms were 1091 MPN/100 ml. Suspended solids were above permissible limits at 108 mg/l exceeding the 100 mg/l standard for inland surface water while the total dissolved solids (TDS) were at 771 mg/l, also exceeding the 500 mg/l desirable limit. Among the cations, only sodium seemed to be under the desirable limits of 102 mg/l but, potassium was above the guideline value set by European Union Standards of 12 mg/l. Calcium and magnesium were above the Indian Drinking Water Standards at 178 mg/l and 134 mg/l exceeding the prescribed limits of 75 and 50 ppm respectively. Nevertheless, the total hardness, alkalinity and chlorides were above the limits at 307 mg/l, 207 mg/l and 217 mg/l respectively.

1.3.1. Benthic and littoral quality of lakes

Benthic and littoral communities within the lake habitat can be used as an excellent reflection of the environmental conditions affecting the lake. For example, a study conducted in Madiwala lake (Chakrapani and Reddy: 2000) recorded the benthic fauna represented by annelids, insects, crustaceans, molluscs and fishes, of which insects have dominated. But, in the littoral fauna, the crustaceans dominated. This is one case example of measuring the trends in micro-biodiversity of littoral community in classifying the importance of a wetland. More studies are needed to represent an overall picture of these indicators for Bangalore region.

1.3.2. Bathymetric study of wetlands

Although not many detailed bathymetric studies on the region's wetlands have been mainstreamed, Ranjani and Ramachandra's work (2000) carried out on bathymetric analysis and the characterisation of Bangalore lakes with a specific focus on Hebbal lake gives an idea on how critical the matter of lake's ecological restoration has become.

This study was carried out to assess the anthropogenic pressures that were already causing environmental degradation of many lakes in Bangalore. A detailed investigation to assess the catchment's characteristics, bathymetric aspects of the lake and physicochemical characterisation was conducted. The characteristics of ecological restoration depend very much on the outcome of such studies where natural conservation of the lake's physical basin and its biodiversity is threatened by desiltation under restoration programs.

1.3.3. Microbial pollution in wetlands

A study of Rejuvenation of Lakes in BBMP on enumeration of fungal, bacterial and actinomeyecetes diversity from samples taken from Puttenahalli, Dorekere; Uttarahalli kere; Chinnapahalli kere; Ambalipura; Kaudenahalli; and Kaikondanahalli lakes showed that the fungi had an average of 81.71×10^2 cfu/g followed by Bacteria with an average of 56.57×10^4 and Actinomyecetes at 16.71×10^3.

Table 10: Water quality of 44 lakes in BMR

Water quality parameters	*Range*
pH	6.5 – 8.7
Dissolved oxygen (mg/l)	0 – 8
Biochemical oxygen demand (mg/l)	1.6 – 312
Chemical oxygen demand (mg/l)	28 – 800
Suspended solids (mg/l)	14 – 364
Dissolved solids (mg/l)	178 – 2250
Sodium (mg/l)	13 – 384
Potassium (mg/l)	2 – 62
Calcium (mg/l)	50 – 336
Magnesium (mg/l)	32 – 300
Hardness (mg/l)	82 – 560
Alkalinity (mg/l)	72 – 700
Chloride (mg/l)	43 – 625
Nitrates as N (mg/l)	0 – 3
Phosphates as P (mg/l)	0 – 3
Sulphate	3 – 166
Total Coliform MPN per 100 ml	31 – 1600
Fecal Coliform MPN per 100ml	31 – 1600

Source: Karnataka State Pollution Control Board:2001

As for *Hebbal* lake, the bacteriological quality of lake, the water harbored tremendous abundance of *E.coli* and *Salmonella*. The MPN of coliform water ranged between 3×10^5/100 ml to 16×10^5/100 ml. The viable counts of E.coli were high throughout the whole study year ranging between 167×10^2/100 ml to 169×10^5/100 ml. The density of viable counts of Salmonella ranged between 8×10^2/100 ml to 128×10^5/100 ml. (Nandini: 1995). Further to that, the impact of this bacterial contamination in fish of Hebbal lake, the MPN estimate of the coliforms in the intestinal content of fish ranged between 23 10^3/100 ml and $16 \mathrm{X} 10^5$/100 ml. The viable counts of E.coli fluctuated between 58×10^2/100 ml and 123×10^7/100 ml. For Salmonella, the viable counts oscillated between 11×10^3/100 ml and 156×10^5/100 ml. This seasonal variation in bacterial count showed higher densities during rainy days and indicated the extreme levels of sewage contamination that many lakes in Bangalore are experiencing with the urban sprawling and lack of proper urban sewerage system.

1.3.4. Antibiotic resistance bacteria in wetlands

To prove the effect of sewage pollution on water quality and biodiversity of Bangalore wetlands and on increasing antibiotic resistant bacteria in the drinking water of Bangalore north *taluk*, a total of about 190 isolates from 46 different ground water sources –

about one third of the total samples collected from the *taluk* developed anti-biotic resistance; a strong correlation between sewage pollution in wetlands.

The microorganisms included *E.coli, Salmonella typhi, Klebsiella pneumoniae, Citrobacter freudii, Aeromonas hydrophilla* and *Enterococcus faecalis*. Out of 190 isolates 18% included *Pseudomonas aeruginosa*, 11% *Citrobacter freundii*, 5% *Aeromonas hydrophilla*, 17% *Klebsiella pneumoniae*, 14% *Enterococcus faecalis*, 18% *Salmonella typhi* and 17% *E.Coli*. This proved the degradation of biodiversity status of Bangalore wetlands and the spread of contamination in ground water sources. 40% of the isolates developed resistance to prescribed antibiotics. This study underscores how wetland pollution is increasingly becoming a human health risk.

1.3.5. Phytoplankton succession in polluted wetlands

Phytoplanktons are the base of the wetland's complex food web. Without these, the entire aquatic life will be difficult to exist. The dangerous depletion of these organisms and the shift towards non-primary producing colonies within that wetland ecosystem poses serious threat to natural capacity of wetland towards environmental resilience and regeneration. Previous studies done on the Agaram lake system which involves Agara, Hulimavu, Madiwala, Doddabeguru lakes show that the number of phytoplankton forms reduced from 22 to 19 between 1985 and 1995. There was also a marginal decrease in Chlorophycean and Bacillariophycean members. However, blue-green algae continued to be a dominant community. This system also experienced reduction in zooplankton forms from 30 to 22 in the same period. The biodiversity of Madiwala lake also had varied account. In 1995, only 11 phytoplankton and 17 zooplankton forms were recorded in comparison to 23 and 22 respectively in the late 1980's. The domination of phytoplanktons shifted from Microcystis to Spirulina in the blue-green algal group.

Agaram lake has always played the role of a physical buffer between Madiwala and Belandur lakes. The lake's plankton diversity has shown improvement over the years with phytoplankton forms increasing from 9 to 22 and among the zooplankton forms from 10 to 25. Chlorophyceae and Rotifers showed marked improvement while Myxophycean components decreased. The 1989 survey of Hebbal lake system diversity once showed presence of at least four rotifer forms. But Nagavara lake's phytoplanktons decreased from 22 to 17 in 1995. Though blue-green algae were represented by only 3 forms compared to 8 forms in 1989 the dominant form was *Phormidium spp*. equally, *Chlorophyceae* in the lake showed reduction from 11 to 6 forms as there was an increase in Bacillariophycean forms. This indicated a bad water quality form.

Figure 6: *Dhobis* at work in Agara lake

Bellandur lake has always been dominated by low forms of phytoplanktons and zooplanktons at 6 and 5 forms respectively. The phytoplanktons include Oscillatoria and Spirulina. Another major lake in the study area, Vartur lake is also predominated Microcystis and Spirulina, both being blue-green algal forms. These trends have changed little ever since.

1.3.6. Bacteriological quality of Vrishabhavathi

The biological quality of Vrishabavarthi stream along Mysore Road in Bangalore has been documented by Balasubramanyam (2002). Several types of bacteria and planktons found in the study include *Salmonella typhi, Vibrio cholerae*. The fungi included *Sphærotilus sp*. Algae were generally not seen but, protozoa *(Rhizopoda - Amoeba* and *Arcella sp.; Mastigophora - Bicosoeca* and *Euglena sp.; Ciliophora - Colpoda, Colpidium, Coleps, Stylonychia, Paramecium, Vorticella* and *occasionally species of Opercularia, Epistylis and Carchesium)* were detected. *Insect larvae (Aulophorus sp.; Mosquito (Culex sp.); Bloodworm - Chironomus sp.*) were also seen.

1.3.7. Pollution in Bellandur lake

Figure 7: Construction debris advancing in Bellandur tank

A study by Chanakya et al (2006) on Bellandur lake in Koramangla Chalagatta valley provides a bleak picture on the status of ground water quality around Bangalore wetlands. The extent of physicochemical pollution of the ground water reveals that the level of nitrates was above permissible limits at 56.13 mg/l, more than six times the concentration of the tap water.

Furthermore, Roselene and Selvam (2007) showed that the specific conductance of the ground water of Bellandur lake was at 4.1 ms/cm while total hardness was at 1,600 mg/l. more than seven times the prescribed limits. DO had less than 1.6 mg/l with high Phosphates variations in concentrations between 0.92 mg/l to 10.4 mg/l. Sulfates also varied between 51 mg/l and 1,900 mg/l exceeding even the standard discharge limits in inland surface water. Total hardness was above the prescribed limit at 320 mg/l and chlorides at 148.3 mg/l. In case of heavy metals, the water was contaminated with iron (Fe) at 0.92 mg/l; and lead (Pb) was 0.436 mg/l. This trend can only be supported by the fact that Bellandur along with another major lake in the valley Vartur is increasingly becoming a malarial prone zone in the region where the bulk of the city's untreated sewage flows towards the eastern watershed.

1.3.8. Ground water quality of Vrishabhavathi

The impact on hydrological cycle in Bangalore due to urbanisation is clearly indicated by the major shift in the frequency and volume of ground water recharge. Table 11 shows a study on the ground water quality along Vrishabhavathi stream within the Vrishabhavathi valley in the year 2000, which reveals varying degree of contamination. The concentration of pH, total hardness, acidity, alkalinity and electrical conductivity were higher than the permissible limits. Moreover, sodium, potassium, iron, copper, chromium, nitrates and chlorides at some locations exceeded the prescribed standard for drinking.

Table 11: Ground water quality in Vrishabhavati Valley (*n = 100 samples*)

Quality parameter	Minimum	Maximum	Average	Permissible limit	Samples within permissible limit
pH	6.22	9.82	7.29	6.5 – 8.5	5
Electrical conductivity	0.38	4.10	1.67	0.4	99
Dissolved oxygen (mg/l)	3.0	13.50	6.75	4 – 8	27
Total hardness (mg/l)	90.0	800.0	370.38	115.0	95
Alkalinity (mg/l)	98.0	800.0	381.72	120.0	98
Sodium (mg/l)	43.0	700.0	122.49	175.0	16
Potassium (mg/l)	1.0	140.0	17.29	12.0	38
Iron (mg/l)	0.0	0.841	0.13	0.30	12
Copper (mg/l)	0.0	0.142	0.06	0.05	51
Chromium (mg/l)	0.0	0.325	0.06	0.05	29
Nitrates (mg/l)	0.0	305.0	61.27	45.0	57
Chlorides (mg/l)	20.0	580.0	193.39	250.0	21
Fluorides (mg/l)	0.01	1.0	0.430	1 – 1.5	99

Source: Santhaveerana Goud:2000

1.3.9. Fluoride contamination in groundwater

In a study of fluoride contamination in the ground water of Anekal *taluk* of Bangalore Urban district by Prakash et al (2004), showed alarmingly higher levels in the three *hoblis* of Kasaba, Attibele and Sarjapura. Around 272 ground water samples collected from 49 locations of these *hoblies* showed excess fluoride than the BIS limits prescribed for drinking water. About 77.55 % of the samples collected from hand pumps showed excess fluoride content. Similarly, 20.4% of miniwater supply and 2% of a pipeline supply showed excess fluoride contents. In Kasaba and Atibele *hoblies* excess fluoride content was observed in 17.22% and 15.84% of the total samples respectively. In Sarjapura, maximum of 35% samples showed excess fluoride. In Kasaba the maximum fluoride observed was 4.6 mg/l at Munimarayana doddi, while in Atibele the maximum fluoride content was 6.6 mg/l at Bendiganahalli. Comparatively less fluoride contents of 3.3 mg/l was observed at Muturayana Swamy temple of Sarjapura *hobli*. Table 12 gives the analysis result of ground water quality of Kasaba, Attibele and Sarjapura.

Table 12: Groundwater quality in Anekal taluk hoblis in Bangalore Urban district

Parameter	*Kasaba*	*Atibele*	*Sarjapura*	*Desirable limit*
pH	7.29 (5.8-8.4)	7.8 (6.9 – 8.5)	7.48 (6.3 – 8.5)	6.5 – 8.5
Total hardness; mg/l	227.6 (67.8-556.8)	264.5 (42 – 556.5)	101.4 (78 -203.4)	115.0
Calcium hardness; mg/l	127.25 (33.9 – 359.6)	187.7 (31.5-399.6)	58.2 (33.9 – 101.4)	
Fluorides (F); mg/l	2.6 (1.5 – 4.6)	2.3 (1.6 – 6.6)	2.8 (2.4-3.4)	1.5

Source: Prakash et al., 2004

1.3.10. Heavy metals in wetlands

Environmental pollution of wetlands causes serious chain reaction in transfer, bioaccumulation and deposition of heavy metals in the wetland system. For example, aquatic macrophytes have the tendency to bioaccumulate heavy metal residues present in water or the sediment stratum. Together with the sediments, they play a vital role in natural life support systems surrounding a lake. Contamination of fodder is a serious human health risk as latest studies show. Worse, contamination of wetland sediments by various chemical pollutants put the entire food web at danger of bioaccumulation and transport of metals from one biome to another.

Figure 8: Solid waste on the banks of Hosakere lake

2. PRESSURES AND UNDERLYING CAUSES

High degree of industrialisation, urbanisation and other anthropogenic activities have led to contamination of wetlands by various chemical pollutants. With high population density, inadequate and irregular rainfall increasing water depletion, many wetlands of Bangalore are now polluted and are fast disappearing. The wetlands are facing crisis for survival as a result of population growth of the region from 26,60,088 in 1991 to 58,68,448 in 2007. Generally, the problems of lake management have been grouped in the context of lake zones. These are catchments and watersheds; the lake's littoral zone and the in-lake basin.

Problems emanating from the lake catchments and watersheds:

- Excess sediment inputs caused by unscientific land use and other land clearance activities. Sediments destroy wetlands and block the penetration of light into water column. They can also act as carriers of nutrients and other pollutants.
- Excess non-point source nutrient inputs which originate from soil erosion in the catchments. This contributes to algal outbreaks and growth of aquatic weeds. This causes reduced oxygen levels.
- Agro-chemical pollution coming from agriculture and horticulture. These agro-chemicals can persist in the lake sediments for a long time
- Excessive water withdrawals or diversion affecting the natural lake inflow volume as against the outflow capacity.
- Industrial pollution caused by direct discharge of industrial waste from shoreline industries.

Problems emanating from the littoral zone:

- Shoreline effluent and storm water discharges caused by untreated or poorly treated effluents from lake shore communities. This exacerbates the BOD, reduce DO and increase in bacterial contamination. Other urban contaminants such as oil, organic matter, heavy metals, also add to pollution load.
- Shoreline water extraction through irrigation activity causing pollution of crops and also drying of lake aquifers.
- Loss of wetlands and littoral habitat.

Problems associated with in-lake basin:

- Unsustainable fishing practices causing decline in fish diversity.
- Introduction of exotic faunal species into lakes threatening the extinction of indigenous fish species.
- Weed infestations which affects the lake water quality, interfering in navigation and transportation, blocking water flows and sometimes triggering development of marsh lands.
- Changes in salinity affecting lake ecosystems
- Immersion of idols during Ganesha Chaturthi increases lead content and siltation of water bodies

Figure 9: Idols ready for immersion

- Nutrient fish cages – Nutrients enter lakes from the excreta of caged fish and from excess food. These nutrients can promote eutrophication and growth of aquatic weeds.

In addition, major issues pertaining to environmental pressures affecting Bangalore wetlands given by Ramachandra and Murthy (2000) include:

- Lack of institutional commitment, cohesive academic research centered on wetland in understanding the importance and essence of conservation and management, owing to financial constraints and lack of infrastructure and required expertise.
- Deficiency in proper management of non point source of pollution like storm water runoff, agricultural runoff and unregulated land use management causing eutrophication, invasion of exotic species, toxic contamination by heavy metals, pesticides and organic compounds.

It should be noted here that since the establishment of N. Lakshman Rao Commission earlier in 1985 to look into the status of Bangalore wetlands and the extent of their deterioration with a measure that became a benchmark of the long journey towards restoration and conservation of the Bangalore wetlands. The restoration efforts have been somewhat diffuse with multiple actors along with diversified priorities. The Lakshman Rao commission had the following major recommendations:

- Tanks should not be breached but retained as water bodies
- To ensure that the lakes will not be polluted by discharge of effluents and industrial waste.
- The catchment basins to be protected through afforestation and removal of encroachments in the context of preventing further siltation of lakes.
- Creation of tree parks as buffer zones for breached lakes

However, with rapid physical growth of the region and multiplication of urban civic bodies (BBMP, BDA and BMRDA), priorities have often shifted towards different directions. While the former have been primarily established for the purpose of development of Bangalore, the latter, (Forest and Irrigation Departments) have had to transfer some of the water bodies to the jurisdiction of civic bodies. The ethical point of view here has been marred by the fact that while ecologically oriented Forest Department's focus was a complete protection of wetlands and their biodiversity, the current civic bodies orientation has always been towards maximising ecological services of wetlands. This has exacerbated issues with various stakeholders hence, undermining the entire process of wetlands restoration and conservation.

Figure 10: Illegal sand mining at Ullal lake

This observation tends to correlate the concept that not only are the pollution, encroachment and degradation is detrimental to the life of wetlands but, the hostile restoration practices can prove to be even more negative. This is because disturbances in watersheds which include deforestation, land conversion for authorised plots, remodelling of the watershed landscape diminishes the wetland capacity for environmental resilience. It reduces its water retention capacity, thus shortening its lifetime, destroying aquatic habitats and reducing the productivity of its ecosystem.

Figure 11: Tipper lorries being washed in a lake

Figure 12: Solid waste dumping on the western bank of Byramangala lake

2.1. CAUSE AND IMPACT ANALYSIS

2.1.1. Sewage pollution

Causes	Effects	Impact
▪ Poor civic planning with missing links on sewage outflows. ▪ Unauthorised construction in areas where municipal sewage lines are not registered. ▪ Mixing of domestic and industrial effluents which flow into storm drains. ▪ Lack of adequate sewage treatment plants allowing raw sewage to enter water channels and water bodies. ▪ Illegal sewage connections with no adequate feeders ▪ Flooded and overflowing municipal drains carrying waste into open water bodies.	▪ Inflow of raw sewage into natural drains ▪ Changes in physicochemical and biological characteristics of water. ▪ Increase in toxicity and contamination of surface and ground water sources. ▪ Contamination of aquatic plants and wetland fodder species. ▪ Drinking of contaminated water by sheep, cattle, etc ▪ Degradation of soil quality due to irrigation of contaminated water. ▪ Reduction in DO and increase in BOD and COD in water	▪ Degradation of surface water and ground water quality of the area ▪ Loss of aquatic biodiversity and changes in aquatic species composition affecting the food web ▪ Disappearance of avian diversity in the wetlands due to degradation of water quality. ▪ Contaminated bore wells and other ground water aquifers with increased health risks on humans ▪ Increase in water-borne diseases and other health risks to humans ▪ Loss of fish and infection of livestock with increased human health risk

2.1.2. Encroachment

Causes	Effects	Impact
▪ Illegal establishment of hospitals, industries, grave yards, bore wells and high rise apartments within the wetland basins. Road constructions have	▪ Destruction of habitat and shrinkage of wetland zones. ▪ Increase in solid waste dumps on various wetland banks.	▪ Loss of wetland area and suffocation of wetlands. ▪ Reduced in the volume of water. ▪ Reduced capacity of wetlands to filter

been paved on the banks of wetlands e.g. Sompura and Ullal lakes ▪ Unauthorised construction on the banks and buffer zones of wetlands. Even some authorised layouts have been commissioned inside wetland zones ▪ Illegal solid waste dumps in catchment areas. ▪ Destruction of upper catchments and construction of roads and highways on the banks of lakes.	▪ Increase in new layouts known as the "lake view" properties built on wetland banks ▪ Increased water pollution degrading the wetland surroundings ▪ Increase in over-grazing activities ▪ Reclamation of wetlands for construction and horticultural purposes ▪ Inflow of silt and top-soil run-offs into wetlands	ground water and reduction in water volumes. ▪ Loss of wetland biodiversity including avian diversity ▪ Polluted water contributing to infectious diseases, malaria, etc. ▪ Excessive invasion of exotic species such as Eichornia crassipes, Salvia spp, and weeds like Cytodon family e.g. in Bellandur, Vartur, Agara, where reduction of water volumes precipitates succession of grasses.

2.1.3. Quarrying within catchment areas

Causes	Effects	Impact
▪ Blasting, digging, cutting of boulders that make up part of catchments, e.g. in Venkateshpura, Hulimavu lakes ▪ Removal of rocks, stones and overburden materials dumped into wetlands e.g. Venkateshpura and Byramangla catchments. ▪ Movement of heavy duty vehicles inside catchments with highest intensity of physical disturbance. ▪ Employment of quarrying operations which uses water extraction intensively ▪ Use of fossil fuels such as petrol and diesel in mining activities including vehicles, electricity generation and the use of coal for migrant labourers	▪ Open pit quarrying and creation of "moonscapes" and this also includes exposure of water tables e.g Venkateshpura lake ▪ Increased noise pollution in the wetland habitat e.g. Hulimavu lake. ▪ Increased air/dust pollution in wetlands and surrounding areas. ▪ Destruction of catchments and pollution of exposed water tables. ▪ Ground water mining for more extensive processing purposes.	▪ Defacement of catchments as in Hulimavu, Venkateshpura, south Somasundarpalaya. ▪ Wetland deforestation and loss of wetland biodiversity. E.g. open barren land of Venkateshpura. ▪ Reduction of ground water table and water pollution with increasing number of borewells dug deep inside the lake basins ▪ Incidence of tuberculosis and silicosis among workers. ▪ Particulate matter pollution near wetlands. ▪ Exposure of forest corridors to illegal loggers and poachers involved in the poaching of pelicans, storks, herons and water snakes

2.1.4. Sand mining in catchment areas

Causes	Effects	Impact
▪ Movement of heavy duty vehicles in and out of wetlands. E.g., Ullal lake ▪ Application of high powered mechanised pumps that extract the sand out of lake beds ▪ Drilling and digging operations that destroy the physical structure of lake basin as found in Ullal lake. The sand is then used primarily for a booming real estate industry in Bangalore.	▪ Destruction of lake beds and levees e.g Ullal, Kanchanapura, Bimakkuppe lake ▪ Degradation of natural aquatic vegetation and fodder ▪ Pollution by fossil fuels and unwanted overburden ▪ Change of water quality and death of fish ▪ Destruction of wetlands that support migratory birds ▪ Change in physical structure of wetland	▪ Loss of wetland biodiversity ▪ Disappearance of migratory birds. ▪ Loss of natural aquatic ecosystem in favor of more tolerant predatory exotic ones. ▪ Punctured water table and drying up of lake bed ▪ Loss of fish rearing activity as a result of siltation and sedimentation. ▪ Reduced water irrigation potential as a result of high level of silt and salinity.

2.1.5. Degradation due to aqua-cultural activities

Causes	Effects	Impact
▪ Over-exploitation of fish yield ▪ Destructive fishing methods using ultra-fine fishing nets ▪ Introduction of exotic fish species that destroy local varieties. ▪ Increasing water pollution and decrease in water depth due to combination of both erratic rainfall and encroachment. E.g. Kenchapura Lake, Siddapura lake	▪ Reduced fish catch yield ▪ Increase in water contaminants and toxicity ▪ Reduced fish size and contaminated fish catch ▪ Fish death caused by fish nets that capture even smaller fish, thereby disrupting the biological balance ▪ Exotic species destroying natural fish population	▪ Loss of fish diversity and decreased capacity of wetlands to support sustainable food web. ▪ Reduced economic profits as a result of decrease in yield ▪ Dominance of exotic species ▪ Loss of fish and emergence of conflict among wetland users between primary resource dependants and commercial investors.

2.1.6. Deforestation of wetland vegetation

Causes	Effects	Impact
▪ Expansion of urban layouts in the catchment zone e. g., the forest and groves of the entire southern shoreline of Bellandur lake have disappeared under the newly constructed chain of apartments ▪ Demand for wood and timber inside the catchment zone and this can largely be experienced in outer Bangalore wetlands as in Byramangala where most of the original catchment canopy vegetation is lost. ▪ Demand for agricultural land inside the wetland flood plains, e.g., Vartur ▪ Demand for land for construction of high rise apartments and large scale property development, construction of roads and highways as seen in NICE road (Sompura) and BDA Road (Ullal lake). ▪ Illegal cutting of trees such as acacia, tamarind, mango, jackfruit, peepal and banyan trees on the banks.	▪ Destruction of wetland biodiversity, especially aquatic vegetation (Thalaghatapura lake). ▪ Loss of wetland flora and fauna as bird diversity is reduced to only couple of water fowls. ▪ Increase in inflow of agro-chemicals as seen in Vartur, Byramangala, Yellamallappa Chetty lake. ▪ Increase in dumping of construction waste materials causing heavy siltation as found in Rachenahalli, Ullal, Arekere, Ibblur. ▪ Loss of bird nesting sites within wetland zones with the disappearance of vegetation disappears. Also when bird's natural predators gain the upper hand as a result of human interference ▪ Exposure of increasingly rare water snakes, e.g., Doddabomasandra lake	▪ Loss of wetland biodiversity. ▪ Accelerated siltation and sedimentation in the basins. ▪ Erosion and physical destruction of wetland banks ▪ Loss of wetland resources and deprivation of wetland ecology, e. g., Gottigere lake. ▪ Loss of key stone species in the lakes such as bilpatre, wild date palms, acacia, ipomoea, etc., which are critical for birds. ▪ No trees are now found around Hulimavu lake and in one field study; only one Acacia tree was found standing on the bank of Venkatespura Lake. An old Peepal tree is now standing over much of the area around Karihobanhalli lake. A coconut grove to the north-west of Karihobanahalli is threatened with more construction on the bank.

2.1.7. Ground water mining in catchment areas

Causes	Effects	Impact
▪ Demand for irrigation and maximum agricultural yield as seen on Jakkur, Byramangala, Vartur, Bellandur and Yellamallappa. ▪ Expansion of agricultural land within the wetland system. ▪ Rising demand for water supply from large-scale recreational parks and aesthetic facilities. ▪ Demand for domestic, municipal and industrial water supply causing forci-	▪ Increase in number of bore wells. ▪ Increase in number of electrical and diesel pumps ▪ Increase in number of masonry and non masonry wells inside catchment zones ▪ Increase in gross area irrigated for crop production ▪ Contamination of water sources by pesticides and fertilisers e.g., Vartur. ▪ Contamination of water sources by	▪ Depletion of reservoirs and ground water table, e.g., Bellandur water spread area has subsided drastically ▪ Increase of land encroachment incidents. ▪ Loss of crops yield and salinisation of agricultural lands ▪ Loss of irrigation and fishery activity because of sinking water levels. ▪ Rising shortages of domestic, municipal and industrial supply of water.

ble extraction of water from wetlands for various secondary purposes.	industrial effluent discharges e.g., Karihobanahalli and Shivapura lakes of Peenya.	

2.1.8. Unsustainable agriculture

Causes	Effects	Impact
▪ Demand for irrigation and maximum agricultural yield as in Vartur, Byramangala, Yellamallappa ▪ Expansion of agricultural lands within the wetlands mostly in the eastern watershed of Bangalore. ▪ Increase in sericulture and horticultural activities that highly depend on the availability of wetland water and this is the case of several horticultural units in Hesarghatta, Bimakkuppe and Kengeri *hobli*.	▪ Increase in demand of land for cultivation purpose ▪ Increase in area under principal crops, mostly vegetables and flowers. In Anekal *taluk*, most farmers have changed their crops to floriculture consuming maximum amount of ground water. ▪ Maximisation of pesticides and fertilisers to increase yield per hectare of principal crops ▪ Increase in the use of agro-based machinery and agrochemicals. ▪ Increase in water withdrawal for irrigation e.g channelisation of Jakkur and Byrmangala lake.	▪ Depletion of water volume in reserviors. ▪ Depletion of ground water table and pollution. ▪ Contamination of catchments with pesticides and fertilisers ▪ Contamination of wetlands and aquatic vegetation such as Eichornia crassipes, Amaranthus spp, ▪ Salinisation of agricultural lands ▪ Reduced crop yield ▪ Shortage of water supply to municipalities and industries. ▪ Emergence of user conflicts especially between fishermen, farmers and herdsmen.

2.1.9. Unsustainable irrigation

Causes	Effects	Impact
▪ Demand for irrigation and maximum agricultural yield ▪ Expansion of agricultural land within wetlands ▪ Increase in sericulture and horticultural activities dependent on wetland water sources. ▪ Increase in major irrigation projects that demand more supply of water.	▪ Increase in demand of water for irrigation ▪ Increase in the use of polluted and contaminated water for agriculture ▪ Diversion of water towards cropping areas ▪ Mixing with pesticides, fertilisers and agrochemicals ▪ Contamination of surface and ground water sources ▪ Decreasing levels of surface water	▪ Depletion of reservoirs and ground water table ▪ Contamination of catchments with pesticides and fertilisers ▪ Water pollution and contamination of wetlands and aquatic vegetation ▪ Loss due to low crop yield and salinisation of agricultural lands ▪ Reduced crop yield ▪ Shortage of water supply to municipalities and industries.

2.1.10. Overgrazing

Causes	Effects	Impact
▪ More demand for adequate pasture for livestock (sheep, goats, cattle). ▪ Increase in heads of cattle, sheep, buffaloes and goats largely for increasing commercial demand ▪ Decrease in available productive land for livestock feed as wetlands disappear and more herdsmen in the urban areas find it difficult to locate natural flora for grazing.	▪ Increased exploitation of wetland zones for livestock feeding. Almost all unfenced wetlands are exposed to over-grazing threats with much of the shrub vegetation affected except for weeds such as lantana sp. ▪ Exploitation of dry lake beds and depleted lakes for grazing e.g. Chikkabanavar lake, even restored lakes such as Doddabomasandra and Tindlu with reduced water levels are now used as foraging zones.	▪ Depletion of wetlands vegetation ▪ Contaminated fodder eaten by livestock and increased health hazards to consumers who eat livestock fed by contaminated fodder, e.g., Narasipura lake which is polluted with sewage inflow. ▪ Conflicts among wetland users e.g. herdsmen, fishermen and farmers when disagreement on the right of using wetland resources arise. ▪ Water birds and other birds get affected as this places immense stress

		on the vegetation. ▪ Butterflies that inhabit the wetland and its vicinity also get affected. ▪ Loss of vegetation leads to soil erosion causing siltation of wetland.

2.1.11. Brick making factories in wetland zones

Causes	Effects	Impact
▪ Rising trends and demand in urban construction which require raw materials for high rise apartments, roads and parks. ▪ Sand mining and water withdrawal for construction and other industrial purposes. ▪ Use of cement and lime-chalk inside wetlands along with other manufacturing reagents ▪ Quarrying activities and movement of heavy vehicles in and around wetlands. E.g. Nagadevanahalli lake	▪ Increase in factory discharges into the wetlands including building waste materials, quarry waste and inflow of chemical reagents into wetlands ▪ Increase in dust pollution as a result of surrounding casting activities and degradation of wetland banks, e.g Ullal, Nagadevanahalli, Hulimavu, Chikkabanavara, Abhigere lakes. ▪ Increase of noise pollution in the surrounding areas.	▪ Contamination of aquatic and wetland vegetation – used as fodder for animals. ▪ Contaminated fishery and loss or change in species composition due to chemical and biological inputs. ▪ Invasion of exotic species and physical degradation of wetlands. Polygonum spp. is considered as pollution indicator species in that it thrives in lakes which have lost their water retention capacity are known as ecological succession indicator. This Species is found in Konasandra, Hebbal, Bellandur, Hulimavu, etc.

2.1.12. Hostile restoration and recreational activities

Causes	Effects	Impacts
▪ Unsustainable lake restoration methods that favor desiltation and destructive modification (saucer-shaping) of physical structures of basins. This has caused detrimental effects on some of the restored lakes causing reduction, if not total loss of aquatic biodiversity of algae, protozoans, rotifers, molluscs, crustaceans, frogs and snakes. ▪ Modification of surrounding flora by converting some of the wetland forests e.g. Bamboo and Areca groves at Malathalli Lake ▪ Privatisation of lakes (mostly lakes already restored by the government) for commercial purposes and not for conservation purposes. This policy has rendered adopted lakes (Nagavara, Venganaiahkere) to be converted for water sports. ▪ Introduction of mechanised water sports activities which bring in customers not necessarily environment conscious.	▪ Physical degradation of wetland in the name of restoration. ▪ Unnecessary giving away of restored lakes for commercial adoption e. g., Hebbal, Nagavara, Venganaiahkere, Agara, etc. ▪ Unsustainable ecological engineering involving removal of the entire aquatic vegetation. ▪ Prevention of fishermen, farmers and other users from using resources inside adopted/privatised lakes. ▪ Increased water noise levels affecting aquatic life. ▪ Increase in the number of people visiting lakes for aesthetic purpose and increase in littering inside the wetland and around the area e.g. Venganaiahkere, Hebbal, Agara lake.	▪ Loss of wetland biodiversity and loss of fishery activity. ▪ Increase in garbage disposal and plastic (bottle) waste floating in lakes, e.g. Venganaiahkere Lake. ▪ Increase in dead floating fish in lakes e.g. Venganaiahkere Lake. ▪ Disrupted food web and loss of sanctuary for local and migratory birds as a result of human disturbance through excessive "de-weeding", remodeling of wetland system. ▪ Loss of livelihoods for other users and conflict among users, new owners and also with authorities. ▪ Detrimental engineering of lake termed as "saucer-shaped" engineering. ▪ Increase in human health risks especially to those coming in contact with the water of such restored lakes.

3. INSTITUTIONAL ASSESSMENT

The most important component in wetlands management is the integrated approach in enforcing environmental policies and goals directed at this sector. There are no strong existing statutes and acts solely for wetlands biodiversity save for those pertaining to protection of national biodiversity hotspots. The Environmental Protection Act (1986) and Rules (1989), the Water Pollution Prevention Act (1974) and Rules (1975), are the only strong laws that can intervene, but only in case of saving wetland from documented pollution. In this case, wetlands are laid legally bare and prone to exploitation until when an act of water pollution occurs. The other effective tool in protecting the wetlands is the Public Interest Litigation. Recently, Karnataka has set up a special environmental court known as the Green Bench in an effort to prioritise environmental issues and resolve legal wrangling in matters pertaining to environmental protection between various stakeholders.

Historically, India is signatory to the Ramsar Convention on Wetlands and since 1980 and there was a National Wetland Management Committee dedicated to conservation and protection of wetland biodiversity. NLCP was put into action in early 2000. Department of Forest was earlier seen as the main vanguard of wetlands but the sheer size and number of wetlands under its jurisdiction plus the maintenance cost proved almost impossible for the Forest Department to manage this task.

The Ministry of Environment and Forest, Government of India, is the principal agency dealing in environmental conservation and protection of biodiversity. The principal tasks include conservation of flora and fauna, prevention and control of pollution and devising national framework for various sectors of environment and forestry. In Karnataka, the Department of Ecology, Environment and Forest implements the national framework for the state.

Figure 13: Burried periphery of Madivala tank bed

3.1. THE LAKSHMAN RAO COMMISSION REPORT

The N. Lakshman Rao Commission which was set up by the State Government in 1986 conducted a rapid survey of lakes and listed the general status of existing lakes and the problems faced by them. The commission, alarmed at what it saw as the unimaginable destruction of Bangalore urban wetlands, recommended that the lakes be handed over to Karnataka State Forest Department for immediate protection and preservation. In addition, the commission also recommended that the principles of Ramsar Convention on Wetlands should be applied to Bangalore lakes at once. Census on various species of migratory birds which is the principal environmental indicator tool for rapid assessment of the health of urban lake systems was conducted. The first census was carried out in 1989 and it was repeated in January 1995. Since then the census of birds on the city's wetlands has been ingrained into several areas of the Bangalore conservation community. Thus, the involvement of people in their efforts for conservation and restoration of city's lakes was gazetted for the first time in Bangalore on February 11, 1988 as per N. Lakshman Rao's recommendations. The Forest Department was handed over a total of 81 lakes around the city. This handing over of lakes was officially effected in 1991. The process of handing over was completed in 1994. Out of these 81 lakes, fencing was done for only 34 lakes (42.5% of the total lakes handed over) and out of 34 lakes, only 8 lakes were selected for extensive ecological engineering works such as desilting, afforestation and recreation facilities. This was done between 1994 and 1995.

3.2. INSTITUTIONAL RESPONSIBILITIES

Prior to inception of Lake Development Authority (LDA), the following agencies were given various responsibilities in conservation, restoration and maintenance of wetlands in BMR. These agencies included BWSSB, BDA; Bangalore Metropolitan Regional Development Authority (BMRDA); Bangalore Mahanagara Palike (BMP); *Zilla Panchayat* and the Forest Department. These agencies initiated efforts for protection, preservation and conservation of wetlands. In July 2002, a new authority was established to pioneer multi-stake holder coordination among the above agencies in a new wave of tackling the lake degradation and pollution. This was called the Lake Development Authority.

3.1.1. Lake Development Authority

LDA, an autonomous body established in July 2002 took charge of the existing reinvigoration plan that was earlier recommended by Sri N. Lakshman Rao Commission and partly implemented by National Lake Conservation Authority, the Central and State Pollution Control Boards. Its task was to function as an important axis in the drive for lake restoration and management programme by acting as a nodal agency for convergence of all responsible agencies such as the BWSSB, BDA, BMRDA, BMP, *Zilla Panchayat* and the Forest Department. Jurisdiction of LDA extends over the entire BMR. The LDA has identified about 60 lakes from six different series of cascades for immediate restoration soon after it was established. These lakes form part of the upstream lakes (prioritised lakes) in 6 different cascades of the region which comprise of 2000 lakes. Cleaning up and restoration of these 60 upstream lakes would reduce pollution on the downstream lakes. The cost of this program was estimated at Rs. 336 crores. These selected series included Yellamallappa Chetty, Vartur, Byramangala, Madhavara, Puttenahalli and Hulimavu. The LDA's main objectives were: Resuscitation of lakes to boost aquifers, diversion and treatment of sewage to generate alternative sources of raw water, improving sanitation and health conditions and preserving the habitat of aquatic life.

LDA formulated the reinvigoration plan which it had implemented in several projects along with agencies like the National River Conservation Authority (NRCA); Department of Ecology and Environment, GoK; Indo-Norwegian Environment Program (INEP); BMP, Karnataka Forest Department (KFD), BDA and BWSSB. The multi-pronged programme has primarily involved in the desiltation of lakes, sewage diversion from storm water drains and biological treatment of sewerage entering the water bodies.

Since 2002 LDA has been working with these agencies on the restoration programs of about 60 lakes. The principal objectives include eco-engineering of the lake shorelines and immediate catchments, peripheries, resuscitation of lakes to boost aquifers, diversion and treatment of sewage lines, improving sanitation and health conditions of areas within the lake catchment systems, preserving the habitat of aquatic life, removal of water hyacinth, etc.

3.1.2. National Lake Conservation Plan

The National River Conservation Directorate, Ministry of Environment and Forests, Government of India, complements the activities taken up by the Government of Karnataka since the pioneering programme of the National Lake Conservation Plan (NLCP). The Directorate has approved various major activities like conservation of lakes in the State under the NLCP during the financial year 2002, 2003 and 2004. Under the NLCP initiatives 70% of funding pattern is by the agency while 30% of budget comes from the State Government.

In 1995 a proposal for the NLCP for Bangalore came out with a new theme of "Integrated Lake Ecology with Water Quality" . This plan was aimed at improving the urban sanitation and health conditions especially for the weaker sections of the society living within the lake catchment area. The plan also called for eco-friendly, low-cost waste management bio-systems like "engineered wetlands". A total of 4 sub-systems comprising of around 20 lakes were selected for the first phase of the NLCP. These four sub-systems included Agara lake system (Hulimavu, Doddabegur, Madiwala, Puttenahalli; Agara Kere); Hebbal system (Narasipura I and II; Dodda Bomassandra, Hebbal Kere and Nagavara); Bellandur lake system (Ulsoor, Bellandur, Vartur) and Dorekere system (Vasanthapura, Janardhana, Dorekere, Moggekere).

The proposal specified the following tasks for restoration such as desilting of lakes, fencing around the lakes, afforestation and gardening, sewage water treatment, interception chambers, diversion channels, oxidation ponds, deweeding of lakes, community sanitation, solid waste and garbage disposal, recreational facilities, etc. This was to be a five-year phasing project (1995 – 2000) divided into Catchment Area Development (CAD), Sewage Diversion Channels, Desilting and Weed Control, Face-lifting of Lake, Biological studies, public awareness program, land acquisition and others.

3.1.3. BBMP initiatives

The BBMP is currently engaged in restoration, conservation and maintenance of wetlands within the core area of BMR. The wetlands that are currently under restoration process include Puttenahali Kere, Malgal

Kere, Dorekere, Ambalipura, Kodigehalli, Attur Kere, Kalkere, Nayandahalli, Yelahanka, Dasarahalli, kaikondanahalli, Allalasandra, Kaudenahalli, Chinnappanahalli, Uttrahalli and Deepanjali nagar. These programmes are undertaken with the support of Jawaharlal Nehru National Urban Renewal Mission (JNNURM) of Government of India.

3.1.4. BDA initiatives

BDA has taken up the following 12 lakes for restoration and conservation programmes of wetlands within the limits of BMR with the support of JNNURM. These wetlands include Jakkur Lake, Sampigehally Lake, Rachenahally, Venkateshpura, Ullal, Kommaghatta, Mallathalli, Ramasandra, Thalaghattapura, Konasandra, Sompura and Kothanur lakes.

3.1.5. Forest Department and conservation of wetlands

By far, the Forest Department was the first nodal agency in taking up more than 114 lakes at a time to save the region's wetlands following Sri Lakshman Rao's recommendations. This agency had the largest contingent of wetlands and took steps to protect and develop these lakes prior to inception of the LDA.

3.1.6. Adopt-A-Lake Policy

This policy is intended for wetlands situated in the midst of residential areas that are restored or are to be restored primarily for their ecological value being eco-sensitive with the help and active participation of local citizen committees, residents, associations, corporates and non-governmental organisations (NGO). But, there has been discontent among the local community members who oppose this policy on the basis of protection of Common Property Resources (CPR) laws meant to safeguard the rights of equitable access by all the users. For example, the practice of handing over wetlands restored under various local and national programs (especially the Indo-Norwegian Environment Project) has been very unpopular with the LDA having forced to revise its policy.

3.1.7. Lake Restoration Advisory Committees

Government bodies such as the BDA and BBMP have formed advisory committees that hold hearings on the detailed project reports prepared to carry out restoration programs on several lakes under their respective jurisdictions. These committees advise authorities on eco-friendly methods of lake restoration that do not harm the geomorphology of the lakes as well as protecting local biodiversity.

3.1.8. Wetland Hotspots and Karnataka Biodiversity Board

Karnataka Biodiversity Board (KBB) has recently come up with a special program aimed at conserving biodiversity hotspots. In urban Bangalore, most of the biodiversity hotspots left surviving are wetlands. Sompura lake is about 18 acres with a catchment area of approximately 93 ha. The unique characteristic feature of this lake within Bangalore area is the richness of its age old species diversity on its immediate banks. These heritage trees are now susceptible to human interference as the lake is due to undergo a major restoration program under BDA. The age old trees found on the banks of this lake include *Ficus religiosa* (Peepal), *Ficus* spp, *Mangifera indica* (Mango), *Tamarindus indica* (Tamarind), *Phoenix sylvestris* (Wild Date Palm), deciduous trees, eucalyptus forest; the field count survey has identified more than 10 age old solitary trees of this type on the northern bank of the lake. Unlike on the eastern part of the lake where the lake is bordered with eucalyptus forest line, the western stretch from north to south is currently exposed to new layout plots and highway construction. This consequently brings an immense measure of stress to these heritage trees. KBB can play a pivotal role in ensuring survival of these heritage trees around the lake.

3.1.9. BWSSB and Clean Drinking Water Program

BWSSB is embarking on applying a new technology to clean polluted lakes of Bangalore to the drinking water standard mark. The board's plan is to supply water from selected lakes and tertiary treatment plants after treating it with Special Ultra Filtration Membrane. The Board has identified 80 lakes and they will be first cleaned up and rejuvenated by BBMP and BDA. The estimated project cost is INR 2,533 crore.

Figure 14: Solid waste scattered along Vrishabavathi river

4. RECOMMENDATIONS

4.1. PROTECTION OF WETLAND BIODIVERSITY

The lakes and reservoirs must be managed as part of a larger ecosystem rather than as independent units. Being closed systems, lakes take hundreds of years to flush out the contaminants and this problem is exacerbated by the fact that management of lakes, irrespective of their size, involve complex processes that are often seen as going contrary to the development or growth of a region attached to that water body system.

Universal goals in wetland management:

- Water resource planning throughout the watershed areas involving the participation of people at the community level.
- Improving the allocation of water resources with respect to irrigation and urban water delivery.
- Pollution prevention and abatement of pollution through controlling both point and non-point source pollution.
- Using policies combining regulations, economic instruments, public education and enforcement measures.
- Applied research and development of sustainable management techniques of lakes.

4.2. WETLAND MANAGEMENT PLAN FOR BMR

Six main components should be involved in the protection of wetlands in BMR:

- Institutions to manage the wetlands and basin resources for sustainable use. Institutions may be local councils aided by national or international organisations.
- Policies to govern the people's use of wetland resources and their impact. At the national level they can be encoded in formal laws, statutes and regulations and implemented by formal institutions. At the local level the policies are implemented through rules of behavior, incentives and education to change the people's behavior.
- Involvement of people is central to wetlands basin management. People can provide knowledge about lakes in their local surroundings and also help in enforcing the rules and accountability. Moreover, people can also be a source of financial support in the conservation and maintenance of wetland basins.
- Investment in better technologies, not cheaper technologies, as those pertaining to ecological engineering and sewage treatment is essential in providing solutions to some of the major problems affecting wetlands.
- Information on and harnessing of both scientific and traditional knowledge promotes efficient management of wetland basins and the surrounding areas.
- Financial support and financial resources in wetlands management is an important aspect in ensuring sustainable maintenance for protection of lakes.
- The flora and fauna of these wetlands needs to be documented in greater detail. This will help in drawing management plans while keeping in mind the species survival in these areas.

4.3. FORMULATING POLICY PROGRAMME IN BMR

- The resource conservation and management of environment needs a holistic approach involving strong cooperation of people in the participatory programs. They further stipulate that the residing community on the banks of wetlands is the stake holder of these resources. It is critical to note that the current efforts of wetland rejuvenation and management in Bangalore are slowed down by the fact that LDA does not have the absolute authority needed to command the sustainable management of wetlands especially in urban area because of the involvement of other new major actors such as BBMP, BDA, BWSSB and Minor Irrigation Department.
- While multi-stakeholder coordination and support is needed to strengthen the objectives of LDA, the current system of entrusting jurisdiction of lakes to various organisations is not helpful for many reasons. These include problems in organisation and dissemination of baseline data, policy implications, planning and implementation, different action plans used for different purposes. It is therefore necessary to come up with a Task Force Command that will bring together wetland restoration and

management focal units of various departments under direct coordination of the State Government.

- The Wetland Management Focal Units can then interact with NGOs involved in scientific, socio-economic and legal sectors of wetlands management. LDA here can still play a role as an empowered platform for those focal units of various departments. This is why the government needs to incorporate, reform and empower LDA instead of curbing its weak authority by diversifying focus towards what other departments can do in a short term under BOT (Build, Operate and Transfer) schemes
- The management programs should adopt economically sound measures that act as incentives for conservation and sustainable use of resources and components of biodiversity of these fragile habitats. But is there a policy specific to tackling the current issues of loss of urban wetland habitats and biodiversity? Is the Karnataka Water Resources Policy in conformity with wetlands management?
- Promoting scientific, technical and socio-economic co-operation with the stakeholders and implementing measures that avoid and minimise the adverse impacts on wetland biodiversity should be encouraged. But a uniform baseline data on environmental status and biodiversity of water bodies in the region is lacking. A lot of scientific literature and findings for Bangalore wetlands remains restricted within academic journals and concerned institutions. Although KSPCB periodically monitors wetland pollution and assess their environmental issues of concern, very little of this work is available in public domain and a published available data is often outdated by the time it reaches the public domain.
- Integrated management with a collaborative approach which brings together interested parties to incorporate social, cultural, environmental and economic values needs to be looked into. NGOs of various sectors of wetlands protection and management need to be included in collecting, documenting and disseminating up-to-date data on water quality and biodiversity of wetlands.
- Socio-economic assessment for conservation, social, cultural and economic activities is an essential component in the development of integrated management plans. Socio-ecological and economic valuation of wetlands biodiversity should also be carried out and this should mainly involve Karnataka Biodiversity Board along with various other stakeholders in the region.
- Use of wetlands for purposes of environment education needs to be given due importance. Only this will prevent/curtail abuse of wetlands in the long run. Suitable agencies should be identified to handle wetland related environment education.
- Enlisting support of local communities for the conservation of wetlands needs to be considered. Their role as watchdogs can help mitigate or stem problems when it is not too late.

4.4. MITIGATION OPTIONS FOR WETLANDS IN BMR

4.1.1. Sewage pollution

Implementation level	Management and policy level	Stakeholders
▪ Application of bioremediation and phyto-remediation technologies in polluted lakes by constructing engineered wetlands. e.g. Agara. Madiwala, Hebbal Lakes ▪ Diversion of inlets carrying raw sewage into water bodies sometimes chokes up lakes as these were natural drains earlier. Instead, sewage can first be treated in a sewage treatment plant before entering engineered wetlands, e.g. Madiwala, Hebbal, ▪ Creation of buffer points in diluting sewage before it enters wetlands, but this often cannot guarantee the improvement of water quality as seen in Venganaiah-	▪ Imparting environmental education for increased awareness on dangers of sewage contamination ▪ Improve primary health care centers and veterinary clinics in the vicinity of wetlands. ▪ Improving hygiene in fish mooring sites e. g., in Yellamallappa Chetty Lake ▪ Adopting a system of on-site STPs treating sewage in planned layouts as a condition in construction of gated community apartments and high rise buildings. ▪ Implementation of proper civic/land use planning is critical if BMR is to address all issues of environmental concerns exacerbated by physical expansion, encroachment and sewage pollution. ▪ Improving sewage lines infrastructure is a funda-	BWSSB; LDA; BBMP; BDA; KSPCB; CPCB ; BMRA; EMPRI; Dept.of Ecology and Environment; Forest Dept.; Dept. of Infrastructure Development; Dept. of Health and Family Welfare (South zone); *Zilla Panchayats*, Bangalore University, Indian Institute of Science; NGOs

kere Lake. Building sewage ponds for long time aeration/oxidation before allowing it to enter wetlands is feasible, only if there was enough space.

- Building on-site STPs to treat municipal, industrial and hospital effluents before allowing entering public sewers is essential in arresting contamination of water bodies, nalas and ground water aquifers.
- Mainstreaming latest technologies such as Membrane Filtration Techniques e.g. at Cubborn Park.

mental factor in proper management of sewage flows. This can be complemented with a generation of GIS database.

- Tracking and penalising defaulters under polluter-pays principle is critical for enforcement. In this context, Fast Track Green Benches and Lok Adalats can be used to prosecute cases of environmental pollution e.g. in the case against Bangalore hospitals being issued with closure notice by KSPCB under High Court of Karnataka orders

4.1.2. Encroachment

Implementation level	Management and policy level	Stakeholders
▪ Generating a GIS and Remote Sensing database of the encroached land to document the total catchment area of all wetlands in BMR. This should involve lands that have been wrongly allocated by authorities for construction and other development activities. ▪ Immediate demarcation for a universal buffer zone following the example of the Coastal Zone Management Rules is required. Until now, no legislated rules on what constitutes a buffer zone from the shoreline up to the margins of anthropogenic activities have been enforced. ▪ Installment of a wire/chain link fence around wetland catchments was started soon after the Rao's Report but was never completed. However, lakes which were fenced were breached e.g Kagadaspura lake, Halarakunte, Hosakere, Kannahalli, Rachenahalli lakes. The first priority is to recognise the borders and isolate them from further anthropogenic activities. This is done currently in Karihobanahalli lake. More needs to be done to rescue many other water bodies surrounded by human interferences. ▪ Reforestation and transplanting of floral species in buffer zones is one vital step in ensuring that buffer zones are not breached. Agara lake is a good example of successful reforestation program on buffer zones. However, challenges of breached afforested buffer zones can be seen in Rachenahalli, Jakkur, Sompura and Kothanur lakes, to name a few.	▪ Imparting environmental education for increased awareness on the dangers of encroachment can be taken alongside legal measures against all those found breaching the buffer zones. For example, in case of Kothanur and Kagaddaspura lakes, residents of apartments illegally built on the immediate banks of these lakes acknowledge the consequences of the tank breaches and the pollution effects they have caused on their own settlements. ▪ A program of public-private partnership here is critical where citizens can be made to play a role of compensating the effects of their own pollution outputs and land encroachment. There are signs of community interest in saving lakes around their settlements by forming societies for conservation of lakes in their own surroundings. These societies need to be registered and mainstreamed into larger part of protection and conservation of wetlands in Bangalore. ▪ Generating a database on economic valuation of wetlands is imperative in arguing for cost-benefit analysis of ecological conservation v/s economic pressures of development. Center for Ecological Sciences has already initiated studies on ecological evaluation of wetlands under BBMP jurisdiction. These studies need to be disseminated into public domain. ▪ Protecting disappearing croplands such as in Bellandur and Vartur lakes is alarming and action must be taken against encroachers as this is dilapidating whatever is left of buffer zones of these lakes. ▪ Immediate closure of dumps and removal of solid waste from the banks of wetlands e.g. Halarakunte, Bellandur is necessary.	BWSSB; LDA; BBMP; BDA; KSPCB; CPCB; KSRSAC, BMRA; EMPRI; Forest Department; Dept. of Ecology and Environment; Dept. of Housing; Directorate of Municipal Administration; *Zilla Panchayats*, Bangalore University, Indian Institute of Science; NGOs

4.1.3. Quarrying in wetland zones

Implementation level	Management and policy level	Stakeholders
▪ Immediate prevention of open cast quarrying sites within wetlands must be enforced. E.g., in Venkatespura lake the quarry effect have cast open the water table in that part of Hebbal valley. Worse, waste construction materials and burrowed rocks are deliberately dumped into exposed water tables in this area. This is dangerous and can affect human health risk caused by ground water contamination ▪ Environmental reclamation and rehabilitation of lands after closure is necessary. But this should be done in a manner that doesn't allow a replacement of quarry activities with other economic sectors such as encroaching the abandoned lands for residential and other industrial purposes as seen in Abigere and Hulimavu lakes. ▪ Proper solid waste disposal methods and proper disposal of fossil fuels used in quarry must be accounted. The practice of transferring quarry waste from one zone and dump them on other wetlands areas must be stopped. This can be seen mostly in the wetlands of the north and north-east areas of Bangalore. ▪ Performing an EIA process on a potential quarry site must be enforced. EIA rules are already streamlined but the focus should also be on how to protect wetlands.	▪ Controlling issues of resettlement, livelihoods, labor, displacement and benefit sharing is an important aspect of social impact assessment of quarry mining as part of the process of controlling this activity in degraded wetlands such as Hulimavu and Venkatespura. ▪ Checking environmental permits and involves public participation in quarry permits is another aspect. Mineral Conservation and Development Rules (1988), National Mineral Policy (1993), Karnataka Minor Minerals Concession Rules (1994), Granite Conservation and Development Rules (1999), Karnataka Mineral Policy, are tools which can be applied in checking random destruction of our wetlands. Immediate action should be taken to save Abigere lake which has become a dry lake bed with few water holes. Quarrying has destroyed the upper catchment and with this, other lakes depending on the same catchment such as Kamagodanahalli is threatened. ▪ Controlling movement of quarry waste disposal in wetland zones for the purpose of land reclamation as found in Halarakunte, Rachenahalli, Hulimavu, Hosakere, must be tackled seriously. ▪ Constructing check bunds and settling tanks to prevent siltation of lakes from quarry run-offs is an essential step in conservation of wetlands.	Mines and Geology; Labour Dept.; Dept. of Industries and Commerce, BWSSB, LDA; BBMP; BDA; KSPCB; CPCB ; BMRA; EMPRI; KSRSAC, Forest Dept.; Dept. of Ecology and Environment; *Zilla Panchayats*; Dept. of Minor Irrigations, Bangalore University, Indian Institute of Science; NGOs

4.1.4. Sand mining

Implementation level	Management and policy level	Stakeholders
▪ Prevention of sand mining activities and immediate protection of several affected lakes such as Bimakkuppe, Kanchanapura, Ullal, Chikkabanavara, Abigere, Bagalkunte, Jakkur, etc ▪ Establishing chain linked fence around the wetlands and especially on those severely affected by sand mining should be given top priority. ▪ Application of ecological engineering of such degraded wetlands can be prioritised to save the watershed drainage and restore the lake's ability to retain its normal water retention capacity. ▪ Monitoring and evaluation of the impact of restoration activities ensure the topography of wetland is undamaged.	▪ Assessment/Rapid Participatory Assessment on ecological economics of sand mining to establish and disseminate data on demand/supply/impact. Inadequate data has been produced at academic level to highlight illegal sand mining activities in Bangalore wetlands. ▪ Identification of the affected wetlands for restoration should be made a priority and issuing of tough penalties on illegal sand miners should be carried out. ▪ Reviewing the rules and regulations governing sand mining industry in the region is a necessity ▪ Environmental education and awareness on impacts of sand mining on wetlands.	LDA; BBMP; BDA; KSPCB; CPCB ; BMRA; EMPRI; Forest Dept.; Dept. of Ecology and Environment; *Zilla Panchayats*, Dept. of Mines and Geology; Labour Dept.; Dept. of Industries and Commerce, Bangalore University, Indian Institute of Science; NGOs

4.1.5. Unsustainable aquaculture in wetlands

Implementation level	Management and policy level	Stakeholders
▪ Controlling exploitation of wetland resources caused by overfishing and unsustainable fishing methods. This can be done by engaging local fisheries societies e.g. at Yellamallappa Chetty lake, Ibblur, Hulimavu, Hosakere, Malathalli. Restoration of fishing society in restored lakes such as in Hebbal and Venganaiahkere lakes under equity rights should be considered. ▪ Controlling introduction of exotic species which has decimated local diversity must be reviewed by society for Advancement of Aquaculture	▪ Conflict resolution programs to harness the co-existence between different users of wetland resources should be enhanced. Restoration of lakes has currently sidelined the issue of fishermen depending on those wetlands for their livelihoods. ▪ Conducting Social Impact Assessment/ Rapid Participatory Assessment on ecological economics of fishery for Bangalore wetlands is important as little data is available specific for Bangalore. This can be done with assessment of diversity of fish species in these wetlands.	Dept. of Inland Fisheries; Society for Advancement of Aquaculture LDA; BBMP; BDA; KSPCB; CPCB; BMRDA; EMPRI; Forest Dept.; Dept. of Ecology and Environment; Dept. of Industries and Commerce; Dept. of Health, Dept. of Agriculture

4.1.6. Deforestation of wetland forest areas

Implementation level	Management and policy level	Stakeholders
▪ Controlling exploitation of wetland flora is essential in maintaining ecological buffer between wetlands and surrounding areas under growth and development. Forest department has planted varieties of floral species on the banks and catchments but in the course of time the vegetation had gradually disappeared. Acacia sp, Ficus sp, Tamarindus indica, Mangifera indica, Phoenix sylvestris, Aegle marmelos, Artocarpus sp, Ferruginia sp, Eucalyptus sp, Bambusa sp, are rapidly disappearing from fringes of Bangalore wetlands. For example, in Ullal and Venkateshpura lake only a couple of Acacia trees and in a few patches on the banks of Jakkur and Rachenahalli are found. Bamboos can now be documented from a few lakes such as Narasipura, Malathalli and Madiwala. Very few lakes such as Sompura, Konasandra, can the healthy forest system be found along the wetlands. Such species need to be re-introduced along with Pongamia pinnata, Casuarina equisetifolia are important in arresting soil erosion. ▪ Existing tree species on the bunds and peripheries of the lakes that are to be restored (BBMP and BDA lakes) especially in Jakkur, Rachenahalli, Kothanur, Konasandra, Somapura, Malathalli, must be protected from being cut. Another example is the remaining phoenix trees on the leeward side of Ullal lake, Kagaddaspura.	▪ Environmental education and create awareness to local people on conservation of floral diversity on the banks and inside wetlands. There is little understanding that aquatic macrophytes such as Ipomoea and Cyperus play a very critical role in sustaining fish breeding and bird's nests as well as providing habitat for frogs, snakes; hence, a complex food web inside the lake. ▪ It is vital to launch helpful programs in introducing social forestry in the buffer zones which can play a role in harvest of minor forest products. ▪ Introduction of PBR programs in documenting floral diversity in Bangalore wetlands should be introduced. ▪ Remaining plantations of coconut, mangoes and areca orchards must be protected from any disturbance. These orchards can currently be seen on the disappearing fringes of Rachenahalli, lake, in Vartur, Malathalli, Bellandur, Kannahalli, Karihobanahalli, Konnasandra, Hosakere, etc. ▪ To conduct an ecological valuation of forest resources in and around wetlands and evaluate the significance of wetland flora already studied. ▪ Demarcation, protection and zoning of forest areas in the wetland catchment is important. Thalagatapura, Ullal, Hulimavu, Venkatespura, Yellamallappa lakes have almost lost most of their tree flora. Aquatic macrophytes such as Eichornia, Polygonum, amarantus, must be controlled from completely infesting lakes, including those restored earlier such as Hebbal, Agara and Hosakere.	LDA; BBMP; BDA; KSPCB; CPCB ; BMRA; EMPRI; Forest Dept.; Dept. of Ecology and Environment; Dept. of Industries and Commerce; Dept. of Agriculture; Dept of Horticulture; Dept of Sericulture. Bangalore University, University of Agricultural Sciences, Center for Ecological Sciences

4.1.7. Unsustainable ground water mining in wetlands

Implementation level	Management and policy level	Stakeholders
▪ Documentation of all mechanised bore-wells illegally installed inside lake dry beds such as found in Bagalkunte, Puttenahalli and Abigere Lakes. In Byramangala Lake, mechanised water pumps have been immersed and buoyed with a distant powered suction source to extract water. These illegal actions must be investigated and reported to concerned authorities. This will help in determining the number of unauthorised and illegal bore-wells inside the lakes. ▪ Introducing the licensing system on mechanised bore well pumps should be enforced and water withdrawals from such fragile sources should be monitored and levied. ▪ All existing industries especially those near the water bodies must be monitored and inspected for unauthorised water withdrawal units.	▪ Implementation of existing laws which require new layouts to adopt the rain water harvesting architecture should be strictly enforced. ▪ All water resource & development policies should be reviewed with a focus on the survival of wetland systems against the increasing demand for water supply in the regions. ▪ Non-governmental organisations involved in wetlands conservation must be involved alongside the local communities in addressing the issues of protection of their own water resources against rising commercial and industrial demand for water. It is critical to note here that despite water mining, pollution of groundwater sources in many lakes such as Hebbal, Vartur, Bellandur, wetlands of Bomanahalli, have been documented. This poses a rising danger and community involvement needs an impetus here.	BWSSB; LDA; BBMP; BDA; KSPCB; CPCB ; BMRA; EMPRI; Forest Dept.; Dept. of Ecology and Environment; Dept. of Industries and Commerce; Dept. of Agriculture; Dept. of Mines and Geology; Irrigation Dept; NGOs, community based wetland conservation societies in different parts of Bangalore.

4.1.8. Unsustainable agriculture in wetland zones

Implementation level	Management and policy level	Stakeholders
▪ Protecting all the catchments from the rising demand on horticultural and floricultural products should be a priority. For example, areas in the western side of Bangalore with wetlands located around Kengeri Tavarekere and northern areas around Hesarghatta; in the south around Anekal Taluk, Vartur, Jakkur. ▪ Application of pesticides and fertilisers, diversion of wetland channels, unauthorised ground water extraction, must be controlled	▪ Environmental education and awareness on sustainable agriculture and water conservation especially in the surrounding villages shifting towards horticulture and floriculture crops should be prioritised. ▪ Documentation of horticulture and floriculture zones within catchments should be carried out along with the types of crop species, pesticides, fertilisers and agro-chemicals used, number of people involved in farming activities, sources of water and methods of storage and disposal of agrochemicals and runoffs	LDA; BBMP; BDA; KSPCB; CPCB ; BMRA; EMPRI; KBB, Forest Dept.; Dept. of Ecology and Environment; Dept. of Agriculture Dept of Horticulture; Dept. of Sericulture; Bangalore University, University of Agricultural Sciences, Center for Ecological Sciences.

4.1.9. Unsustainable irrigation

Implementation level	Management and policy level	Stakeholders
▪ Prevention of unauthorised diversion of feeder channels which could cause the reduced normal surface water level of wetland. For example, Jakkur, Vartur, Byramangala. ▪ Restoration of sluice gates that can control and regulate the normal flow of water in the outlet channels.	▪ Reviewing policies on major and minor irrigation projects with focus on wetland conservation and restoration ▪ Coordination between Department of Minor Irrigation and LDA is needed in taking up baseline studies on the trends in use of water bodies for rising crop production demand and supply.	LDA, Dept. of Minor Irrigations, Forest Dept.; Dept. of Ecology and Environment; Dept. of Agriculture Dept. of Horticulture; Dept. of Sericulture

4.1.10. Over-grazing

Implementation level	Management and policy level	Stakeholders
▪ Control of all the catchments from over-grazing by increasing number of livestock population is essential. Shrubs form an integral part of wetland vegetation for both domestic and wild animals such as reptiles, birds and small mammals. When there is heavy concentration of domestic animals such as goats and sheeps the wetland can support its shrub vegetation. As a result, the wetland loses its capacity for regeneration as vegetation loses its sustainability. This can be seen on the banks of Thalagatapura, Kothanur, Kannahalli Venkatespura, where most of the wetland terrain is laid bare due to over-grazing.	▪ Prohibition of grazing on demarcated buffer zones of wetlands is critical in restoring floral abundance that can also support wildlife and biodiversity as well. ▪ It is also important to engage the people involved in livestock keeping in imparting awareness on the dangers of over-grazing not only for wetlands but also for the well-being of their livestock. For example, extensive pressure on disappearance of fodder on the wetland banks forces herdsmen to illegally draw their animals into engineered wetland vegetation of restored and protected lakes as seen in Hebbal, Agara and Madiwala. This breach of access is dangerous when animals feeding on contaminated fodder are used for human consumption.	LDA, BDA, BBMP, Dept. of Agriculture, Forest Dept.; Dept. of Ecology and Environment

4.1.11. Hostile restoration and recreational activities on wetlands

Implementation level	Management and policy level	Stakeholders
▪ Detailed Project Reports required to design the proposals on restoration of wetlands normally do not consider the biodiversity part of wetland restoration process. To most engineering aspects of lake restoration much attention is being given on the hydro-geological dynamics and designs and not on how biodiversity of that system is going to be protected or conserved during the entire process. In this case, a careful review of each DPR must reflect the biodiversity conservation goals. A DPR should not be accepted for a project implementation unless the biodiversity part is documented in detail, issues identified and mitigation measures for conservation are clearly marked. Hebbal, Sankey, Doddabomasandra, each of which represents an important case study on how ecological restoration of lakes can change the biodiversity composition and therefore bringing about the beneficial effects on natural ecosystem.	▪ Lake restoration is highly influenced by its objectives. Recreational activities often proposed for the case of lake restoration outweigh the issues of ecological stability of lake leading factually to a hostile restoration. Most restored lakes have been turned into recreational parks with water sports installed for some of them (Venganaiah Kere and Nagavara lake). This is done with an assumption that an ecologically engineered bird “island” will resolve the space required for avian wildlife and the entire lake de-weeded of aquatic vegetation. This is ethically incorrect as not all birds are ecologically adapted to dwell on ecologically engineered islands. Some birds are adapted to dwell within the aquatic vegetation such as in Cyperus, Ipomoea and other small aquatic weeds for nesting and food. It is imperative for authorities to study the potential of any lake to host recreational activities based on its size, locations, biodiversity value, so that even when some lakes are cleared for water sports activities the lake should have special zones open for public while others preserved for their respective micro-biospheres.	LDA; BBMP; BDA; KSPCB; CPCB; BMRA; EMPRI; Forest Dept.; Dept. of Ecology and Environment; Bangalore University, University of Agricultural Sciences, Center for Ecological Sciences

4.1.12. Brick making factories on wetlands

Implementation level	Management and policy level	Stakeholders
▪ Protection of all catchments and banning of brick making units from immediate catchments found in many lakes including Nagadevanahalli, Chikkabanavara, Hulimavu	▪ Prohibiting the brick making factories inside catchments and relocation of the existing brick making factories outside wetlands ▪ Performing clean-up operation on solid waste materials left on the banks	LDA, BDA, BBMP, Forest Dept.; Dept. of Ecology and Environment

4.5. PROPOSED ACTION PLAN

From the above account, the following needs to be assessed and implemented with utmost urgency:

1. Enhanced measures to carry out regular and periodic monitoring of the water quality of urban wetlands. This requires an establishment of a permanent research station dedicated to measuring the quality of water and environmental impact on the flora and fauna. Acquiring sophisticated field testing equipment is necessary for such monitoring.

2. A study to document the biodiversity of urban wetlands including identification and documentation of flora and fauna is necessary. A study on the quantitative and qualitative analyses of phyto-planktons and zooplanktons and current trends in their ecological dominance within the urban water body systems is necessary. This will provide useful information on the pollution status of water body systems and the bathymetrical pattern in relation to pollution load.

3. A few studies on the diversity of amphibian species in urban wetlands of Bangalore have been published focusing on the physiological effects of pollutants on amphibians and not on the status of their population in these urban water body systems. A special study is required on the population dynamics of amphibians of urban wetlands, their distribution, diversity and environmental impacts affecting population.

4. Studies on the environmental status of fishery in urban wetlands are critical for protection against human health risks factored in the consumption of contaminated fish from urban wetlands. It is therefore, imperative to establish an environmental link between the dwindling fish resources in terms of quantity and quality (size, diversity) and the rising pollution loads in urban lakes. This will require cooperation with inland fisheries department.

5. A detailed population diversity study on water snakes and other reptiles of wetlands needs to be carry out for keystone species. Further studies should be initiated on the status of water snakes with their terrestrial counterparts in relation to disappearing terrestrial habitats and the role of surviving urban wetland systems in providing shelter to displaced terrestrial snakes.

6. Remote sensing study to locate, register, monitor and identify the urban wetlands should be carried out. Moreover, remote sensing technique has helped the limnologists in determining the relief and drainage patterns with respect to urban/agricultural run-offs and unaccounted storm water/sewage flow; the extent of encroachment and land use activities of a catchment zone, water spread area, wetland size and status of vegetation on temporal and spatial basis. Remote sensing studies can also provide a picture on environmental impact of water bodies and disseminate critical information on the establishment of zoning policies and land use categories, apart from environmental management plans on waste-effluent disposal, establishment of standards, etc.

7. A policy on privatisation of wetlands under the name of restoration must be stopped and reviewed. The existing pattern of privatisation of wetlands does not reflect the importance of ecological preservation and maintenance of urban wetlands; Biodiversity of these wetlands is likely to be permanently damaged and irreversibly affected. A number of privatised wetlands have been ecologically disturbed, drained and sometimes depleted of their original ecosystem. Moreover, desiltation and dredging of lake beds destroys the benthic diversity, loss of natural aquatic flora and fauna, loss and change of quantity and quality of nutrients and even disrupts the hydrological balance between the surface water and ground water table causing reduction of surface water volume retention capacity.

8. Encroachment of lake zones and catchment peaks has affected the capacity of lakes to maintain their own environmental resistance. As a result, a number of lakes have disappeared or dried out exposing their lake beds which have been in turn converted into sand mining zones. Moreover, the cascading lake channels which form a network link between lake basins have been encroached with houses and sewage lines established inside the lakes and between the lake basins. Action must be taken as soon as possible to restore these cascading links by removing the physical structures that intervene in saving these hydrological chain-links.

9. As a result of road widening expansion in Bangalore city, a number of heritage trees have been identified for removal. Currently, a program is under way in formulating the conservation plan that will enable these heritage trees to be transplanted in protected wetlands basins and buffer zones around the lake. This artificial symbiotic program will help in saving the heritage trees of Bangalore facing the axe and at the same time restoring the canopy cover inside the protected buffer zones of Bangalore wetlands.

10. New residential and industrial layouts are being demarcated within the critical catchment zones. This demarcation has sometimes caused a physical alteration of surface terrains that direct the rain water run-offs into basins. As a result, the capacity of urban basins to harvest the monsoon rains into

their natural tanks has been extremely reduced. Tanks are now suffering from reduced water storage level. This has caused a gradual loss of urban tanks in replenishing their annual hydrological volume. There is an immediate need to suspend the demarcation of residential and industrial layouts within the critical catchment areas of lakes and tanks and review the loopholes existing in the rules and regulations.

11. A holistic study targeting the people living around water bodies including families and relatives of farmers, horticulturalists, fishermen, miners (especially on quarries and brick making factories) must be initiated in order to establish an information system that links up a socio-economic profile with environmental conservation and protection of biological resources within and around the urban water bodies. Various tools and methodologies can be utilised including the People's Biodiversity Register (PBR), Rapid Participatory Assessment (RPA), Semi-Structured Questionnaire Study, open meetings, etc.

12. The Forest Department, BBMP, BWSSB, BDA, KSPCB and other concerned bodies must play an equally pro active role alongside the LDA in pursuing a "hot policy" of protection of water bodies. Pro-active role is critical if the LDA truly succeed in implementing its lake management policies.

13. Educating the citizens, particularly college and school students, the importance of retaining and managing wetlands sustainably should be undertaken.

14. An independent audit of the status of wetlands in the BMR should be undertaken at least once in three years so that corrective measures could be suggested and implemented.

15. It is vital to safeguard the catchment area of each wetland/water body/tank by reforestation and removal of impediments.

16. It is advisable to post forest guards round the clock at important wetlands for monitoring the activities going on and prevent illegal activities in and around the wetlands.

Chapter 3

Water Supply and Sanitation

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TABLES

FIGURES

1. CURRENT STATUS

1.1. SIGNIFICANCE OF WATER AND SANITATION

Access to safe drinking water and adequate sanitation are immediate prerequisites for realising improved human health and welfare. For cities in developing countries around the world this constitutes a challenge so great that enabling access to safe drinking water for half of the world's population by 2015 has been declared a Millennium Development Goal (MDG) by the United Nations. The worldwide unsatisfactory state of water supply and sanitation in rapidly burgeoning urban areas calls for attention. In Asia, 98 million (7%) urban dwellers live without adequate access to safe water and 297 million (22%) without sanitation. For India these percentages are not very different. About 7% of the entire population do not have access to safe and sufficient drinking water and 28% lack improved sanitation services (World Bank, 2006). The last Census Report 2001, nevertheless, put the share of households without access to safe drinking water at 22%.

Inadequacy in the provision of water and sanitation contributes to or causes serious health problems, unemployment, poverty and environmental degradation. It directly affects the quality of life and productivity of people irrespective of differences in their standard of living. Worldwide the death of 2.2 million people per year, most of them children, is attributed to inaccessibility of safe drinking water, inadequate sanitation and poor hygiene (WHO and UNICEF, 2000).

The UN HABITAT Report 2003 defines as "reasonable access" 20 litres of water per person a day within 1 kilometre of the user's dwelling, either from a household connection, a public standpipe, a bore well, a protected dug well or a protected spring or rain water. In standpipes water should be available at least on alternate days for six hours per day. In Bangalore even meeting such basic needs poses a great challenge for urban local bodies.

1.2. NATURAL DRAINAGE AND WATERSHEDS

Bangalore is located at an altitude of about 921 meters above sea level and it falls in the water deficit zone. The topography of Bangalore is characterised by distinct valleys which radiate from a high ridge to well graded slopes of areas with a natural system of watershed and drainage. Arkavathi, Kanva and South Pennar are the main rivers. The river Cauvery flows in the southern boundary of Bangalore Rural district; Kumudvathi, Vrishabhavathi and Suvarnamukhi are semi-perennial streams in these districts. The drainage system of Bangalore Metropolitan Region (BMR) falls into two basins which form the drainage system of rivers viz., Cauvery, South Pennar and Palar; which are east flowing rivers to Bay of Bengal. The collective drainage pattern of Bangalore Urban district constitutes dendritic and parallel to sub parallel types formed by the number of streams.

All three districts of BMR fall in the water resource region of Bay of Bengal consisting of Cauvery and Krishna basins comprising of 631 and 1,697 watersheds respectively (Table 1 and Figure 1). Bangalore urban district has many lakes and tanks that have been built in the past across the natural valleys and seasonal streams for impounding the monsoon runoff to meet drinking water needs as no reliable and perennial sources of water supply from rivers exist. The river Vrishabhavathi was the only seasonal drinking water supply and lifeline of Bangalore. According to the Lakshman Rao Committee Report there were 278 lakes in and around Bangalore City covering an area of more than 40 ha (KSPCB, 2002) and they supported the water needs of the city partially. To meet the growing demand for drinking water Thippagondanahalli (TG Halli) reservoir was constructed across Arkavathi river in 1930, which has the catchment area of 1,453 square kilometres The natural system of watersheds was highly reliable in the past. However, unchecked encroachment and industrial pollution have destroyed the ecological balance of these watersheds. This inadequate and indifferent approach has compromised the valuable ecological benefits derived from these watersheds such as improving groundwater table and also meeting future water needs at low cost.

Table 1: Watersheds of BMR

Watershed types	Number of watersheds	
	Bangalore Urban	Bangalore Rural and Ramanagar
Watersheds	6	14
Sub-watersheds	51	146
Mini-watersheds	99	296
Micro-watersheds	475	1,241
Total	**631**	**1,697**

Source: KSRSAC, 2003

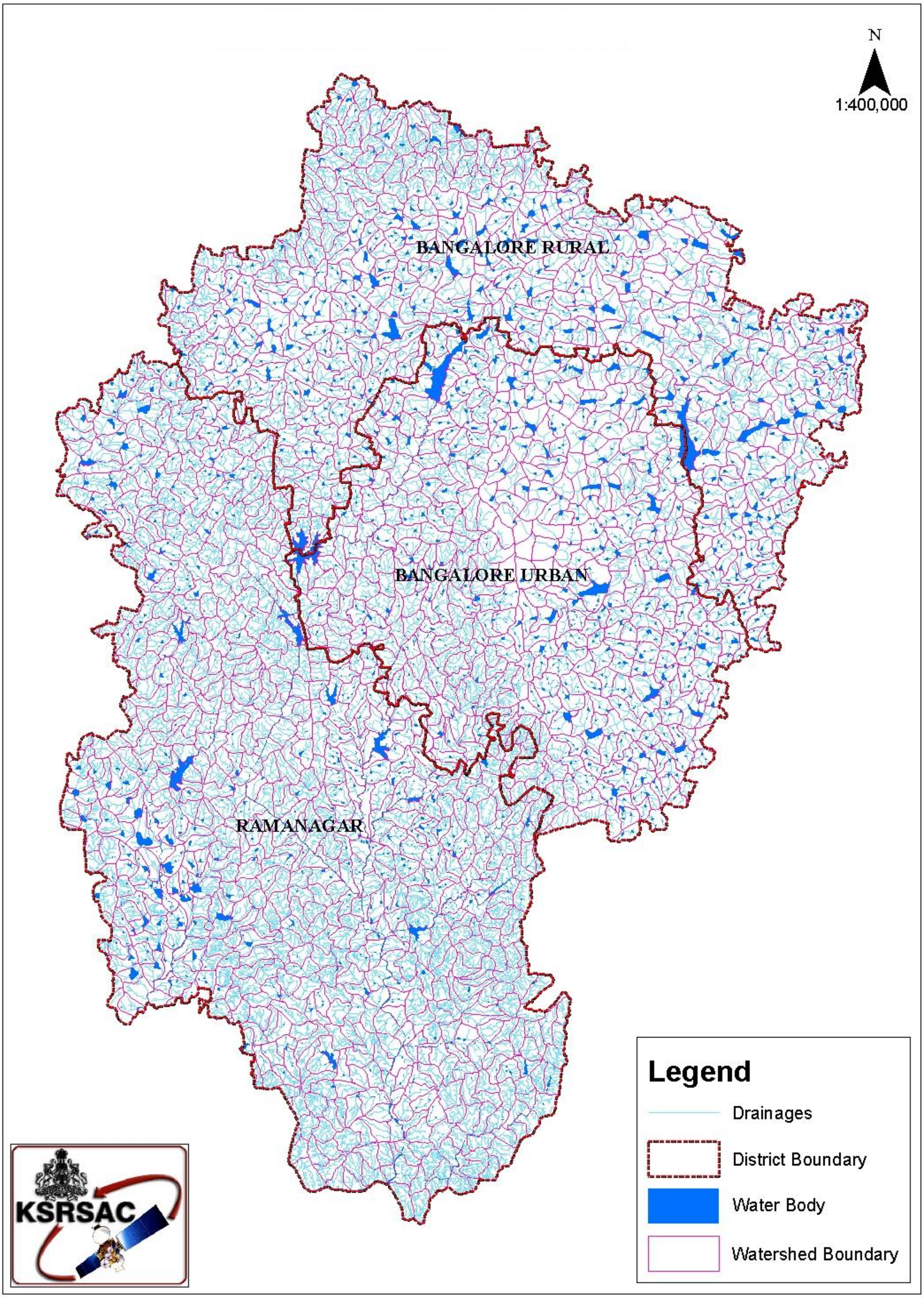

Figure 1: Watersheds and natural drainages

1.3. DRINKING WATER SOURCES

The major sources of drinking water for BMR are surface and groundwater.

1.3.1. Rainfall

Bangalore receives an average annual rainfall of 970 mm from southwest monsoon (June to September) and northeast monsoon (November to December) with nearly 70 rainy days spread over the year. The annual average rainfall received in 2004 and 2005 was 923 and 1,121 mm respectively, an amount twice the water requirement of Bangalore. This implies that rain water harvesting has tremendous potential. So far government efforts in this direction are not sufficient despite foreseeing an imminent water crisis in near future. This could lead to the continuation of present woes of piped water shortage and alarming depletion of groundwater table. The state of the water crisis in the city needs the Government of Karnataka to bring an immediate amendment to bye-laws with respect to existing, newly constructed and government buildings thereby making rainwater harvesting mandatory in order to minimise groundwater exploitation and also to reduce the dependence on piped water supply.

Table 2: Average rainfall (mm) in BMR

District	2001	2002	2003	2004	2005
Bangalore Urban	797	526	524	979	1,036
Bangalore Rural and Ramanagar	724	421	534	868	1,206
Total	760	437	529	923	1,121

1.3.2. Surface water

Bangalore receives surface water from two important rivers namely, Arkavathi and Cauvery. The treated water from both the sources is distributed by Bangalore Water Supply and Sewerage Board (BWSSB). The main sources of surface water of Arkavathi are TG Halli reservoir and Heseraghatta lake, both of which have defecit reserves. Other limited surface water sources are several lakes and ponds in and around the city.

As per the Cauvery Water Dispute Tribunal, the allotted share of drinking water for Bangalore City is 19 thousand million cubic feet (TMC) or 1,470 MLD. Of this 12 TMC (928 MLD) are already being utilised under the existing CWSS Stage I, II, III, and IV Phase I. Further, in order to meet the city's growing demand for drinking water BWSSB has taken up CWSS Stage IV Phase II in 2007 to increase water supply by an additional 7 TMC (542 MLD) by 2011-12 thereby exhausting the quota of 19 TMC allotted by the tribunal. Future reliance on Cauvery for drinking water supply is uncertain unless the Government of Karnataka makes a fresh application to the central government for additional allotment for meeting the growing demand of Bangalore. A reasonable allocation and distribution of water among southern states of India continues to stir the never-ending Cauvery water dispute. Therefore, future reliance on Cauvery water remains uncertain and further decision by the Cauvery Water Dispute Tribunal is not expected anytime soon. Drawing water from rivers such as Hemavathi and Netravathi involves high costs due to the long distance and also faces stiff confrontation from farmers of the command areas of these rivers.

The major sources and routes of surface water supply for Bangalore are given in Figure 2. BWSSB's inability to meet the current demand of piped water has forced many households, commercial establishments and industries to rely on groundwater as secondary or even primary source.

Table 3: Surface water sources of Bangalore

	Sources	Commis-sioned	Distance in km	Installed capacity in MLD	Availability in MLD
1.	Heseraghatta	1896	18	36	0
2.	Arkavathi (TG Halli)	1933	28	148	58
3.	Cauvery Stage I	1974	100	135	145
4.	Cauvery Stage II	1982	100	135	146
5.	Cauvery Stage III	1993	100	270	324
6.	Cauvery Stage IV Phase I	2002	100	270	250
7.	Cauvery Stage IV Phase II*	2011	100	(500)	(0)
	Total			**994**	**923**

** Under development since 2007, installed capacity as proposed* *Source: BWSSB*

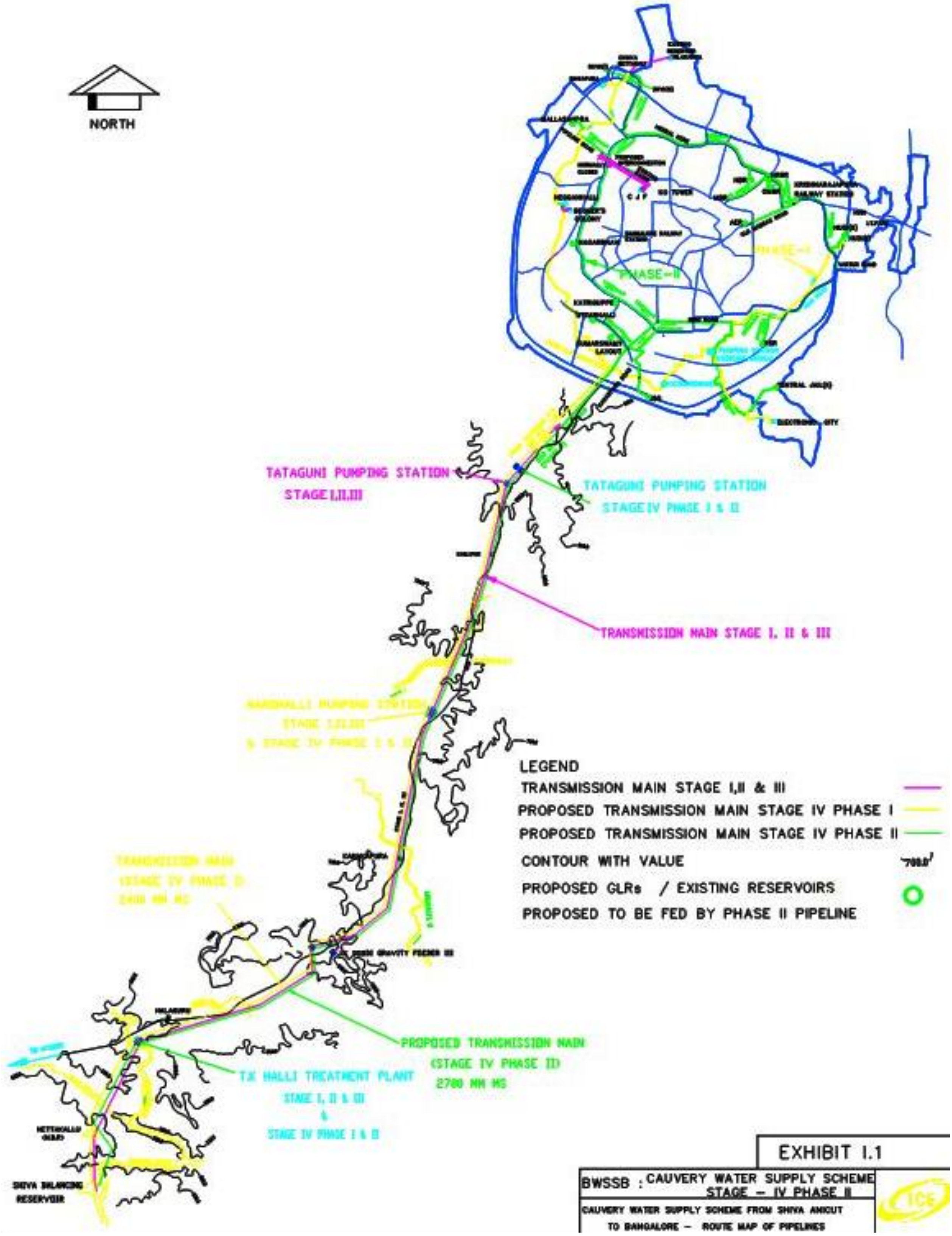

Figure 2: Sources and routes of Bangalore's surface water supply

1.3.3. Groundwater

BWSSB, apart from drawing 923 MLD of water from river sources, meets drinking water needs by extracting an estimated 282 MLD of groundwater from more than 7,000 public bore wells in Bangalore. Further, an estimated 120 MLD are drawn from an approximately 80,000 private bore wells in the city. BWSSB's bore well drawings amounting to 103,000 million litres per annum (MLA) accounted for 28% of the total drinking water supply in 2001-02 (Karnataka Development Report, 2007).

Table 4: Groundwater drawings

Sources	Estimated number	Drawings in MLD
BWSSB bore wells	7,000	282
Private bore wells	80,000	(estimated) 120

The Department of Mines and Geology (DMG), Government of Karnataka and Australian Agency for International Development (AusAID) state that about 40% of potable water requirement of Bangalore is met through extraction of groundwater (DMG, 2003 and AusAID, 2002). The high reliance on groundwater for drinking and irrigation is prevalent in all the City Municipal Councils (CMCs), Town Municipal Councils (TMCs) and rural settlements of BMR where water supply by BWSSB is not yet established. Only 7 CMCs and 3 TMCs receive both piped and groundwater but limited availability of piped water from BWSSB forces them to depend on 3,568 tube wells that supply about 57 MLD of water. Many households in these areas also depend on public and private tankers. According to an estimation by Bangalore Water Supply and Environmental Sanitation Masterplan Project (BWSESMP) 2002 of AusAID, the majority of households in Bruhat Bangalore Mahanagara Palike (BBMP) area depend on groundwater for other domestic requirements except for drinking and cooking. About 17% of the population representing lower income groups in slum areas completely rely on groundwater for both drinking and other domestic requirements. Further, people's dependence on groundwater is very high particularly in peripheral areas of BBMP where piped water is inadequate and also piped water networks are yet to be developed.

Groundwater prospects

Karnataka State Remote Sensing Applications Centre (KSRSAC) has assessed the groundwater prospects of BMR based on hydro geomorphic maps. The results show that Bangalore Rural and Ramanagar districts have moderate prospects for development and exploration, while it is poor for Bangalore Urban district. The absence of perennial surface water in these districts naturally imposes an additional burden on groundwater. A groundwater potential map using satellite imagery shows the unevenness of the groundwater table in BMR (refer to Figure 3).

Over-exploitation

Over-exploitation of groundwater beyond the rechargeable limit has resulted in emergence of increasing number of semi-critical, critical, over-exploited and over-developed watersheds (refer to Table 6). The groundwater extraction in Bangalore Urban district accounts for 567 MLD, nearly half of BMR's entire drawings estimated to be 1,216 MLD (649 MLD for commercial non-irrigation use and 567 MLD for irrigation). BMR's groundwater recharge from all sources however, is estimated to be only 221 MLD as against utilisation of 1,216 MLD. The recharge in BBMP area is approximately 195 MLD as against drawings of 282 MLD. In comparison, the recharge in BMR appears implausibly low as compared to the total recharge in the much smaller BBMP area. This inconsistency is intrinsic to the official data available and can, unfortunately, not be clarified. The report on Groundwater Resources of Karnataka, 2004 prepared by the Department of Mines and Geology also stresses that there is alarmingly increasing gap between groundwater exploitation and its recharge. Extraction greatly exceeds recharge in both BMR and BBMP areas. A discussion of the disastrous impact of over-exploitation onto wetlands is available at Chapter 2 "WETLANDS", section 2.

Table 5: Groundwater extraction and recharge

Area	Area in acres	Drawings		Recharge	
		MLA	MLD	MLA	MLD
Bangalore Urban district	528,559	207,000	567	*(no data)*	
Bangalore Rural district	574,520	*(no data)*		*(no data)*	
Ramanagar district	879,201	*(no data)*		*(no data)*	
BMR area	**1,982,280**	**444,000**	**1,216**	**81,100**	**221**
BBMP area	**197,684**	**103,000**	**282**	**71,000**	**195**

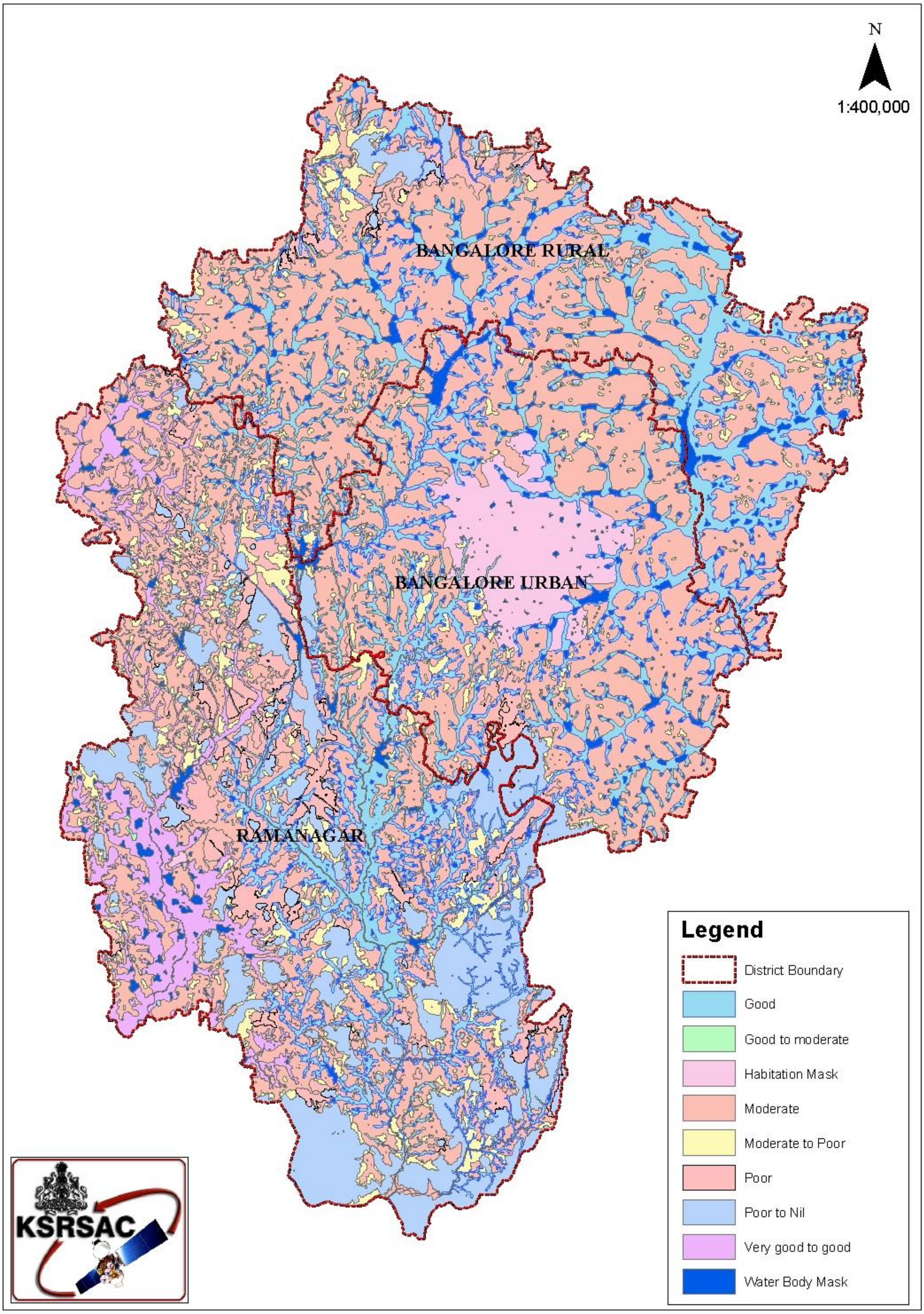

Figure 3: Groundwater potential of BMR

Table 6: Over-exploitation of groundwater

Taluk	Area in acres	Number of watersheds			
		Semi critical	Critical	Over-exploited	Over-developed
Bangalore Urban					
Anekal	130,472	99	1	91	191
Bangalore North	222,889	*(no data)*			
Bangalore South	175,198	83	58	5	146
Subtotal	***528,559***	***182***	***59***	***96***	***337***
Bangalore Rural					
Doddaballapura	112,927	24	0	0	24
Devanahalli	197,190	12	0	182	194
Hoskote	134,920	96	87	89	272
Nelamangala	129,483	64	0	0	64
Subtotal	***574,520***	***196***	***87***	***271***	***554***
Ramanagar					
Channapatna	134,672	0	5	0	5
Kanakapura	392,898	71	30	0	101
Magadi	197,190	0	68	0	68
Ramanagar	154,441	0	106	0	106
Subtotal	***879,201***	***71***	***209***	***0***	***280***
Total	**1,982,280**	**449**	**355**	**367**	**1,171**

Source: Department of Mines and Geology, 1999

1.4. WATER SUPPLY

1.4.1. Bangalore Urban district

BWSSB was established in 1964 for providing reliable water supply and sewerage services to Bangalore city as well as satellite towns developed by BBMP and Bangalore Development Authority (BDA). BWSSB has 1,306 km^2 of Bangalore Metropolitan Area under its jurisdiction for water supply and sewerage maintenance.

About 8% of households in the city are lacking access to safe drinking water and those who have access to piped water are facing inadequate quantity of water supply. Apart from surface water, households, commercial establishments and industries compensate the shortfall in piped water with groundwater. BWSSB is unable to meet the WHO water requirement standard of 150-200 litres per capita and day (LPCD) and standard of 150 LPCD prescribed by Central Public Health and Environmental Organization (CPEEHO), Government of India for metropolitan cities such as Bangalore. The quantity of drinking water supplied has declined from 145 LPCD in 1995 to 75 LPCD in 2007.

According to estimation of BWSSB, the drinking water requirement of the city is 1,219 MLD while only 870 MLD are being supplied. Bangalore is facing a shortfall of 349 MLD or 40% and the shortfall has been projected at 420 MLD by 2015 and 615 MLD by the year 2020 by BWSSB (refer to Table 7 and Figure 5).

Figure 4: The city's lifeline – Water tank at Basavangudi

BWSSB is trying to plug the gap by commissioning the Cauvery Water Supply Scheme Stage IV, Phase II in 2011-12. When completed, the project provides an additional 500 MLD of drinking water. Nevertheless, in view of the projected demand in 2020 additional sources need to be identified. The dependency on Cauvery river has grown with the increase in the number schemes of BWSSB.

Table 7: Annual water supply from different sources

Sources	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07
1. TG Halli	45,746	23,966	276	6,493	21,103	30,379
2. Hesaraghatta	1,597	1,623	702	0	0	0
Total from Arkavathi	***47,343***	***25,589***	***978***	***6,493***	***21,103***	***30,379***
1. CWSS I Stage	50,738	52,810	53,913	54,193	53,127	51,179
2. CWSS II Stage	51,031	52,218	54,190	54,360	53,468	88,920
3. CWSS III Stage	110,924	116,189	115,013	119,383	118,284	115,828
4. CWSS IV Stage Phase 1	-	28,070	83,586	87,504	90,946	100,403
Total from Cauvery	***212,693***	***249,287***	***306,702***	***315,440***	***315,825***	***356,330***
Total in MLA	260,036	274,877	307,680	321,933	336,928	386,708
Total in MLD	**712**	**753**	**843**	**882**	**923**	**1,059**

Source: Annual Performance Reports of BWSSB

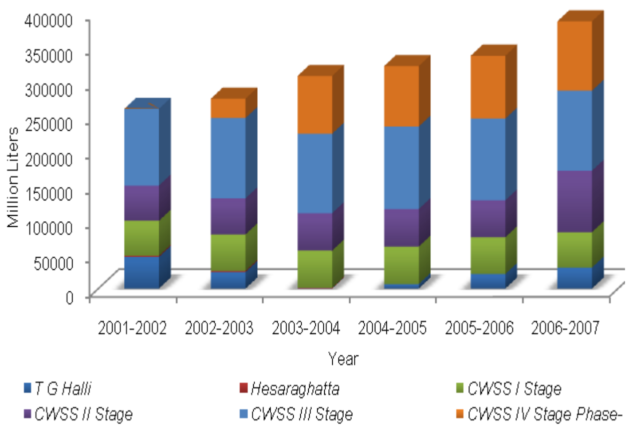

Figure 5: Annual water supply from different sources

Apart from fast depletion of surface water sources and limited availability of water from Cauvery, the present problem of water shortage is aggravated by an increasing loss of water due to leakages and reckless use. The unaccounted-for water (UFW) is the difference between the actual water produced minus water consumed and water in store. The UFW in Bangalore due to water leakages is about 48%, which is considered to be the fourth highest among urban water utilities in India. Out of total water supply to the city of 923 MLD, only about 417 MLD of water is actually billed. The share of UFW has increased from 16% in 1990-91 to 48% in 2006-07 and is evidently higher than the entire domestic consumption of 36% (refer to Table 8 and Figure 6). This clearly reflects the inefficiency of operation and maintenance of BWSSB's water supply networks.

A certain inefficiency in supply owes to the fact that Bangalore is located at a high elevation relative to the Cauvery river basin. Therefore, pumping of water from 100 km distance to an overhead of 540 meters to the water distribution system located at Bangalore after treatment obviously consumes more energy and involves high operational and maintenance costs. BWSSB incurs electricity costs amounting to about 65% of its revenue for pumping the water to the city, the distribution network and treatment of wastewater.

Bangalore Water Supply and Sewerage Board (BWSSB) at a glance

BWSSB is a statutory board established in 1964. It provides water supply and sewerage services for BMP and surrounding areas developed by BDA, serving 6.0 million people in 2001. The utility is responsible for water production, distribution and source development. It draws 94% of its surface water from Cauvery river and the rest from Arkavathi. The private sector is involved in the operation and maintenance of water treatment plants, pumping stations and wastewater treatment through service contracts. BWSSB follows a master development plan covering the period 2000 to 2025. The utility has a partly developed management information system.

BWSSB provides for 92.9% of the population in its area 74 LPCD of water at an average of 4-5 hours per day. It has the fourth highest unaccounted-for water (UFW) among 14 utilities. Nearly 96% of connections have functioning meters. The operating ratio of 0.8 is good but accounts receivable of 7.1 months is indicative of high outstandings. Though the average tariff of 20.55 INR/m^3 is the highest among the utilities compared, the high UFW ration keeps the revenues at a mere cost recovery. BWSSB needs to reduce its non-revenue water (NRW), improve on water availability and collection efforts. It could further improve metering of connections to better account. The average consumption per house connection is about 20,000 litres/month.

Source: www.bwssb.org and MoUD and ADB, 2007

The efficiency of the water supply infrastructure network, some part of which stems from the British regime, is constrained by a combination of inadequate operation, poor maintenance and financial limitations. The inefficiency of water infrastructure and poor operation and maintenance limits the distribution of water around the clock with sufficient pressure.

The quality of tap water supplied by BWSSB is a cause for concern. There are frequent water related health problems, particularly in extension areas of the city attributed to the consumption of polluted tap water. Residents of these areas frequently report the receipt of greyish water with foul odour. Poor water quality forces citizens to rely on tanker water and private bore wells and some people purchase bottled water. The major source of contamination is infiltration of sewage into fresh water. In many areas, wastewater from the pipe has percolated to the ground causing pollution of the groundwater table.

Table 8: Water consumption by user groups in Bangalore

Year	Consumption of water in MLA					Supply of water in MLD		
	Domestic connections	Industries, defence and railways	Public fountains	Lorry loads	Total	Gross supply	Net supply	UFW
1990-91	59,772	21,371	32,999	(no data)	114,143	375	312	62 (16%)
1991-92	54,790	20,203	33,433	(no data)	108,427	341	297	44 (13%)
1992-93	59,803	21,599	41,868	(no data)	123,272	406	337	68 (17%)
1993-94	65,109	20,299	46,894	168	132,471	467	362	104 (22%)
1994-95	65,607	20,619	54,051	135	140,413	549	384	164 (30%)
1995-96	71,334	19,517	55,062	193	146,106	566	400	166 (29%)
1996-97	70,325	19,704	54,911	192	145,133	551	397	153 (28%)
1997-98	70,815	18,656	54,912	942	145,307	574	398	176 (30%)
1998-99	76,863	19,714	54,912	906	152,396	614	418	196 (32%)
1999-00	81,504	20,956	55,062	228	157,751	651	433	218 (33%)
2000-01	90,825	21,136	54,912	200	167,074	678	458	220 (32%)
2001-02	92,763	20,905	54,912	230	168,810	712	462	250 (35%)
2002-03	99,830	21,796	54,912	199	176,737	753	484	269 (36%)
2003-04	105,237	26,306	55,062	329	186,934	843	512	331 (39%)
2004-05	113,464	28,788	54,912	624	197,788	882	542	340 (39%)
2005-06	123,044	34,110	27,455	280	184,898	923	506	417 (45%)
2006-07	124,445	21,262	54,912	280	200,899	1059	550	509 (48%)

Source: Annual Performance Reports of BWSSB

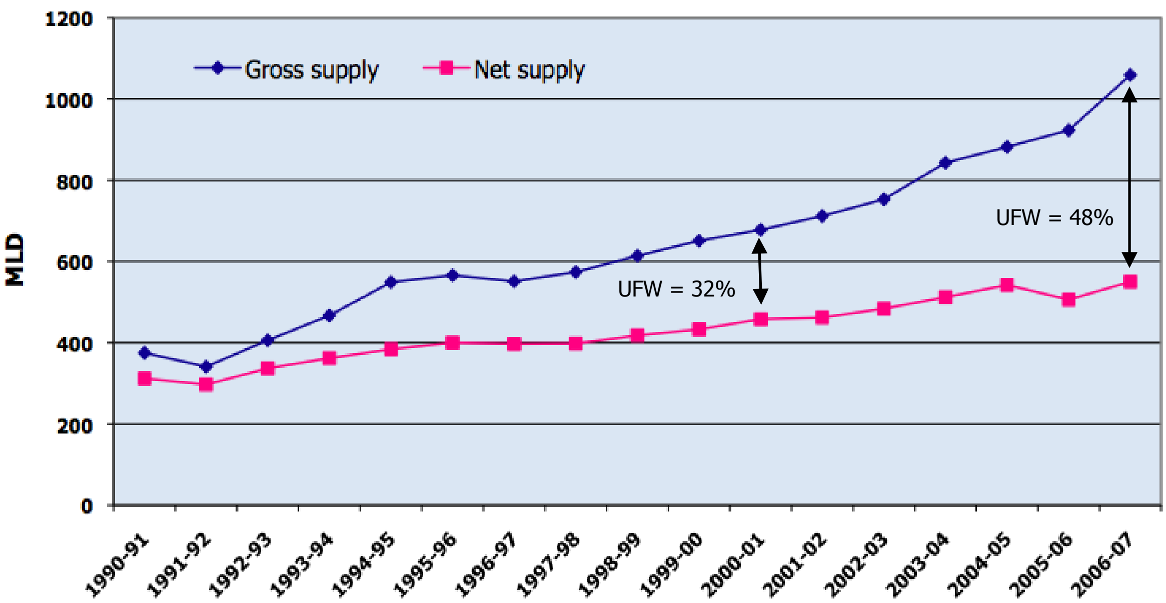

Figure 6: Trends of water supply and UFW in Bangalore City

1.4.2. Bangalore Rural and Ramanagar districts

Bangalore Rural and Ramanagar district are predominantly dependent on groundwater resources owing to non-availability of surface water. Anekal town from Bangalore Urban district and Devanahalli, Doddaballapura and Nelamangala towns of Bangalore Rural district are completely dependent on groundwater. However, Ramanagar, Channapatna and Kanakapura towns with their proximity to the main Cauvery water supply pipeline, are benefited from supply of backwash water and water from gravity main of BWSSB. Magadi town receives water from Manchanabele reservoir. Hoskote town depends on both bore wells and open wells. Those towns dependent on groundwater are experiencing water scarcity during the summer season and hardness of water due to over-extraction. About 68% of households have access to tap water; however, many households depend on hand pumps, tube wells and tanks. The per capita availability of drinking water in Bangalore Rural district is found to be less than the prescribed normative standards (refer to Table 9).

Table 9: Status and source of water supply

Taluk	Population (2001 census)	Source of water supply	Distance from the city in km	Supply (LPCD)
Ramanagar	79,365	Backwash water of BWSSB	35	100
Channapatna	63,561	Backwash water of BWSSB	20	65.5
Doddaballapura	71,509	Bore wells	-	45
Magadi	25,000	Manchanabele reservoir	17	80
Devanahalli	23,190	Bore wells	-	*(no data)*
Hoskote	36,333	Bore wells, open wells	-	*(no data)*
Kanakapura	47,047	Tapping BWSSB gravity main	10	70
Nelamangala	25,206	Bore wells	-	60

1.5. WATER UTILISATION

BWSSB divides Bangalore into six subdivisions. West and South Bangalore divisions have the highest number of domestic water connections as compared to other divisions. Non-domestic connections are the highest in Central Bangalore. Domestic connections account for 90% and non-domestic connections for 5% of the total number of connections of 529,118 as on February 2008 (refer to Table 10). Considering that there is an estimated 70,000 industries in BMR, the total of merely 99 industrial connections reflects heavy dependence on groundwater resources.

Table 10: Water connections in Bangalore City as of February 2008

Subdivisions	Domestic	Non-domestic	Industries	Others	Only sanitary	Total
Central Bangalore	40,240	7,790	2	1,844	952	50,828
East Bangalore	70,660	2,361	15	2,453	947	76,436
North Bangalore	77,843	3,467	3	3,094	1,287	85,694
South Bangalore	102,741	4,395	0	4,388	1,604	113,128
West Bangalore	127,346	4,582	60	5,203	2,062	139,253
South-East Bangalore	55,930	4,250	19	3,060	520	63,779
Total	**474,760**	**26,845**	**99**	**20,042**	**7,372**	**529,118**

Source: BWSSB, 2008

45% of water is unaccounted for (UFW), 37% is utilised by the domestic sector and 8% by public fountains (refer to Figure 7). The per capita availability of water is largely reduced by high prevalence of UFW. Through tankers BWSSB supplies water also to areas inaccessible to piped water. Piped water supply from BWSSB in conurbation area is not yet accessed by a majority of households who still depend on hand pumps, public fountains and mini water supply schemes.

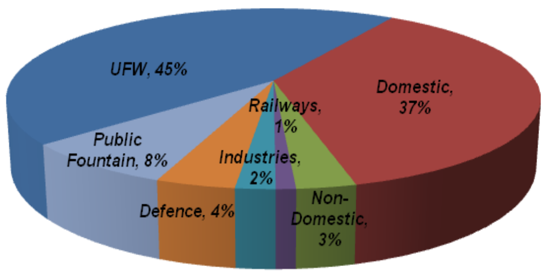

Figure 7: Sectoral utilisation in Bangalore 2005-06

1.6. WATER POLLUTION

The availability of surface and groundwater in the future is jeopardised not only by today's over-exploitation but also due to the increasing presence of pollutants in water bodies, a large share of which is contributed by the poor sewerage system in the city. Contamination of water bodies causes ill health, inflicts tremendous health costs and human suffering on account of water borne diseases. Diseases such as typhoid and cholera are highly prevalent in developing countries due to contamination of drinking water sources. An in-depth assessment of the effects of water pollution on human health can be found at Chapter 5 "HEALTH", section 3.3.

A 1995 study by World Bank shows that the total cost of environmental damage in India is estimated as USD 9.7 billion (INR 305 billion) annually or 4.5% of the gross domestic product. Of this, 59% of costs result from health impacts of water pollution. Therefore, Lee Jong-wook, Director General of WHO rightly remarks, "*Water and Sanitation is one of the primary drivers of public health.*"

Figure 8: Overflowing manhole contaminating wells in the neighbourhood, Shivaji Nagar

1.6.1. Surface water pollution

The contamination of water bodies has further restricted the availability of water for citizens of the city. The poor sewerage system, frequent blockages and rainwater stagnation have resulted in increasing pollution of surface and groundwater, which in turn caused waterborne diseases such as cholera, typhoid and viral hepatitis. About 1,812 cases of waterborne diseases were reported in 2007.

Figure 9: *Nala* lined with garbage, Mysore Road

Vrishabhavathi river, the erstwhile drinking water supply lifeline of the city, has virtually been turned into a sewerage that carries highly polluted domestic and industrial wastes. The surface water quality of selected localities of Bangalore is given in Table 11. According to a study carried out by Latha (2003) the surface water quality of Vrishabhavathi river at various sample spots is alarmingly poorer than desirable limits for a wide range of parameters. Further, lakes in and around the city including Vengaiahnakere, Benniganahalli, Kempambudi, Karithimmanahalli, Nyandahalli, Yediyur, Nagavara, Begur, Yellamallappa, Jakkur, Agaram and Bellandur lakes are highly contaminated with organic and inorganic pollutants. Increasing surface water contamination is mainly due to poor disposal of domestic sewage. Of the 1,000 MLD sewage generated in the city only 400 MLD or 40% of sewage is collected and treated by BWSSB and the remaining sewage is let out into storm water drains, which finds its way into lakes, tanks and the groundwater.

Table 11: Surface water quality in Vrishabhavathi river catchment areas

Parameter	Desirable limits	Peenya Industrial Area	Nandini Layout	Kamakshipalya Industrial Area	Rajajinagar Industrial Area	Mysore Road	Nagarabhavi 1st Stage
Ca mg/l	75	67	61	72	54	66	78
Mg mg/l	30	20	22	34	24	30	41
Na mg/l	--	130	549	162	161	140	154
K mg/l	--	17	13	20	19	26	23
Fe mg/l	0.3	1.4	3.00	0.68	1.2	1.95	0.38
HCO_3 mg/l	200	412	436	490	441	466	529
CO_3 mg/l	--	Nil	83	nil	Nil	Nil	Nil
Cl mg/l	250	140	372	148	123	115	140
NO_3 mg/l	45	11	43	25	30	26	23
SO_4 mg/l	200	10	383	64	47	62	74
TDS mg/l	500	630	1,780	800	750	730	830
SC µhmos/cm	--	1,100	2,900	1,390	1210	1250	1450
TH mg/l	300	248	240	316	232	284	360
pH	6.5-8.5	7.68	9.03	7.81	7.28	7.71	7.81
F mg/l	1.0	0.24	0.34	0.26	0.29	0.22	0.25

Legend In excess of desirable limits

Source: Latha, 2003

1.6.2. Groundwater pollution

Rapid industrialisation, urbanisation, the poor sewerage system and improper disposal of waste have caused heavy groundwater pollution, rendering it unfit for consumtption in several areas of the city. Over-exploitation of groundwater has also resulted in high concentrations of pollutants such as hardness, iron, pH, nitrate and total dissolved solids (TDS).

According to Department of Mines and Geology a study on the water quality of Bangalore Urban area in 2006 shows that 58% of groundwater is not potable due to contamination with nitrates, phosphates, iron and the high hardness values. The department analysed 15 parameters of 918 water samples collected from 735 different bore wells and the results were compared with drinking water specification of ISO 10500 of 1991. The presence of nitrates in excess of 45 mg per litre could potentially cause cancer and lead to methaemoglobinemia, also known as blue baby syndrome. Excess fluoride over 1.5 mg per litre may lead to fluorisis, which is a physically debilitating disease. For an in-depth discussion of the effect on human health refer to Chapter 5 "HEALTH", section 3.3.

About 77% of water samples tested were unfit for drinking. Groundwater is highly polluted in Vrishabhavathi river catchment area and values beyond desirabale limits were recorded at Peenya, Peenya Industrial Area, Nandini Layout, Kamakshipalya Industrial Area, Rajajinagar Industrial Area, Mysore Road, Nagarabhavi 1st Stage, Mahadevpura, Thimmpasandra, Vittasandra, Doddavangala, Bellandur village, Shampura, Bharathinagar and Geddlahalli. High nitrate concentrations were also found in Sulthanpalya, Cholanayakanahalli, Hebbal, Srirampura, Doddabanaswadi, Jayanagar 4th Block and Banashankari. Chapter 2 "WETLANDS", section 1.3.8 provides further insight into the groundwater quality of Vrishabhavathi river bed.

Figure 10: Oil leaking out of a transformer at Madivala tank bed

Table 12: Groundwater quality in Vrishabhavathi river catchment areas

Constituents	Desirable limits	Peenya Industrial Area	Nandini Layout	Kamakshipalya Industrial Area	Rajajinagar Industrial Area	Mysore Road	Nagarabhavi 1st Stage
Ca mg/l	75	173	51	83	94	122	134
Mg mg/l	30	49	36	33	24	45	43
Na mg/l	--	187	67	117	151	125	165
K mg/l	--	2	1	8	1	16	9
Fe mg/l	0.3	0.55	0.45	0.698	0.25	0.17	0.025
HCO_3 mg/	200	549	287	456	529	407	508
CO_3 mg/l	--	Nil	Nil	Nil	Nil	Nil	Nil
Cl mg/l	250	316	76	98	109	190	207
NO_3 mg/l	45	54	18	27	1	66	71
SO_4 mg/l	200	98	64	69	69	122	104
TDS mg/l	500	1190	490	700	750	920	1020
SC µhmos/cm	--	2080	840	1210	1320	1560	1740
TH mg/l	300	628	272	340	332	484	508
pH	6.5-8.5	7.03	7.83	7.46	7.78	7.44	7.08
F mg/l	1.0	0.24	0.37	0.22	0.37	0.28	0.29

Legend In excess of desirable limits

Source: Latha, 2003

Table 13: IS 10500 drinking water standard

Characteristics	Acceptable level	Cause for rejection	Characteristics	Acceptable level	Cause for rejection
1. Turbidity (NTU)	5	10	18. Residual Chlorine mg/l	0.2	>1.0
2. Colour (units on platinum coat scale)	5	25	19. Zinc (as Zn) mg/l	5.0	15.0
3. Taste and odour	Unobjectionable	Unobjectionable	20. Phenolic Compounds (as Phenol mg/l)	0.001	0.002
4. Potential of Hydrogen pH	7.0 - 8.5	< 6.5 to > 9.2	21. Anionic detergents mg/l (as MBAS)	0.2	1.0
5. Total Dissolved Solids mg/l	500	2,000	22. Mineral Oil mg/l	0.01	0.03
6. Total Hardness (as $CaCO_2$) mg/l	300	600	23. Arsenic (as As) mg/l	0.05	0.05
7. Chloride (as Cl) mg/l	250	1,000	24. Cadmium (as Cd) mg/l	0.01	0.01
8. Sulphate (as SO_4) mg/l	200	400	25. Chromium (as Cd) mg/l	0.05	0.05
9. Fluoride (as F) mg/l	1.0	1.5	26. Cyanide (as CN) mg/l	0.05	0.05
10. Nitrate (as NO_3) mg/l	45	45	27. Lead (as Pb) mg/l	0.05	0.05
11. Calcium (as Ca) mg/l	75	200	28. Selenium (as Se) mg/l	0.01	0.001
12. Magnesium (as MG) mg/l	$\leq$ 30	150	29. Mercury (total as Hg) mg/l	0.001	0.001
13. Iron (as Fe) mg/l	0.3	1.0	30. Polynuclear aromatic hydrocarbons (PAH) mg/l	-	-
14. Manganese (as Mn) mg/l	0.1	0.3	31. Pesticides total mg/l	Absent	0.001
15. Copper (as Cu) mg/l	0.05	1.5	32. Gross Alpha Activity (Bq/1)	-	0.1
16. Aluminium (as Al) mg/l	0.03	0.2	33. Gross Beta Activity (Bq/1)	-	1.0
17. Alkalinity mg/l	200	600			

1.7. SANITATION

Considering the inadequate access to sanitation, health for slum children is a mirage. According to a 2006 World Bank report, across India about 65% of urban authorised slums have only access to water through communal taps, 25% obtain access through wells and hand pumps and the rest from tankers. About 70% of Indian slums do not have access to sanitation. Poor sanitation facilities and open defecation are responsible for transmission of infectious diseases including cholera, typhoid, hepatitis, polio, cryptosporidiosis and ascariasis. WHO estimates of 2004 show that about 1.8 million people die annually from diarrheal diseases where 90% are children under five, mostly in developing countries.

Table 14: Inequality in of sanitation

Nature of inequality	Typical measure	Differentials
Infrastructure to remove toilet wastes (sewers)	Sewer connection	Many cities and most smaller urban centres in Africa and Asia have no sewers; in most cities in low-and middle -income nations that have sewers, large sections of populations are unconnected
Risk of faecal contamination of water supplies	Coliform count	Very large differentials between households in most urban centres; the risks are particularly high for households who have to store water or use unprotected sources. Piped systems with intermittent supplies often become contaminated
Time taken to access toilets	Distance to toilet time spent queuing	Households with their own toilets spend very little time waiting to use them; households that rely on public toilets often spend a significant amount of time each day queuing
Infrastructure to support drainage	House connected drainage system	Many urban districts with little or no provision for drains; many have drains that are ineffective because of poor maintenance and blockages from solid waste
Sewerage connection charges	Price per connection	High charges for new connections
Inclusion in solid waste collection	Extent to which settlement has regular collection household waste	Within many urban centres, large sections of the populations (typically those living in informal settlements) have no public service to remove household wastes, or the quality of service is inadequate. Where provision for sanitation is inadequate, household wastes often contain excreta; so a regular waste collection service helps disposal of these wastes safely
Citizen rights	Accountability of utility to citizen	Middle and upper income groups are likely to have more possibilities of holding water and sanitation providers to account than low-income groups

Source: UN HABITAT, 2003

According to Census of India 2001 Bangalore's greater metropolitan area has more than 733 slums. A survey conducted by Karnataka Slum Clearance Board (KSCB) in 1999 showed 361 officially recognised slums. A total of 102,000 houses were found in these, giving shelter to 591,000 slum dwellers. The survey findings also indicate that about 10% of the city's population live in slums. Further, various research studies on poverty of urban areas of Bangalore have estimated that the proportion of poor comprises about 30% of the total population of the city. Contrary to the KSCB survey, about a third of the urban poor lived in recognised slums and over 700,000 in mixed settlements of poor without having access to proper shelter, safe drinking water and hygienic sanitation. Apart from variations in water accessibility and reliability of water supply services across socio-economic groups and areas of the city, access to improved sanitation provision is universally poor and inadequate in many recognised and unrecognised slums.

For sanitation, improved provision means access to private or shared toilet connected to a public sewer or a septic tank or access to a private or shared pour-flush latrine, simple pit latrine or ventilated improved pit latrine (see Box below). The state of urban sanitation facilities such as under ground drainage (UGD) system, wastewater treatment plants, public toilets and latrines reflect the health of a city. The city receives migrants every day engaged mainly in the informal sector that is generally associated with economic and social deprivation. Acute poverty ultimately pushes many to lead their lives in slums. High user costs, long queues, dirtiness and non-availability of water in public toilets are mainly blamed for open defecation. The high cost of construction of toilets has enabled 96% of socio-economically higher categories to have toilets in their homes as compared to 32% of households in the lower income category.

Sanitation deficiency is largely prevalent in the conurbation and green belt of Bangalore. In conurbation areas, only 47% of households have toilets, 19% share toilets and a significant 35% defecate in the open. But the state of sanitation is worse in green belt areas where only 26% households have toilets while 4% share toilets and a staggering 70% defecate in the open. This shows that there is a high disparity in access to sanitation facilities across the core area and suburban and rural areas. The absence of a sewage network in conurbation areas, the green belt and rural areas is the main shortcoming. The state of public toilets is pitiable as their capacity is inadequate to meet the requirements of the people. Community or shared toilets are afflicted with lack of water, lights, taps and cleanliness, which fail to attract people defecating in public places.


Source: Adapted from Sudhira et al, 2007

Figure 11: A slum in Bangalore

Apart from poor infrastructure and service in paid toilets, the high expenditure incurred by slum dwellers towards usage charges is a deterrent. Studies have shown that slum dwellers reported to be incurring INR 54 per month towards the use of public toilets. Poor sanitation is also directly attributed to poor provision of water supply in slum areas of the city. Most of these areas experience large-scale deficiency in water supply resulting in poor state of sanitation. Poor provision of sewage and sanitation services in many unauthorised slums assists fast breeding of communicable diseases. Therefore, improved sanitation including housing, improved latrine with water for proper disposal of human excreta to prevent it from mixing with water bodies, proper sewerage system is an important prerequisite to ensure good health and hygienic environment. Provision of basic amenities by BWSSB and KSCB including housing, drinking water, sanitation (latrines, bathrooms, sewage, storm water drains) roads, streetlights, enables slum dwellers to live in a more hygienic environment. In unrecognised slums such provisions are unheard of even though no data is available to support this fact.

Provision of adequate sanitation is considered as a basic human right and universal need. Human development, poverty alleviation and primary healthcare of slum dwellers and economically weaker sections of the society largely depend on public provision of safe water and adequate sanitary measures for disposal of excreta. Studies have shown that adequate provision of safe drinking water and sanitation services followed by imparting education on hygiene can effectively reduce the mortality caused by diarrhoeal disease by an average of 65% and the related morbidity by 26%.

Karnataka Slum Clearance Board (KSCB)

For providing improved sanitation and housing facility for slum dwellers of the city, Government of Karnataka has passed Karnataka Slum Areas (Improvement and Clearance) Act 1973 and Karnataka Slum Clearance Board was created in 1975. The main objectives of the Board are:

- To study the socio-economic conditions of slum dwellers
- To identify and declare slum areas for their improvement,
- To make provision of environment improvement, clearance and their development,
- Enable the slum dwellers to live in hygienic conditions by providing basic amenities such as drinking water, street lights, roads, drains, community bathrooms, latrines and halls, storm water drain and community halls
- Provision of housing for slum dwellers

KSCB, according to its survey, has identified 473 slum areas and out of them, 218 slums have been legally declared in Bangalore city. The Government has launched slum areas development schemes to improve sanitation and other basic needs viz., Valmiki Ambedkar Malin Basti Awas Yojana (VAMBAY), National Slum Development Programme (NSDP), Asian Development Programme, Mega city Scheme (MCS), Nirmala Jyothi Scheme and Nirmal Bharath Abhiyan Yojana. Under Nirmal Bharath Abhiyan Yojana, the Government of India had sanctioned INR 11.16 crore for providing 279 community toilets to the slum dwellers. The Karnataka Slum Areas Act was amended through the Karnataka Slum Areas (Improvement and Clearance) Rules 2004 which provides broader strategy for slum development.

Future plans

- To provide Basic Services for the Urban Poor (BSUP) project under JNNURM covering 6 slums
- Proposal to construct 11,603 houses for slum dwellers in 30 slums in the first phase and 3,151 houses under second phase for 16 slums.
- Residents of these areas will get transit accommodation and employment during construction.

1.8. WASTEWATER MANAGEMENT

Bangalore is naturally advantaged with undulated terrain and slope, which has largely helped easy flow of wastewater in all the four directions of the city. The city has three principal valleys viz., Vrishabhavathi, Koramangala and Challaghatta flowing generally in southerly directions and five minor valleys. The sewer system was introduced in 1992 for domestic and industrial wastewater through an underground drainage (UGD) system. The city generates approximately 1,000 MLD wastewater accounting for 80% of its daily water consumption from both surface and groundwater sources. Wastewater treatment is carried out at various locations adjoining to main sewage systems. BWSSB treats presently about 721 MLD of wastewater and provides tertiary treatment to 70 MLD. Mmajor and minor sewers have a combined length of 243 km and cover an area of 229 km^2. Table 15 shows the existing major sewers and sewerage catchments in Bangalore city.

Table 15: Core area sewerage network in Bangalore

Sewers	*Area in km^2*	*Classification*
1. Hebbal	48	major
2. Challaghatta	36	major
3. Koramangala	37	major
4. Vrishabhavathi	38	major
5. Taverekere	19	minor
6. Kathariguppe	16	minor
7. Arkavathi	35	minor
Total	**229**	

Source: Annual Performance Report 2006-07, BWSSB

Table 16: 400 mm sewerage in Bangalore's core area

Zones	Total length	Existing inside SWD	Number of manholes
Hebbal	45 km	9 km	1,650
K and C	113 km	35 km	2,857
V Valley	85 km	18 km	1,746
Total	**243 km**	**62 km**	**6,253**

Source: Annual Performance Report 2006-07, BWSSB

In recent years BWSSB has given high priority to wastewater treatment as the city is struggling with growing scarcity of drinking water. It is estimated that the requirement of wastewater treatment plant per one lakh population is about 10MLD. BWSSB has 12 secondary sewage treatment plants in all directions of the city, treating about 40% of BMR's sewage. Sewerage networks are directly linked to plants for treatment up to secondary level. Secondary treated water is used for construction purposes, the golf course and similar purposes.

Figure 12: Treatment plant at Vrishabhavathi Valley

There are two tertiary treatment plants of a total capacity of 70 MLD. The treated water is reused for purposes other than drinking and is supplied to Bangalore International Airport, Bharath Electronics Limited, Wheel Factory and other industries. BDA has set up tertiary water treatment plants using different technologies. It has established 1.5 MLD capacity tertiary treatment plant at Lalbagh that uses an extended aeration process. Another tertiary treatment plant with a membrane bioreactor of 1.5 MLD was set up at Cubbon Park.

Presently 15% of water charge is levied as sanitary cess on monthly water bills. The growing demand for drinking water and scarcity of surface water has forced BWSSB into commencing implementation of wastewater recycling project for drinking purposes under JNNURM at a cost of INR 4.72 billion. Under this project wastewater from Vrishabhavathi valley will be put through tertiary treatment with ultra filtration and a membrane process, aiming to supply an additional 135 MLD of water by 2010.

Table 17: Wastewater treatment plants

Location	Treatment method	Capacity in MLD
Primary and secondary treatment		
1. Vrishabhavathi Valley	Trickling filter	180
2. Kempambudhi	Reclamation plant	1
3. Mailsandra	Extended aeration	75
4. Nagasandra		20
5. K and C Valley	CMA SP	218
6. K and C Valley	Extended aeration	30
7. Madivala	Reclamation plant	4
8. Kadabeesana-halli	Extended aeration	50
9. Hebbal Valley	ASP	60
10. Raja Canal	Extended aeration	40
11. Jakkur	UASB, extended aeration	10
12. KR Puram	UASB, extended aeration	20
Subtotal		**721***
Tertiary treatment		
1. Vrishabhavathi Valley		60
2. Yelahanka		10
3. Cubbon Park	Membrane bioreactor	1.5
4. Lalbagh	Extended aeration process	1.5
Subtotal		**73**

** According to BWSSB* *Source: Annual Performance Report 2006-07, BWSSB*

However, the sewerage infrastructure is inadequate to meet the growing requirement as the existing system consists of over 2,200 km of gravity sewers of 150 to 2,000 mm diameter, three major and two minor treatment plants and three sewage-pumping stations. Further enhancements of treatment and pumping capacity needs to be taken up to achieve at least 10% reuse of wastewater. The establishment of sewage treatment plants in the satellite towns Devanahalli, Doddaballapura, Hoskote, Kanakapura, Bidadi and Nelamangala needs to be planned. Reuse of wastewater can effectively mitigate the present demand for freshwater of 1,200 MLD. However, BWSSB finds that lack of funds for operation and maintenance of secondary and tertiary treatment plants, lack of skilled manpower, irregularities and breakdown of power supply, high operational cost have adversely affected the capacity of sewage treatment. Low cost wastewater treatment technologies could reduce the financial burden on the part of BWSSB and pave the way for increasing wastewater treatment. Placing of dual water supply system for reuse of wastewater along with fresh water in new layouts should be a long-term target. Decentralised wastewater treatment systems (DEWATS) with reduced operation and maintenance costs have a promising potential for hospitals, apartments, industries and even slums.

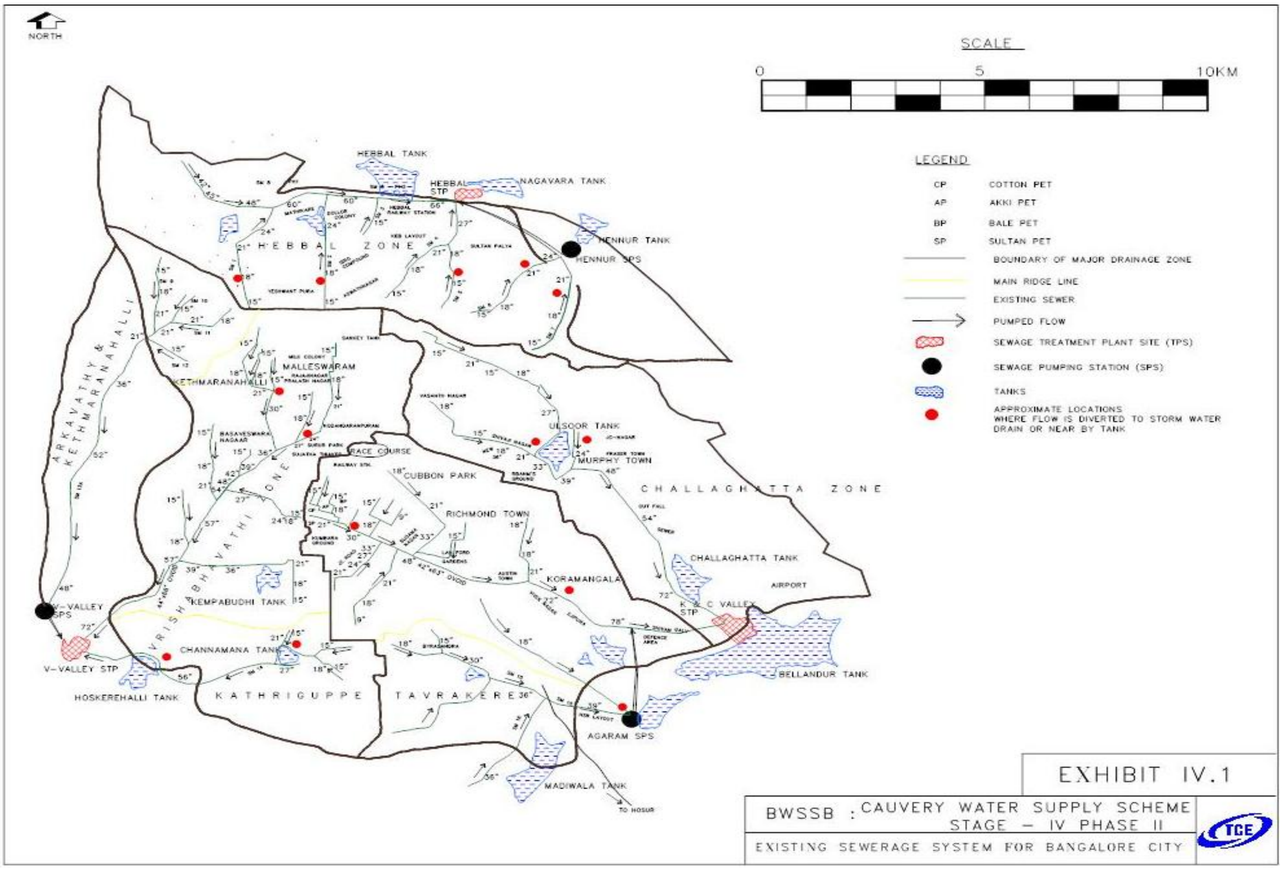

Figure 13: Existing sewers and sewerage catchments in Bangalore

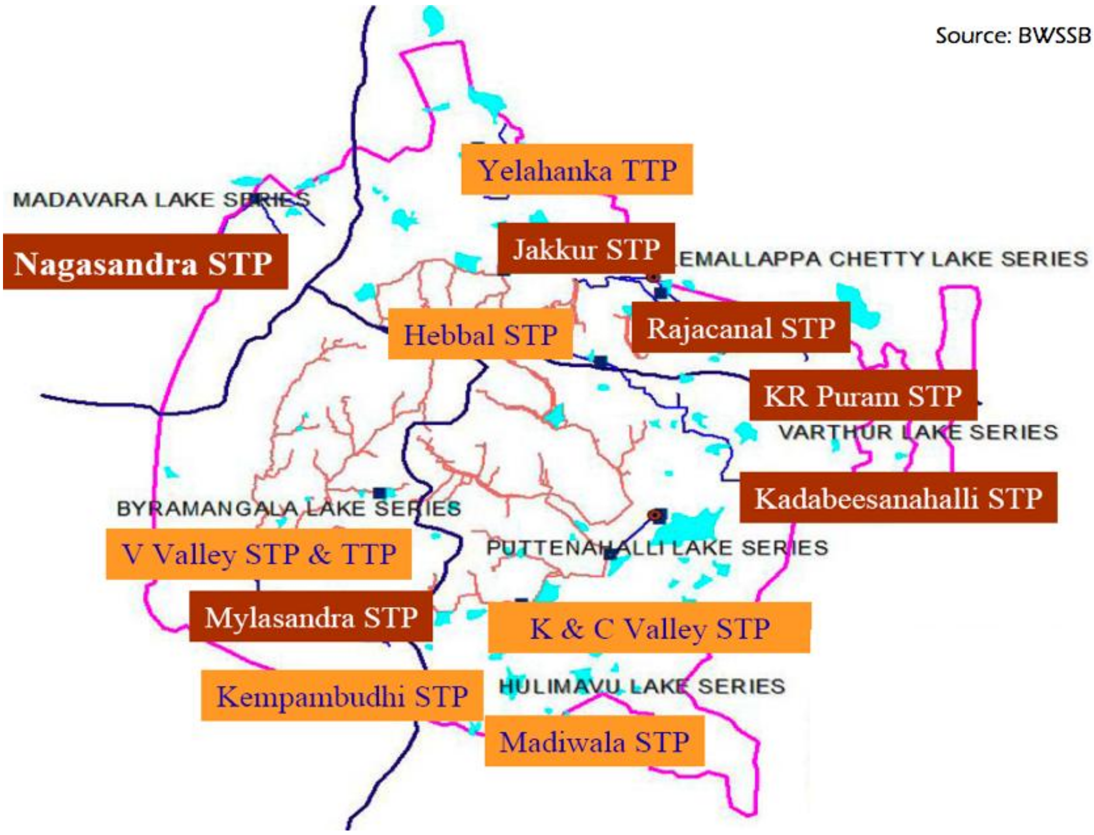

Figure 14: Existing sewage treatment plants

2. ISSUES

2.1. ACCESS TO WATER

Disparities in the provision of water among different parts of the city and socio-economic groups are an area of concern. Inequality of water access is in part caused by insufficient pressure in the distribution system. Mini water schemes supply drinking water to 21% of households in CMCs and TMCs. Water supply within the municipal corporation area is not equitable across different locations and different socio-economic categories. Some of the areas falling in the old Bangalore City Municipal Corporation receive more water per day as compared to extension areas. The provision of quality and quantity of water is highest for 60% of households that fall into the higher socio-economic category and declines for lower income sections. About 30-35% of the population in the city belongs to urban poor and about 17% live in slums, authorised or otherwise, with limited access to water supply. Consequently, slum residents rely heavily on public stand posts, bore wells, water vendors and BWSSB water tankers. A few organisations such as the Sri Satya Baba Trust also supply drinking water through tankers to slums. Pilferage or illegal tapping of water from public fountains is prevalent due to poor affordability and accessibility.

Uncertainties of tenure of land occupied by slum dwellers prevent applications for water connections, apart from the fact that many slums have not been given recognition. This has resulted in 12% of households not having connections. For 20% of households the connection cost of approximately INR 1,800 is considered unaffordable. About 30% of households do not have connections due to absence of water networks in several slums. Further, some of those who have connections, particularly poor slum dwellers, do not have storage strategies such as underground or overhead tanks made necessary by irregular supply. Access to alternative sources including groundwater, illegal connections and public fountains has dissuaded them from seeking connection to piped water.

Figure 15: Public tap sans tap in J. P. Nagar

71% of Bangaloreans have taps at home, indicating better access to water than offered in Chennai, Delhi or Kolkata. The share of citizens served by public taps or fountains is with 29% highest among the cities compared in Table 18.

Table 18: Comparison of water supply in major cities

City	Population with house taps in %	Population served by public taps in %	Water availability in hours per day	Unaccounted for water in %	Average tariff in INR/m^3
Bangalore	71.0	29.0	6	45	20.55
Chennai	68.0	26.4	4	20	10.37
Delhi	65.8	*(no data)*	3.5	26	1.42
Kolkata	24.1	20.3	10	50	0.46
Mumbai	99.9	0.1	5	18	2.43

Water availability, as indicated by the daily average supply, varies in Indian cities; 10 hours in Kolkata, 4 hours in Chennai, 3.5 hours in Delhi, 5 hours in Mumbai and 3-4 hours in Bangalore. This reflects both inequality and inadequacy, affecting particularly low-income groups and leading to several problems (refer to Table 19). The supply of a certain average quantity per capita and day, usually given in LPCD, does not consider the inequalities in coverage of different socio-economic classes or georgraphic areas. Supply varies from one area to another and is generally low for slums. Water quality monitoring is irreguar in many areas of the city. Even though residents have access to an assured quantity of water, access to reasonable quality is not ensured. Poor enforcement of metering curtails the fair availability of water to metered households. Further, access to piped water is declining every day with increasing population sharing the same quantity of water supplied by the BWSSB.

Table 19: Inequality in the provision of water supply

Nature of inequality	Indicator	Differentials
Volume of water availability	▪ Litres per person and day (LPCD)	Within most low and middle income nations there are very large differentials within cities where a section of the population lack access to piped water supplies
Quality of water	▪ Coli form count and many other measures	
Accessibility	▪ Time spent each day collecting water ▪ Distance from tap ▪ Number of persons per standpipe	From households with internal connections who spend no time getting water to households where one or more people have to spend one to three hours a day queuing, fetching and carrying water
Reliability	▪ Hours a day or week that water is available	Varies from 24 hours a day to one or two hours a day, or in some instances a few hours every few days; low income areas often get more water cuts than higher income areas
Cost per unit volume	▪ Price per cubic meter or per litre	Often high ratios (10-15:1) between the cost of water from vendors or kiosks and the cost of water from piped supplies to the home
Cost of connections to piped water supplies	▪ Price per connection	Connection charges are often too expensive for low-income households

Source: UN HABITAT Report, 2003

2.2. THE RISE OF UNACCOUNTED-FOR WATER

Unaccounted-for water (UFW) is the difference between the total water produced minus water consumed and water in store. The share of UFW has increased over the last years to a staggering 48% or 509 MLD. This is much higher than the 15-20% achieved in well-managed urban water utilities in major cities of the world. The percentage of UFW in Indian metropolitan cities is as follows: Kolkata 50%, Chennai 20%, Delhi 26% and Mumbai 18%. In hard numbers the UFW would be more than sufficient to meet the water demand of Bangalore and guarantee every citizen a 150 LPCD. Presently availability is just about 75 LPCD for domestic consumption against the official estimation of 120 LPCD. The difference of 45 LPCD water is attributed to leakages incurred by mains, service pipes and stand posts, accounting for almost 89% of all leakages of a pilot project (refer to Table 20).

The successful augmentation of water supply through various stages of Cauvery river water supply projects has been offset by the dominance of UFW while the target of 150 LPCD remains unfulfilled. BWSSB, however, has taken several measures to reduce the UFW and nearly 50,000 unauthorised water connections have been regularised since 1993. Despite regularisation drives and penalties of INR 10,000 and six months imprisonment for law violators, pilferage is unabated. BWSSB has installed meters for 227 out of 8,000 public fountains in the city. On an average each public fountain consumes about 4,460 litres per day.

Table 20: Reasons for leakage in the pilot project

Leakage reasons			
Mains	38.1%	Stop valve	1.6%
Service pipe	32.8%	Ferrule	0.7%
Stand post	17.6%	Air valve	0.1%
Main valve	6.6%	Others	0.5%
Meter joint	2.0%		

Source: BWSSB Annual Performance Report 2005-06

2.3. NON-REVENUE WATER

Water theft and leakages are estimated at 48%. UFW does not generate revenue and impacts on financial performance of BWSSB adversely. Presently, metered public fountains consume an average of 151 MLD of non-revenue water (NRW). The total number of legal water connections in the city is at 329,170 and unauthorised connections are estimated to be about 30,000. The financial implication of NRW has resulted in increasing the unit cost of production of water. Further, drinking water supply involves huge investments since water is supplied from a distance of 100 km and lifted to an altitude 540 meters above the source. BWSSB spends about 65% of its revenues on energy costs incurred in pumping and distribution. The increasing gap between water supply charges and distribution costs is the main obstacle for better performance of BWSSB. For instance, BWSSB charges INR 5 per cubic metre of water while the supply of the same costs INR 40. Among Indian cities BWSSB collects with 20.55 INR/m^3 a much higher tariff as compared to Chennai at 10.87 INR/m^3, Ahmedabad at 1.39 INR/m^3 and Kolkata at 1.13 INR/m^3. Despite the high tariff, Bangalore has an excellent overall record in urban water provision with metered production and consumption.

Table 21: Water utility performance indicators of metropolitan cities of India

Parameter	*Bangalore*	*Chennai*	*Ahmedabad*	*Kolkata*	*Mumbai*
Water supply coverage (%)	92.9	89.3	74.5	79.0	100
Water availability (hours)	4.5	5.0	2.0	8.3	4.0
Per capita consumption (LPCD)	74	87	171	130	191
Production/population (m^3/d/c)	0.185	0.131	0.168	0.246	0.2
Unaccounted-for water (%)	45	39	ND	35	13
Connection metered (%)	95.5	3.5	3.0	0.1	75.0
Operating ratio	0.80	0.44	1.43	4.73	0.49
Accounts receivable (months)	7.1	1.1	8	2.4	11.8
Revenue collection efficiency (%)	112	152	67	100	189
Average tariff (INR/m^3)	20.55	10.87	1.39	1.13	4.60
New connection fee	1,740	1,930	100	1,000	660
Capital expenditure (INR/connection)	787	10,080	427	2,247	3,790
Staff per 1,000 connections	5.2	13.3	2.2	14.7	17.2

Source: MoUD 2007, ADB 2007

3. IMPACT

3.1. THE BURDEN OF GROWTH

Bangalore with a population of nearly 7 million in the 2007 has been attracting an increasing number of formal and informal workers from rural areas and from other states too. As a consequence of the increasing population, the Greater Bangalore Metropolitan Area was formed. Within 60 years the city area grew tenfold, from 69 km^2 in 1949 to 800 km^2 in 2007. Rapid expansion of urbanisation has resulted in significant growth in informal settlements around the city. Poor provision of water with inadequate quality and quantity, lack of sanitary facilities are exposing people to water borne diseases. Poor sanitation in slum settlements has resulted in widespread contamination of water as disease bearing human wastes easily mix with surface water bodies such as lakes, streams and ponds.

3.2. EMERGENCE OF A WATER MARKET

The emergence of a water market in Bangalore evidently shows that water is not a free commodity or renewable resource. Privatisation of water supply services would essentially lead to monopolistic situation where water is owned by corporates. This might pave the way for water theft and leakages, destabilising the existing water networks. Increasing demand for water for domestic and industrial use has paved the way for growth of a water market. The bottled water market is growing at 55% annually in India. It may be construed from the emergence of a water market that people are willing to pay more if municipal corporations ensure the reliability and quality of water supply.

3.3. SUPPLY SHORTAGES

Supply of drinking water on alternate day for less than 5 hours has clearly shown the scarcity and unreliability of water supply in Bangalore City. Many studies have shown that even the poor have expressed willingness to pay more money to have better access to reliable, quality and good services of water supply. However, poor quality services impact negatively on their willingness to pay.

3.4. RESOURCE LIMITATIONS

Apart from the quantity and quality of water, supply is also constrained by other factors. According to a study conducted by the Department of Mines and Geology, Bangalore Urban district is categorised as Gray Zone for its exploitation of groundwater resources beyond recharge. About 50 watersheds in BMR are critically exploited. This implies deterioration in both groundwater quality and quantity. The high presence of both organic and inorganic substances in groundwater body is also causing serious health and environmental impact.

Financial indiscipline and inefficiency in water supply by urban local bodies create scope for emergence of alternative water supply management mechanisms such as public-private partnerships (PPP). JNNURM for instance calls for PPPs in urban water supply. However, many efforts in this direction have failed to meet the desired goal in developing countries due to mismatch between investment and cost recovery. However, the present state of water supply and sanitation is mainly attributed to poor public expenditure in India's cities. In India USD 1 is spent per person on water supply, sanitation and garbage collection as compared to USD 1,000 to 2,200 per person in cities such as Helsinki, Stockholm, Tokyo and Vienna.

3.5. ENVIRONMENTAL IMPACT

1) Water pollution: Both surface and groundwater pollution in the city impose limitations on both fresh and groundwater availability for productive uses while water pollution is contributing to waterborne diseases.
2) Water exploitation: Rapid depletion of groundwater table due to over-exploitation and limited availability of surface water has posed serious threat in terms of water availability for drinking purpose in future.
3) Water coverage: Water supply coverage particularly in slums is very poor. Poor residual pressure in many part of the city prevents adequate water availability for many households. Residents of the city complain of water shortage.
4) Water quality: The quality of water supplied by BWSSB is poor due to mixing of water with sewage. Residents in many areas who depend on municipal water supply frequently complain about contamination of water and muddy water supply in rainy seasons. The analysis of water samples collected from different points of municipal supply indicates that it does not meet the standards for potable water.
5) Fresh water availability: The yield of water from river Arkavathi is gradually declining owing to encroachment of its catchment area. Water withdrawal from river Cauvery is legally restricted to 19 TMC. Groundwater availability is limited due to groundwater pollution and alarming decline of water table. Lakes and ponds in and around the city are increasingly being encroached and polluted thus restricting water availability for human consumption.
6) Sanitation: Poor sanitation provision results in open defecation which in turn imposes high health risks among slum dwellers and has a generally negative socio-economic impact on other city dwellers as well.
7) Sewage disposal: Direct disposal of industrial and domestic liquid waste and dumping of solid waste into sewerage system has caused blockages, especially due to plastic waste and overflowing of manholes. Inadequate wastewater treatment has increasingly polluted the water table, surface water and soil resulting in transmission of various diseases to human beings and animals while damaging plants and crops on agricultural land.

Figure 16: Not a rare occurance – Sewage overrun in Shivaji Nagar

4. TRENDS

4.1. URBANISATION AND LAND USE

Bangalore has undergone a paradigm shift in its land use pattern with extensive and intensive use of land for residential, commercial and industrial needs apart from widening of roads. Apart from horizontal growth, the vertical growth of buildings including residential apartments, hospitals, and commercial complexes have imposed high demand for public provision of drinking water. The real estate boom contributes to spiralling land prices, which has resulted in extensive encroachment on public lands particularly, land under water bodies such as lakes, ponds and streams shrinking their size to a great extent in recent years. The land utilisation for various needs is also fast changing for various uses. The land under economic use was estimated about 284 km^2 in 1990 and it has increased to 741 km^2 in 2007. Consequently, the built up area has increased while wastelands and water bodies have shrunk. Residential areas are expected to grow from 99 km^2 (35%) to 244 km^2 (43%) in 2011 (refer to Table 22). The increase in residential and commercial areas and their demand for water supply and sanitation facilities are a considerable challenge even today. The present trend of urbanisation also imposes more capital cost on institutions involved in meeting drinking water and sanitation needs.

Table 22: Land use change from 1991 to 2011

Type of land use	Area in km^2		Percentage	
	1991	2011	1991	2011
Residential	98.8	243.7	34.8	43.2
Commercial	6.8	16.4	2.4	2.9
Industrial	20.4	38.	7.2	6.8
Parks and open spaces	21.3	77.9	7.5	13.8
Public and semi public	26.2	49.1	9.2	20.7
Transportation	21.4	117.0	31.5	20.7
Unclassified	89.5	22.1	7.5	3.9
Total	**284.0**	**564.7**	**100**	**100**

Source: BWSSB, 2002

4.2. FUTURE WATER SUPPLY AND DEMAND

It is predicted that Bangalore will face a severe drinking water shortage in the coming years due to unchecked growth of population, migration and urbanisation. For realising the growing demand of drinking water by 2025 the Government of Karnataka has sought additional allocation of 851 MLD (11 TMC) of water from river Cauvery from Department of Central Water Resources, Government of India. The demand is also put forward before the CWDT. In view of the delay in allotment of water from the river Cauvery the state government has constituted an expert committee to assess the feasibility of providing water from Hemavathi and Netravathi rivers. The expert committee that found that the exploitation of water in Cauvery River catchment areas is legally binding with prior approval by the CWDT. Further, the farming communities that are directly benefited the rivers have also expressed strong reservations about the project. Therefore, available sources of surface water to meet the growing demands of drinking water are limited.

Even though the water potential has increased from 705 MLD in 2000 to 959 MLD in 2007, the per capita availability of water has not increased. The growing population in the city has completely offset increased water potential to 959 MLD. Besides, the inadequate operation and maintenance of water supply facilities by BWSSB is reflecting the alarming increase of UFW fromF 33% to 48%. The increasing level of UFW is another factor that prevented the BWSSB in meeting 150 LPCD standard norms of CPEEHO. BWSSB can effectively meet the above standard if UFW is brought down to acceptable standards achieved by other cities. However, the growing population requires additional water supply against the current net supply of 550 MLD in 2007, which implies that citizens receive only 80 LPCD of water as against the prescribed norm of 150 LPCD (refer to Table 23).

The BWSESM project of AusAID assessed the water demand for Bangalore in 2002 based on the existing meter data, consumption rates and water connections. The demand for water is predicted to grow at a rate of 6.3% per annum in a high growth scenario while growth is assumed to be at least 5.1% per annum (refer to Table 24 and Figure 17). This implies that the water requirement may increase to 1,575 MLD against 1,459 MLD, leaving a supply gap of merely 116 MLD owing to the implementation of CWSS IV Stage Phase 2 by 2012 that adds an additional 500 MLD. However, with increase of population to 9.7 millions, the supply and demand gap is expected to widen by 514 MLD in 2025. Therefore, additional sources of water need to be explored besides reducing UFW.

Table 23: Potential production and shortage of water

Year	Population (In lakh)	Water potential in MLD	Net supply in MLD	UFW water in MLD	Water requirement		Shortage	
					At 150 LPCD	At 200 LPCD	At 150 LPCD	At 200 LPCD
2000	57.05	705	433	218 (33%)	862	1150	-157	-445
2001	62.24	705	458	220 (32%)	934	1245	-229	-540
2002	64.41	995	462	250 (35%)	966	1288	29	-293
2003	66.66	995	484	269 (36%)	999	1333	-4	-338
2004	63.74	959	512	331 (39%)	956	1275	3	-316
2005	65.42	959	542	340 (39%)	981	1309	-22	-350
2006	67.11	959	531	372 (41%)	1006.5	1342	-46.5	-383
2007	68.79	959	550	509 (48%)	1032	1376	-73	-417

Source: Annual Performance Reports, several years, BWSSB

Table 24: Water demand and supply

Parameter	1991	2001	2007	2011	2025	
Population in lakhs	40.8	58.0	65.26	73.4	97.0	
Available water in MLD	372	647	923	1,459	1,800	Projections are subject to availability of water from River Arkavathi
Water demand in MLD	924	1,433	1,464	1,575	2,314	Subject to 20% of UFW up to 2010 and 15% from 2011 onwards
Supply gap in MLD	552	786	541	116	514	

By 2025 the average water demand is expected to increase to 154 LPCD as compared to today's 101 LPCD (including 48% of UFW). UFW, which is currently higher than the domestic consumption of 36%, is the major stumbling block that prevents from reaching the target of 150 LPCD. The projections for 2011 and 2025 are based on the assumption that water from the river Arkavathi is available and UFW is reduced to 20% in 2010 and to 15% from 2011 onwards. It is projected that the supply gap will grow to 514 MLD in 2025 when the water availability will be 1,800 MLD against a demand of 2,314 MLD. Included in this calculation are 25 MLD of harvested rainwater, 198 MLD of reused effluent and 239 MLD of groundwater. The estimation by BWSSB also shows that there is a growing supply gap due to limited availability of surface water. Therefore, Government of Karnataka, on priority basis, should prepare an action oriented long-term blueprint to address the predicted shortage of drinking water in Bangalore by 2025.

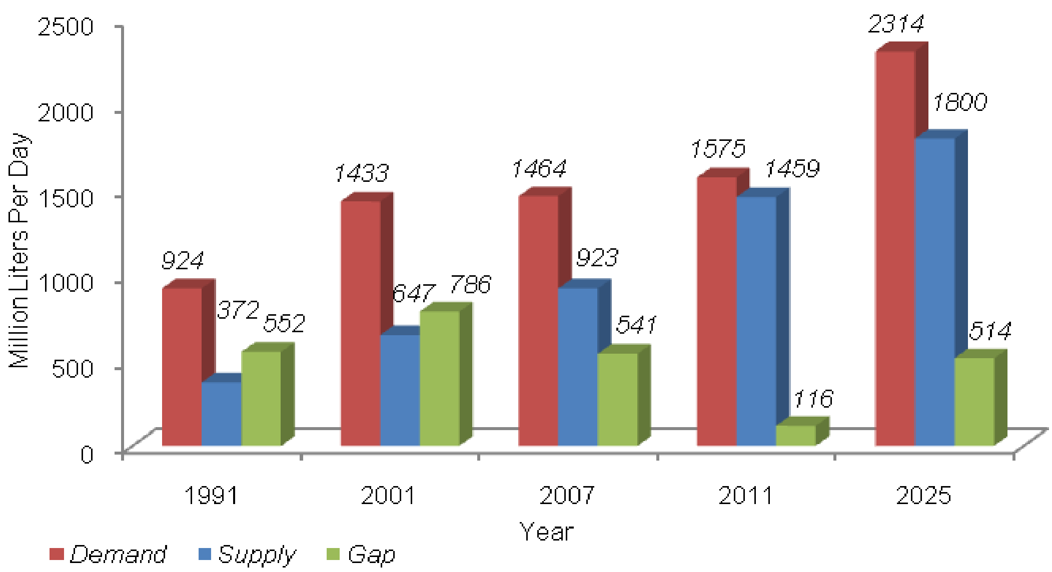

Figure 17: Water supply gap trend

5. CURRENT ACTION PLANS

5.1. POLICY FRAMEWORK

5.1.1. Central and state level

Sustainable development of urban areas crucially depends on the existence of water supply. Considering its importance the Government of India initiated structural reforms in urban water supply sector under the Jawaharlal Nehru National Urban Renewal Mission (JNNURM). The mission tries to make water available on a 24x7 basis to citizens, including the urban poor. The reforms of the mission are mainly aimed at service improvement i.e. bringing more accountability, financial discipline and transparency in water utilities. Further, community participation in service delivery is given a high priority. The National Water Policy 2002 and State Water Policy 2002, emphasise the importance of adequate and safe drinking water as the first priority (see Box). They have also given more thrust to bring the entire urban population on the network of drinking water provision. To realise the State Water Policy objectives the Government of Karnataka has prepared an Urban Drinking Water and Sanitation Policy (UDWSP) in 2003. The policy aims at empowering the institutions of the water supply and sewerage sector to realise its vision.

National Water Policy

National Water Policy, 2002 stipulates progressive new approaches to water management. It considers drinking water the top priority over other competing water uses. It states that monitoring and limitation of groundwater exploitation, monitoring and enforcement of water quality measures and increasing awareness of conservation measures and water scarcity should be major priorities.

State Water Policy of Karnataka

The policy of 2002 aims to ensure fair, just and equitable distribution and utilisation of water resources to benefit the people of the state through legislation, administration and infrastructure development. The state policy also wants to achieve the sustainable provision of 55 LPCD potable water in rural areas, 70 LPCD in towns, 100 LPCD in city municipal council areas and 135 LPCD in city corporations. Further, it stresses on improvement of performance of all water resource projects, productivity of irrigated agriculture by involving water users association and harness hydropower potential of the state.

According to UDWSP 2003, BWSSB needs to provide piped water supply and sanitation services to all citizens and to increase the coverage of underground drainage in the next ten years. AusAID assisted BWSSB by implementing the USD 8 million BWSESP. The project was implemented for helping BWSSB to prepare a water supply and environmental sanitation master plan. The plan is a comprehensive blueprint for providing essential water and sanitation services for the city's citizens. The project will be instrumental in assisting BWSSB to attract capital investment from multilateral or private sources to refurbish and build the infrastructure needed to extend the reliable drinking water access for the poor. Government of Karnataka has also taken several measures such as use of treated wastewater for construction activities in Bangalore. It has emphasised the need for watershed and catchment area protection. TG Halli catchment area protection has received importance as the effluent discharge limit is fixed for industries. Government of Karnataka has established the Lake Development Authority (LDA) with the aim of rejuvenating and restoring degraded lakes in urban areas. LDA is entrusted with the responsibility to protect water bodies. Mega City Scheme (MCS) was launched in 1993 for the cities such as Bangalore, Chennai, Hyderabad, Kolkata, and Mumbai. Under this programme, a revolving fund has been created for financing urban infrastructure particularly in slums for adequate provision of water supply and sanitation facilities.

5.1.2. City level

Government of Karnataka in its meeting on Agenda for Bangalore Infrastructure Development (ABIDE) 2008 has reviewed the state of drinking water supply and sanitation in Bangalore. Water supply on alternate days and limited to 4 to 5 hours reflects the growing water scarcity. BWSSB is presently facing a shortfall of 349 MLD (40%) to meet the drinking water needs of the city. BWSSB plans to meet this shortfall by harvesting water from lakes and the Government has planned to conserve lakes and it has decided to immediately cease the privatisation of lakes. BWSSB also plans to treat the surface water of selected lakes to potable level from Bellandur, Kalkere, Kengeri, Nagavara, and Vengainhakere lakes. BWSSB is also planning to ensure supply to households on a daily base by 2011 and to extend water supply to newly added areas under greater Bangalore by the end of 2009. Residents of these areas presently depend on mini water supply schemes. The state government has sanctioned INR 100 crore towards mini water supply schemes and drilling of bore wells. BWSSB has planned a massive replacement programme for all old and corroded water pipelines and installation of dual pipelines in all new layouts at a cost of INR 170 crore in the next two years. Wastewater recycling has been planned in Bellandur and Nagavara lakes. The state also plans to give more policy thrust towards integrated water management to meet the increasing drinking water demand in the city in the coming years. Several policy measures of BWSSB aim at conserving water.

5.1.3. Adequacy

The policy of central and state governments towards augmentation of domestic drinking water supply are highly commendable. However, the policy fails to give adequate attention to demand side management and creation of awareness about judicious use of water. The conservation of water at the users' end is not given the top priority it deserves. Policy on sanitation, treatment of wastewater, prevention of groundwater depletion and water quality deterioration is unfortunately rather weak. Government policies have not succeeded in attracting more investment for creation of infrastructure, fixing of water prices, cost recovery and reduction in UFW.

5.2. WATER SUPPLY

Government of Karnataka, BWSSB and BBMP are under severe pressure to ensure sustainable drinking water supply in the coming years for the growing population. Alarming depletion of groundwater table and realisation of threshold level of drawing water from rivers has worsened the drinking water supply situation. Feasible alternative water resources are restoration of existing lakes, treatment and reuse of wastewater generated, harvesting of rooftop rainwater and examination of availability and utilisation of reservoir waters from other rivers. According to a study of AusAID, the projected utilisation of surface water will increase from the present 60% to 80% in the year 2025. However, the proposed dependence on groundwater decreases from the present 40% to 10% and effluent reuse is expected to increase from 0.3% (3 MLD) to 9% (90 MLD). Rainwater harvested is projected to rise to 25 MLD or 1% of the total water availability. It is projected that both effluent reuse and rainwater could contribute about 10% of the water needs by 2025 (refer to Table 25).

Table 25: Sourcing of water in 2000 and 2025 in BMR

Water sources	2000		2025	
	Drawing in MLD	Utiliza-tion in %	Projected drawing in MLD	Utiliza-tion in %
Surface water	655	60	1,852	80
Groundwater	427	40	239	10
Effluent reuse	3	0.3	198	9
Rainwater har-vesting	-	-	25	1
Total	**1,085**	**100**	**2,314**	**100**

Source: AusAID, 2002

BWSESMP's master plan estimated the potential of water sources for meeting the future drinking water needs of Bangalore city (refer to Table 26).

Table 26: Present and future water resources proposed for BMR

Water sources	Potential in MLD	Distance from Bangalore	Use
Cauvery river		Source options:	Municipal supply, potable
Stages I, II and III (Existing)	540	99 km, Shiva Anicut	
Stage IV Phase I	270	126 km, KRS Dam	
Stage IV Phase II (Part-1 UC)	258	175 km, Hemavathi	
Stage IV Phase II (Part-2)	257	205 km, Netravathi/ Hemavathi	
Stage V	686		
Subtotal	***2,011***		
Arkavathi river			Municipal supply, potable
TG Halli	100	25 km	
Hesaraghatta	4	17 km	
Subtotal	***104***		
Groundwater	**190**	Within city limits	Municipal supply, potable
Rainwater harvested	**20-50**	Within city limits	Commercial and household supply
Reuse of treated effluent	**170-220**	Within city limits from BWSSB's STPs	Industrial and non-domestic supply, non-potable
Total	**2,575**		

Source: AusAID, 2002

It has proposed that the potential can be enhanced with the commissioning of CWSS Stage IV, Stage V and Phase 2 from the current 970 MLD to 2,011 MLD. It has also proposed to draw drinking water from other river sources such as Shiva Anicut (99 km), KRS Dam (126 km), Hemavathi (175 km) and Netravathi (205 km). The potential from groundwater and rainwater harvesting has been estimated at 140 MLD. The potential through wastewater treatment amounts to 170-220 MLD. Efforts of BWSSB to harvest drinking water from the above rivers have met with several practical impediments. BWSSB actually plans to draw water from Hemavathi and Netravathi rivers to meet the shortfall. However, a study by the expert group concluded that tapping of water from Hemavathi dam would lead to protests from farmers that might render the project unfeasible. Nevertheless, tapping into Netravathi river is being pursued and the government is expected to take a decision on the diversion of water for drinking needs. There is also a proposal to get water from the river Tunga Bhadra yet the expert group observed that high operating costs discourage the implementation of the project. It is estimated that the cost of tapping Hemavathi and Netravathi exceeds 20 INR/m^3 of water. It can be inferred from the above that sourcing of fresh water for Bangalore has clear limitations and faces significant practical problems. Harvesting of rainwater, reuse of treated wastewater, reduction of UFW and rational use of surface and groundwater therefore emerge as priority for policy action.

5.3. WASTEWATER TREATMENT

BWSSB has given high priority for wastewater treatment by establishing and commissioning of two major tertiary water treatment plants at Yelahanka (10 MLD) and Vrishabhavathi valley (60 MLD) plants. These plants supply 70 MLD of tertiary treated water for industries and non-domestic purpose at an affordable rate that helped conserving 70 MLD of fresh water. BWSSB with the financial assistance of Japan Bank for International Cooperation (JBIC) plans to adopt international technology to reduce the water leakage in distribution system equivalent to seven-day water supply and improve revenue flow by 20 to 30% at a of INR 400 crore.

5.4. WATER CONSERVATION

5.4.1. Conservation of lakes

Lakes, which were earlier meeting drinking water needs of the city are virtually under rapid extinction due to myopic and unsystematic urban development. Neglect of lakes by the government has resulted in successive encroachment by industrial estates, builders of apartments and residents. Further, lakes have been converted into garbage pits of municipal waste and construction debris. The rainwater inflow is blocked due to unmanaged sewage lines that are encroached and choked with waste. Although there are 596 lakes including the small ones, in the BDA's official records only 55 are surviving. In view of the fast depletion and deterioration of lakes the LDA was established in 2002 by the state government to "rejuvenate, revitalise and restore the dying lakes in the state and to protect them against further pollution in order to recharge the depletion of groundwater and to improve the surrounding environs and the local sanitary conditions with the help of community participation".

LDA is an autonomous body with regulatory, planning and policy formulation functions for protection, conservation, reclamation, restoration, regeneration and integrated development of lakes. A blueprint for the rejuvenation of 12 identified lakes based on the expert report was prepared (refer to Table 27). The lakes of the city are still considered as fragile ecosystems as they are highly polluted. Some of them were privatised by LDA due to lack of funds. Consequently, public lakes are developed and used for commercial entertainment purposes that could jeopardise the flora and fauna rather than protecting it. The prohibition of the general public in privatised areas also curtails social benefits. Therefore, the government should withdraw its policy of privatisation of public lakes.

Table 27: Lakes selected for rejuvenation

Lake		Size in acres
1.	Ullala lake	31.1
2.	Mallathahalli	50.4
3.	Konaghatta	18.3
4.	Jakkur and Sampihalli	65.2
5.	Rachenahalli	36.1
6.	Venkateshapura	6.4
7.	Kottanur	18.3
8.	Talaghattapura	25.1
9.	Konasandra	38.3
10.	Sompura	7.1
11.	Ramasandra	101.3
12.	Vengaiah	35.0

5.4.2. Watershed development in Bangalore Rural

Realising the danger of fast depletion of groundwater table leading to acute drinking water shortage and reduction in agricultural yield in Bangalore Rural district in recent years, the Bangalore Rural *Zilla Panchayat* has identified 85 potential areas for groundwater recharge through intensive watershed development programme in the four *taluks* Devanahalli, Doddaballapura, Hoskote and Nelamangala (refer to Figure 18). The District Perspective Plan 2006-16 has given prioritisation for watershed development.

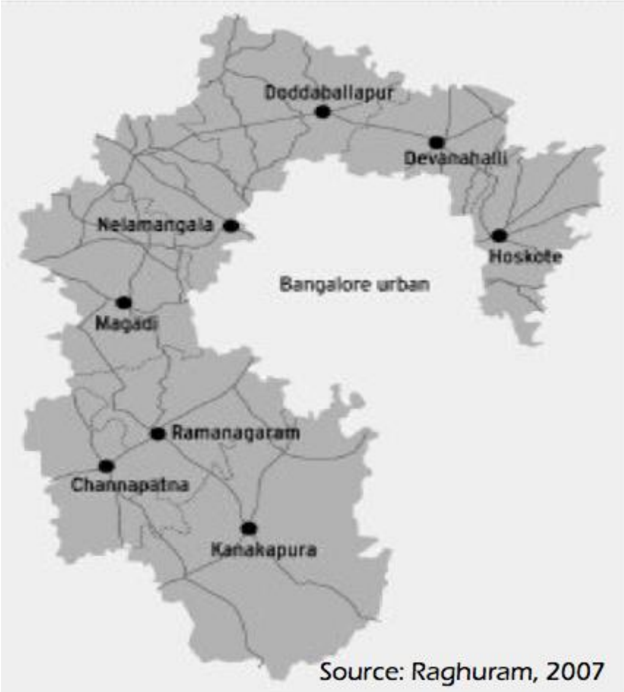

Figure 18: Micro watershed projects in Bangalore Rural and Ramanagar

Figure 19: Water conservation through Watershed Development Programme

The groundwater table in these districts has dropped alarmingly within a decade from 12.3 metres in 1997 to 16.4 m in 2007 despite an average rainfall of 970 mm. Commercialisation of agriculture, intensive cultivation and silt formation in water bodies are responsible for over-exploitation of groundwater in the district. However, for effective implementation of watershed development programs, the acute scarcity of land for construction of watersheds in Devanahalli *taluk* is the major roadblock for the *Zilla Panchayat*. Presently, Devanahalli *taluk* has an area of 7,305 ha under the watershed area development programme. The most important watershed in Devanahalli *taluk* is Aradeshanahalli, which extended over an area of 7,223 ha and the Vishwanathapura watershed has been developed on an area of 717 ha. More integrated watershed development programmes should be taken up in the district. The awareness about advantages of watersheds in enhancing groundwater table and also promoting agricultural and allied activities has to be created in rural areas.

Water in the desert of Rajasthan

Rajendra Singh, who has undertaken extensive water conservation projects in drought-prone eastern Rajasthan, has won the 2001 Ramon Magsaysay Award for Community Leadership. The non-governmental organisation Tarun Bharat Sangh (TBS), which Rajendra Singh leads as its general secretary, has since 1985 built some 4,500 earthen check dams, or johads, to collect rainwater in some 850 villages in 11 districts of Rajasthan. The TBS has also helped revival five rivers that had gone dry. The award is not only a recognition of his conservation efforts but also an acceptance of the traditional wisdom of the people of rural Rajasthan. Not long ago, when a group of five youths from Jaipur, which included Rajendra Singh, landed in Alwar district's Thanagazi *tehsil*, the villagers viewed them with suspicion. The backward Gujjars and the tribal Meenas branded them as child-lifters and terrorists. They were not to blame, for the villages, nestled in eastern Aravallis, were going through difficult times in the 1980s. Most parts of Alwar district had been declared a "dark zone", which meant there was very little groundwater left. Rivers and ponds were drying up and most of the men folk had left for cities in search of work. Life in the villages had come to a standstill with farming activities getting severely affected and the bovine wealth, the backbone of rural economy, shrinking in the absence of fodder and water. Fifteen years and many *johads* later, water has restored life and self-respect in Alwar. Of late, several villages in the neighbouring districts of Jaipur, Dausa, Sawai Madhopur, Bharatpur and Karauli have been revived by the TBS. Neembi in Jamwa Ramgarh tehsil of Jaipur district is one such village which caught the fancy of planners this summer as the perennially drought-prone village had water at three feet from the ground in the third consecutive drought year. Neembi's residents, who spent INR 50,000 in 1994 to construct two earthen dams with the help of TBS, now produce vegetables and milk worth INR 3 crore annually. Farming activities have resumed in hundreds of drought-prone villages with the rivers Ruparel, Arvari, Sarsa, Bhagani and Jahajwali flowing again after remaining dry for decades. The villages, which were deserted by its inhabitants, have been populated once again. There is a sense of belonging among the people as the *gram sabhas* created by the TBS to facilitate the management of *johads* have a say in the general well-being of the community as well. The rebirth of Arvari was a miracle. In 1986, the residents of Bhanota-Kolyala village, with the help of TBS constructed a *johad* at its source. Soon villages around the catchment area and along the dry river constructed tiny earthen dams. When the number of dams reached 375, the river began to flow. "We were amazed," says Rajendra Singh, recalling the revival of Arvari, which earned him the titles of water diviner and miracle man. "It was not our intention to re-create the river, for we never had it in our wildest dreams," he remarked. The villagers who revived the Arvari were felicitated by President K.R. Narayanan with the Down to Earth Joseph C. John Award in March 2000.

Source: www.tarunbharatsangh.org

In view of imminent surface and groundwater scarcity, integrated watershed development programs and lakes conservation should be given high priority. Rajendra Singh pioneered a new development model in water conservation by undertaking extensive water conservation efforts in drought-prone eastern

Rajasthan (see Box). This pioneering model needs to be emulated and replicated in Bangalore as well as Karnataka for meeting present and future water needs.

5.4.3. Conservation of TG Halli reservoir catchment area

TG Halli reservoir, one of the largest water bodies in BMR, used to quench the thirst of Bangaloreans. Its decrease in inflow is alarming. The main reasons are the diversion of water from its catchments due to urbanisation around the Bangalore International Airport, choking of natural drains and recharge routes are attributed. Water inflow will be further reduced unless major thrust for watershed area development in the catchments is taken up on priority. The Government of Karnataka took several policy decisions to conserve the TG Halli reservoir and its catchments. It realised that the imminent drinking water shortage is due to poor inflow of water and widespread water contamination in the catchment areas. The government should plan land use and cropping pattern in the catchment areas to enable present conservation activities. Appropriate economic incentives need to be given to farmers in the catchment area towards implementation of watershed development programmes, conservation of water and soil, adopting suitable cropping pattern and planting of varieties of trees.

Restoration of Thippagondanahalli reservoir

TG Halli reservoir situated about 34 km from Bangalore was built in 1930 at the confluence of Arkavathi and Kumudvathi rivers to ensure Bangalore's supply of drinking water. The reservoir supplies 125 MLD of water to the city in normal rain years. The area of the reservoir is about 1,453 square kilometres having capacity to store 85 TMC of water. The catchment occupies an area of 462 square kilometres. The increased development of industrial estates in the catchment areas such as in Dobbaspet, Doddaballapura and Peenya has negatively impacted the water inflow, storage capacity and longevity of the reservoir apart from increasing the pollution of groundwater. The quality of water in the reservoir has deteriorated due to unauthorised effluent discharge. Government of Karnataka and Karnataka State Pollution Control Board received many complaints against the state of TG Halli reservoir by BWSSB and general public. BMRDA with the technical support of ISRO has initiated a study to ascertain the reason for reduced inflow of water to TG Halli reservoir based on satellite (land sat) imagery. Main recommendations of the report:

- The TG Halli catchment area should be declared as "Protected Area or Conservation Zone" because of its ecological fragility.
- Setting up of a separate TG Halli catchment area conservation authority.
- To declare TG Halli catchment area as "Greenbelt Area" in Comprehensive Development Programme (CDP).
- Preparation of a land utilisation strategy by taking into account increasing demand of land for residential and industrial needs.
- Monitoring of groundwater over-exploitation and restoration of lake in the catchment area.
- To remove all obstacles in Arkavathi and Kumdvathi river basins for free inflow of water to TG Halli catchment area.
- To instruct all the departments concerned to implement the CDP for ecological restoration of catchment area and to ensure increase of inflow of water to TG Halli reservoir.

Policy measures for conservation

- Regulation and checking of over-exploitation of groundwater in the catchment area.
- Granting of fresh license and leasing of new mining, quarrying and stone crushers to be stopped.
- Mandatory scientific treatment of solid and liquid waste by industries and banning of dumping of waste in the catchment area.
- Adoption of rainwater harvesting system in all the existing and new buildings to be made mandatory.
- Promotion and encouragement of organic farming and utilisation of bio-fertilizers and bio-pesticides by farmers in the catchment area.
- No permission is given for non-agricultural activities within 2 km radius of TG Halli reservoir area.
- Rainwater harvesting and setting up of wastewater treatment plant are made compulsory for all the industries in greenbelt area.
- Non-compliance of the above directions to result in the attraction of penal action under section 15 and 17 of the Environment (Protection) Act, 1986.

Source: Karnataka State Pollution Control Board (2007)

5.4.4. Rainwater harvesting

Rainwater harvesting has tremendous potential in Bangalore. At low investment costs it effectively prevents water runoff, evaporation and seepage. It enhances water availability, checks the declining water table and prevents soil erosion and flooding, especially in urban areas. Rooftop water harvesting should be considered as integral part of meeting the present and future water needs of Bangalore. Rainwater harvesting can be effectively adopted for reuse and recharging of bore wells and groundwater sources in the city. Rooftop rainwater harvesting needs to be developed as an alternative water supply model for Bangalore with collection and storage of rainwater in every household, channelling of rainwater to tanks and lakes, provision of recharging groundwater in parks and wastelands.

Figure 20: Rainwater collection pipes at Vidhana Soudha

Bangalore receives well-distributed rainfall with an average of 970 mm annually for the last one decade. With this a 100 square metre roof area can generate approximately 97,000 litres of water per year, of which about 77,600 litres could be harvested assuming 80% capture efficiency (Vishwanath 2001). It is estimated that with an average consumption of 100 LPCD the rainwater is sufficient for 194 days a year. Existing apprehensions about the quality and adequacy of rainwater can be overcome by creating better awareness. Awareness also needs to be created about costs and economics of rainwater harvesting systems, percolation pits, trenches, storage sumps or tanks and recharge wells. Rainwater harvesting is demonstrated in major government buildings and apartments and BBMP buildings and Vidhana Soudha have excellent facilities. Economic incentives should help propagate wider application.

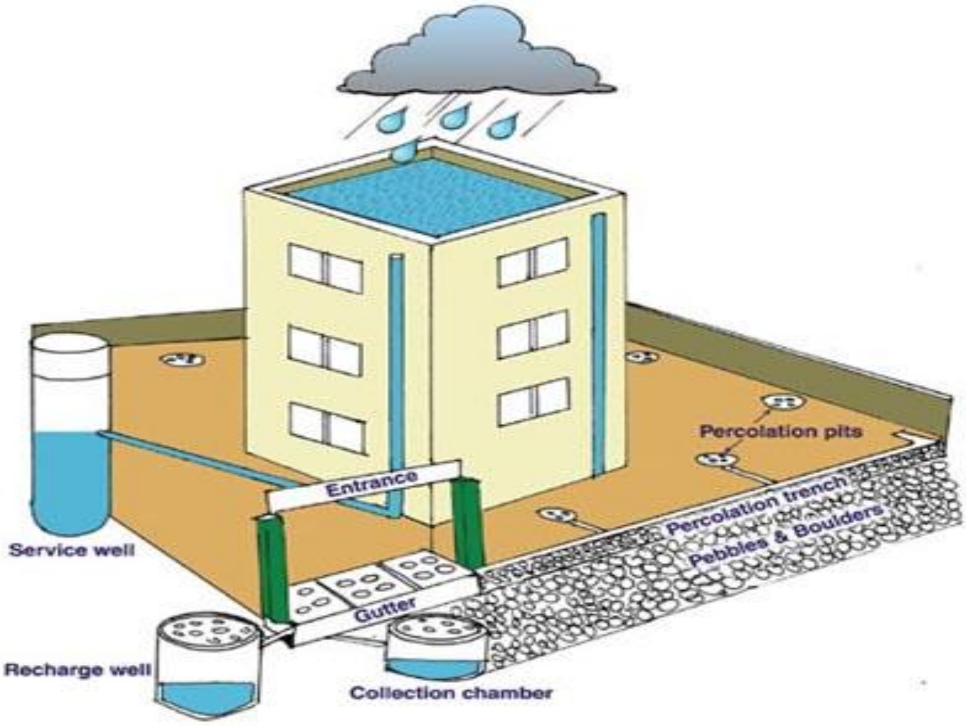

Figure 21: Roof top rainwater harvesting system

6. PROPOSED ACTIONS

6.1. CONCLUSIONS

Although Bangalore has made significant progress in recent years in terms of water supply coverage, meeting the demand continues to remain as a major challenge. There is a considerable gap between access to water supply infrastructure and water supply services as per the four main indicators or criteria: reliability, financial sustainability, environmental sustainability and affordability. BWSSB still needs to meet the CPHEEO norm of 150 LPCD and improve the quality of water supplied. Water is supplied on alternate days for a period of 4 to 6 hours per day while neither its frequency nor duration can be relied upon.

The sustainability of water supply is severely jeopardised by the alarming decline of the groundwater table on one hand and pollution of water bodies and piped water on the other. Water quality has deteriorated, which is caused by inadequate sewage and effluent treatment facilities, resulting in the spread of water borne diseases. Government policy has to prioritise the rejuvenation of degraded traditional surface water bodies such as lakes and ponds in and around Bangalore. Better efforts towards water conservation inevitably demands some sort of economic incentives in the form of payment and rewards for the restoration of water ecosystems. Therefore, devising instruments such as subsidies, payments or compensations are the need of the hour. Rainwater harvesting, especially on rooftops, is considered to be the best and most cost-effective option but this has to be implemented strictly by making new laws with adequate incentives. Enhancing wastewater treatment capacity will reduce the burden on fresh water requirement in future. Judicious and economic use of both tap and groundwater has to be encouraged while imparting awareness about growing concerns in respect of fresh water scarcity. Preventing water bodies from contamination of industrial and domestic pollutants needs to be given priority in policy. Finally, the growing scarcity of water sources and increasing cost of production and distribution essentially recommends that water be treated as conditionally renewable economic commodity of high economic and social value. Over-exploitation and inadequate recharge has compromised renewability.

6.2. WATER MANAGEMENT NEEDS

6.2.1. Supply-side management

Supply-side management of water means increasing efficiency, equity, affordability and sustainability in water supply to city dwellers. Important supply side management options are recharge and augmentation of surface and groundwater bodies, rainwater harvesting, lake restoration and wastewater treatment. It is estimated that more than 75% of the water consumed goes back to the sewage system as wastewater. Therefore, wastewater treatment and its reuse for economic activities will enormously decrease the burden on fresh water utilisation. Water saving and reuse of wastewater needs to be given top priority in the government policy. The following issues need to be given importance:

1) Water conservation through rejuvenation of degraded lakes and ponds.
2) Promotion of rainwater harvesting by bringing new laws with provision of adequate economic incentives.
3) Improve groundwater across BMR, especially in TG Halli catchment areas through integrated watershed development programmes.
4) Ensure water supply reliability, coverage, required quantity and quality through efficient operation and maintenance.
5) Extend the water supply network to newly created BBMP areas and later to CMCs and TMCs.
6) Exercise caution regarding drinking water supply through PPP as success examples are very rare in developing countries.
7) Renovation and modernisation of water supply network system to reduce UFW and NRW.
8) Proposed water supply schemes should look at economics besides technicla feasibility
9) Increase wastewater treatment capacity. Recycled wastewater to meet at least 10% of water demand.
10) Adopt suitable measures to prevent further depletion and over-exploitation of groundwater.
11) Use geographical information based systems for water conservation and balanced exploitation.
12) Improve sanitation amenities in slums through adequate investment.
13) Encourage people’s participation in water conservation and make them assume responsibility for conserving and managing water.
14) Bring more efficiency, transparency and accountability in water utility services.
15) Bring necessary Institutional reforms for BWSSB to ensure good governance in water supply services.

6.2.2. Demand-side management

Demand for water is estimated based on projections and normative requirements for the growing population but, the effect of price on the demand for water has not been properly evaluated. Whenever the demand for water exceeds supply, urban utilities quickly design supply strategies that give little or no importance to strategies aimed at containing the demand. Authorities have failed to incorporate demand-side factors in policies, resulting in institutional misdirection. For instance, in Bangalore city, without addressing the high level of UFW of 48%, BWSSB has tried to harness already strained water source by incurring huge public investment without offering adequate economic justification for taking up new water supply projects. Demand-side management can invoke ways to operate within limits of current supplies. Supply enhancement strategies even today dominate the urban water resource planning in developing countries over demand management opportunities, despite the fact that developed countries have suspended its dominance in their policies. The following demand-side management issues need to be given importance:

1) Reduce NRW and achieve parity in water supply cost and revenue by increasing tariffs without hurting the economically weaker sections.
2) Reduce the cost of new water connections and encourage authorised use of water.
3) Ensure cost effective water supply with fixing of reasonable price through increasing efficiency in revenue recovery.
4) Ensure reliability of water supply to reduce water theft and spillage in slums.
5) Bring down illegal water connections and unauthorised use of water through installation of water meters.
6) Promote judicious and economic use of water by taking into account its scarcity and recharge capacity in comparison to current and future harvesting rate.
7) Replicate water conservation efforts such as *Neeru-Meeru* ("Water and you") and Tarun Bharat Sangh with people's participation in Karnataka.
8) Collect special water charges towards conserving the forest ecosystem at Kodagu district and other Cauvery river catchment areas that support continuous water supply to Bangalore.
9) Prepare a strategic action plan to overcome water shortages due to climate change and natural catastrophes such as droughts and breakage of main pipes.
10) Restore old and corroded water supply assets to reduce water pilferage and leakages.
11) Frame groundwater policy for monitoring, regulation, protection and promotion of efficiency, equity and sustainable use of aquifers.
12) Achieve millennium development goals with sustainable provision of water and sanitation to poor people by allocating more funds from central and state governments.

Table 28: Water supply enhancement and demand management strategies

Supply enhancement strategies
1. Harness rain water
2. Waste water treatment and reuse
3. Reduction of unaccounted for water
4. Lakes rejuvenation
5. Tapping of leakages
Demand management strategies
1. Reduce non-revenue water
2. Metering of taps
3. Raise water rates
4. Water rights and conservation options
5. Educate water users

6.3. RECOMMENDATIONS

1. Recommendation: Control of water pollution	
Issue	Unabated ground and surface water pollution in and around Bangalore
Root cause	Industrial and domestic wastewater disposal to sewage and lakes, open defecation, poor drainage system.
Impact	Health impact from waterborne diseases and water that is unfit for drinking.
Magnitude	The problem is very serious due to high presence of organic and chemical pollutants in ground and surface water bodies beyond permissible limit.
Benchmark	Reduce ground and surface water pollution through water quality assessment and strict monitoring.
Action plan	Enhancement of wastewater and industrial effluent treatment, imposition of pollution charges and fines and closure of effluent discharging industries and hospitals.
Implementing agency	BWSSB, KSPCB, LDA, DMG

2. Recommendation: Halting of further depletion of groundwater table	
Issue	Depletion of groundwater table beyond its carrying capacity
Root cause	High density of bore wells cause over-exploitation of groundwater by residents and industries.
Impact	Health impacts due to presence of pollutants in excess of permissible limits.
Magnitude	Many watersheds in BMR are declared as critical and over exploited.
Benchmark	Reduce number of watersheds under-critical and over-exploited to natural condition.
Action plan	Groundwater exploitation should be monitored through introduction of new groundwater use and monitor bill. Watershed conservation through Integrated watershed development programs. Increase piped water supply of surface water. Increase the water table through rainwater harvesting.
Implementing agency	DMG, BBMP, Municipal Authorities, *Zilla Panchayat*, BMRDA, KSPCB

3. Recommendation: Reduction of unaccounted for water and non-revenue water	
Issue	High percentage of UFW and NRW causes inefficiency in operation and maintenance of water utilised by BWSSB
Root cause	Water leakages, theft or spillage, absence of metering of public taps and fountains, old and corroded pipes and unauthorized connections
Impact	Drinking water availability is only 75 LPCD against 150 LPCD norms of CPEEHO for Bangalore.
Magnitude	Loss of 48% UFW causing high percentage of NRW.
Benchmark	Reduce UFW and NRW to world standard of 15% of total potable water received for supply.
Action plan	Replace old and corroded water networks and reduce unauthorized connections, install water meters for public taps and fountains and improve water tariff collection.
Implementing agency	BWSSB, BBMP

4. Recommendation: Enhancement of wastewater treatment and reuse capacity	
Issue	Ground and surface water pollution
Root cause	Poor underground sewage system and inadequate wastewater treatment
Impact	Health impact, impact on agricultural land and animals
Magnitude	Vrishabhavathi, Koramangala, Challaghatta and Hebbal valley sewage systems are overflowing with un-treated organic and inorganic pollutants causing pollution of surface and groundwater bodies beyond permissible limit.
Benchmark	Wastewater treatment capacity should be increased from present 718 MLD to 1,200 MLD. The capacity of present tertiary treatment plant (70 MLD) should be increased to meet at least 10% of water needs of the city. 170-220 MLD of treated effluents should be reused to meet the growing water demand in future.
Action plan	Enhance wastewater and tertiary treatment capacity and improve groundwater drainage system.
Implementing agency	BWSSB

5. Recommendation: Improve state of sanitation	
Issue	Poor sanitation amenities in slums such as housing, water supply, toilets, drainage, roads and street-lights.
Root cause	Rapid urbanisation due to rural-urban migration and poor urban development strategies.
Impact	Health and socio-economic impact,
Magnitude	There are 733 slums with a population of 6.5 lakhs comprising about 10% of the city's population without adequate sanitation amenities.
Benchmark	Legally recognition of unauthorised slums under slum area development schemes such as VAMBAY, NSDP, MCS, NJY, and NBAY to improve the state of sanitation.
Action plan	Provide basic services to improve the sanitation conditions in slums under JNNURM schemes.
Implementing agency	KSCB, BWSSB, BBMP

6. Recommendation: Improve water delivery and coverage	
Issue	Water delivery and supply coverage is poor
Root cause	UFW, absence of extension of water networks, and poor maintenance and operation
Impact	Shortage of water for domestic consumption results in groundwater exploitation, dependence on tank water supply and water theft
Magnitude	Water availability is 75 LPCD against stipulated norms of 150 LPCD and water delivered for 4-5 hours on alternate day against 24 hours a day
Benchmark	Improve water supply to 150 LPCD with water supply delivery to at least 12 hours a day bring BBMP and BMR regions under water supply network
Action plan	Ensure reliability through supply-side and demand-side management of water supply
Implementing agency	BWSSB, BBMP

7. Recommendation: Promotion of rainwater harvesting	
Issue	Alarming depletion of groundwater table beyond threshold limit and limited availability of surface water sources
Root cause	Rapid urbanisation and limited sources of water availability for future use
Impact	Increasing cost of water supply, increase in water charges, high investment for improving the supply network
Magnitude	Scarcity of both ground and surface water will jeopardise the economic development of Bangalore city
Benchmark	20-50 MLD of rainwater should be harvested to meet future water demand
Action plan	Frame new legislation that makes rainwater harvesting for existing and new residential commercial, industrial, hospital buildings mandatory
Implementing agency	BWSSB, BBMP BDA, BMRDA

8. Recommendation: Conservation of lakes	
Issue	Lakes are increasingly polluted and encroached
Root cause	Discharge of untreated domestic and industrial effluents to lakes
Impact	Decay of lake ecosystems due to high presence of pollutants
Magnitude	Several lakes in the city are highly polluted according to KSPCB and many lakes are under the verge of disappearance due to encroachment
Benchmark	Improve water quality of lakes to required COD and BOD level
Action plan	Bring stringent law against untreated effluent discharging units and prevent further encroachment of lakes.
Implementing agency	BWSSB, KSPCB, LDA, DMG

9. Recommendation: Renovation and modernization of water supply networks	
Issue	Poor operation and maintenance is reflected in high percentage of UFW
Root cause	Old and corroded water supply networks and poor operation & maintenance
Impact	Increasing capital and operational and maintenance cost
Magnitude	Inefficiency in water supply management contributing towards high investment on new water supply projects.
Benchmark	Reduce UFW to 15% of total water received
Action plan	Take up renovation and modernisation of water supply networks, reduce O&M costs and improve efficiency in water supply
Implementing agency	BWSSB

10. Recommendation: Create public awareness about judicious use of water	
Issue	Wastage of water
Root cause	Ignorance about the value and scarcity of water
Impact	Scarcity of water for potable and non-potable uses
Magnitude	Water is wasted without productive uses by many residents and industries
Benchmark	Save every drop of water which is very precious to save millions of life
Action plan	Impart education about scarcity and importance of water for our life and existence. Create public awareness about judicious use of water
Implementing agency	All government, non-government organizations

Chapter 4

Air

CONTENTS

TABLES

FIGURES

1. AMBIENT AIR QUALITY

1.1. MONITORING PROGRAMMES

Ambient air is being monitored by Karnataka State Pollution Control Board (KSPCB) on behalf of Central Pollution Control Board (CPCB) as part of the National Air Monitoring Programme (NAMP). The programme monitors standard air pollutants, namely suspended particulate matter (SPM) PM_{10}, respirable SPM (RSPM), sulphur dioxide (SO_2) and nitrogen dioxide (NO_X) at six locations. The locations include industrial, mixed and sensitive areas.

KSPCB is also monitoring CO, NO_X, SO_X and SPM at the City Railway Station and SG Halli through its continuous monitoring stations at two prominent locations. KSPCB's mobile laboratory is also monitoring NO_X, SO_2, SPM, O_3 and CO at traffic intersections and other pollution hot spots. In addition to this, industries located at various industrial estates are monitoring ambient air quality as a part of regulatory requirement. The monitoring sites shown in Figure 2 attempt to represent both residential and industrial areas and account for the major land uses.

Figure 1: Monitoring station analysising relatively clean air at Madivala tank

Table 1: Air monitoring stations

Location	
Airport Road	Mekhri Circle
Indian Express Circle	Peenya Industrial Area
Jayanagar	Residency Road
K.G. Circle	Town Hall
Mahatma Gandhi Road	Victoria Hospital
MC Tollgate	Yeshwanthpur, Police Station

In spite of the monitoring programmes the data is insufficient. The following limitations have been identified:

- Monitoring stations are limited to urban areas only and there is no representation of rural settings.
- Some data results from a mere 8 hours monitoring, a period too short for conclusions.
- Though particulate matter has shown to exceed the limits for most of the monitoring series, its chemical composition, required for identification of sources, is not studied well.
- Source profiles are not available. Though a source apportionment study is currently being carried out for Bangalore the results were not available for this present analysis.

Table 2: National Ambient Air Quality Standards (NAAQS)

Pollutant	*Parameter*	*Industrial areas*	*Residential and rural areas*	*Sensitive areas*
Suspended Particulate Matter (SPM)	Annual average	360 µg/m³	140 µg/m³	70 µg/m³
	24-hour average	*500 µg/m³*	*200 µg/m³*	*100 µg/m³*
Respirable Suspended Particulate Matter (RSPM), less than 10 microns	Annual average	120 µg/m³	60 µg/m³	50 µg/m³
	24-hour average	*150 µg/m³*	*100 µg/m³*	*75 µg/m³*
Sulphur dioxide (SO_2)	Annual average	80 µg/m³	60 µg/m³	15 µg/m³
	24-hour average	*120 µg/m³*	*80 µg/m³*	*30 µg/m³*
Oxides of nitrogen as NO_X	Annual average	80 µg/m³	60 µg/m³	15 µg/m³
	24-hour average	*120 µg/m³*	*80 µg/m³*	*30 µg/m³*
Carbon monoxide (CO)	8-hour average	5.0 mg/m³	2.0 mg/m³	1.0 mg/ m³
	1-hour average	*10.0 mg/m³*	*4.0 mg/m³*	*2.0 mg/m³*

Annual average: Arithmetic mean of a minimum of 104 measurements per year taken twice a week 24-hourly at uniform intervals.
24/8-hourly average: Values should be met 98% of the time in a year while 2% may exceed but not on two consecutive days.

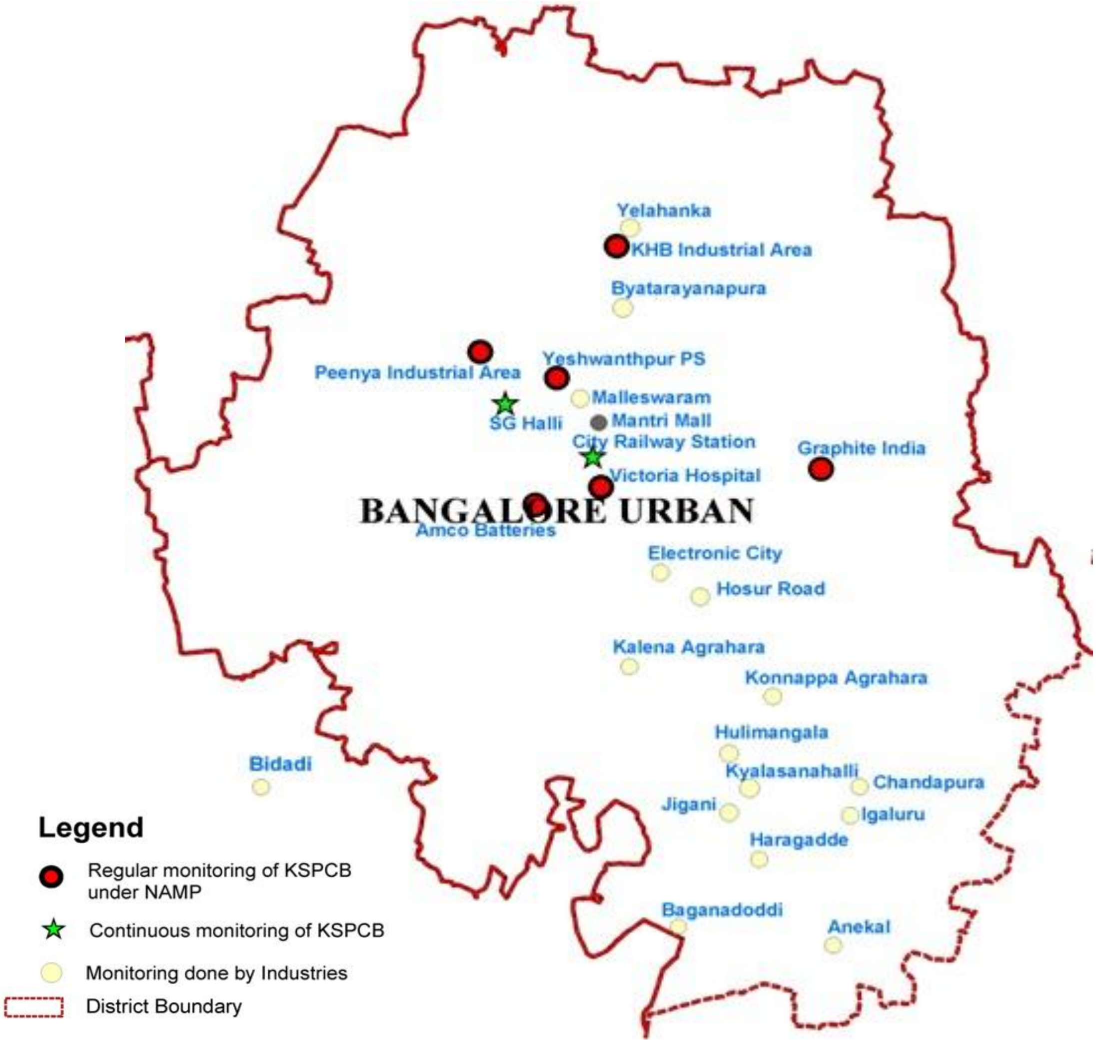

Figure 2: Air quality monitoring stations

1.2. DATA OF NATIONAL AMBIENT AIR MONITORING PROGRAMME

Annual average air quality data monitored for SPM, RSPM, SO_2 and NO_X under the National Ambient Air Monitoring Programme (NAMP) covers the period from 2002 to 2007. KSPCB maintains this data in electronic format. The data pertaining to the period 2006-07 is presented in Figure 3. The independent monitoring series at City Railway Station and SG Halli recorded hourly averages of RSPM, CO_2 NOX and SO_X continuously between December 2007 and April 2008. In the following sections the results of both monitoring series are given.

1.2.1. Suspended particulate matter

The average annual concentration of suspended particulate matter (SPM) during the year 2006-07 shows that the concentrations of SPM at Victoria Hospital, a sensitive area, exceeded the National Ambient Air Quality Standards (NAAQMS) for sensitive areas of 70 $\mu g/m^3$ (refer to Table 1). It even exceeded the limit for industrial areas of 360 $\mu g/m^3$ indicating that the hospital area is highly pollution prone. Also the annual average concentration at Graphite India, located in an industrial area, exceeded the standards for industrial areas.

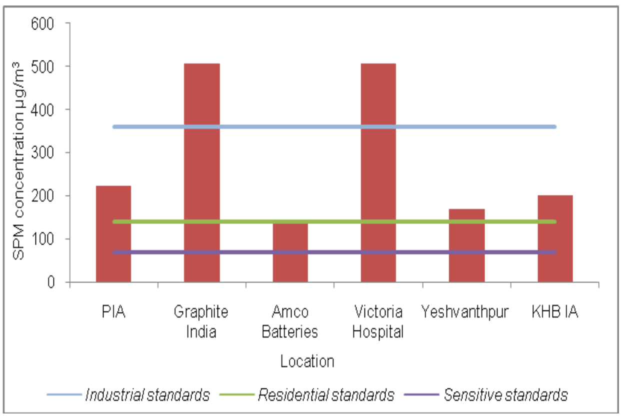

Figure 3: Annual SPM concentration in industrial, residential and sensitive areas in 2006-07

The major air pollution source is the combustion of fossil fuel of which transport, industry and domestic sectors are the main consumers. As a result SPM has become the major problem of Bangalore. It shows a prominent increase in annual average concentrations at major industrial areas and traffic intersections. The fact that concentrations in industrial areas also exceed the prescribed limits indicating the degree of severity and resulting in an adverse impact on human health.

1.2.2. Respirable particulate matter

Combustion processes, especially of normal sulphur diesel fuel also produce inhalable and toxic emissions smaller than 10 microns. This is the major source of respirable dust. At Victoria Hospital the data of 2006-07 shows that concentrations exceed the limits set for sensitive areas of 50 µg/m^3. Also at Graphite India, situated in an industrial area, the limit of 120 µg/m^3 has exceeded as well. Only in residential areas presented by Yeshwanthpur and Amco Batteries the concentrations were found to be just within the prescribed limit of 60 µg/m^3. Based on the data available, it can be estimated that 30% to 40% of particulate matter is respirable. This indicates that sources other than combustion are also contributing to air pollution in Bangalore.

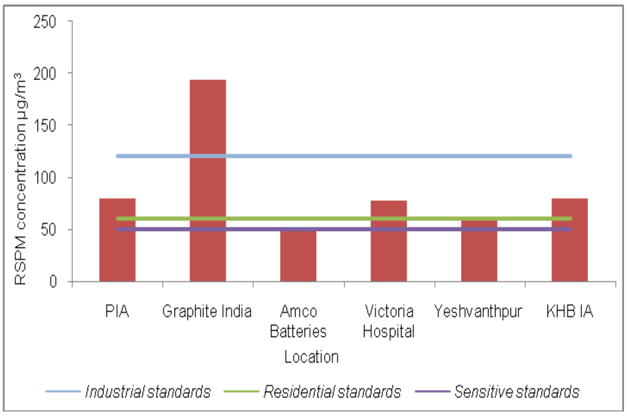

Figure 4: Annual RSPM concentration in industrial, residential and sensitive areas in 2006-07

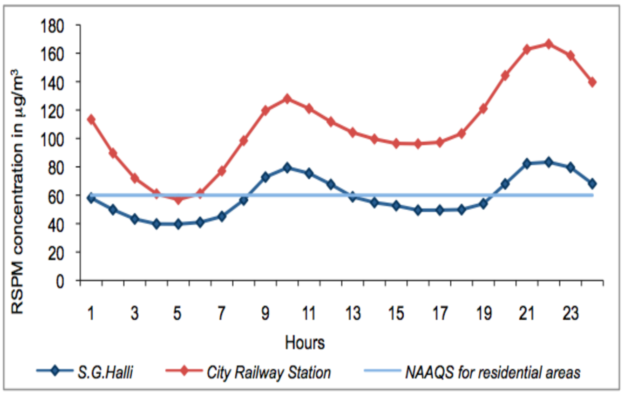

Figure 5: 24-hour RSPM concentration in residential locations in 2007-08

At City Railway Station and SG Halli RSPM concentrations were highest at peak hours i.e. morning 8 am to 12 pm and in the evening between 7 pm and 10 pm while the trajectories of both locations show a striking similarity. It should be noted, however, that throughout the day RSPM at the railway station is nearly double as high as at SG Halli and well beyond permissible limits for an alarming 23 hours a day.

1.2.3. Sulphur dioxide

Sulphur dioxide (SO_2) is a major air pollutant emitted from combustion processes of all fossil fuels. Air monitoring results of Bangalore show that the annual average concentrations are by and large compliant with applicable standards. The values obtained for all locations do not significantly exceed the limit prescribed for sensitive areas (15 µg/m^3) although, with the exception of Victoria Hospital, none of the areas needs to be classified as sensitive.

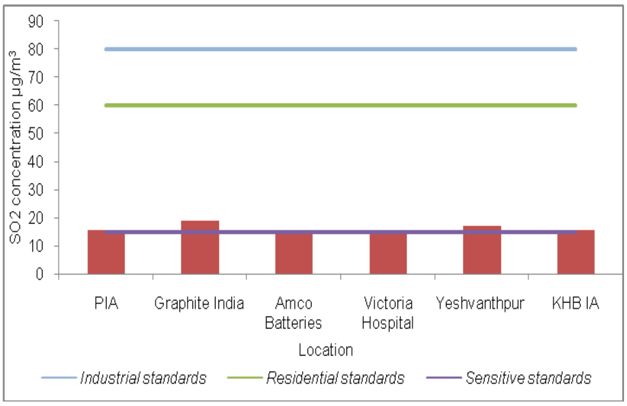

Figure 6: Annual SO_2 concentration in industrial, residential and sensitive areas in 2006-07

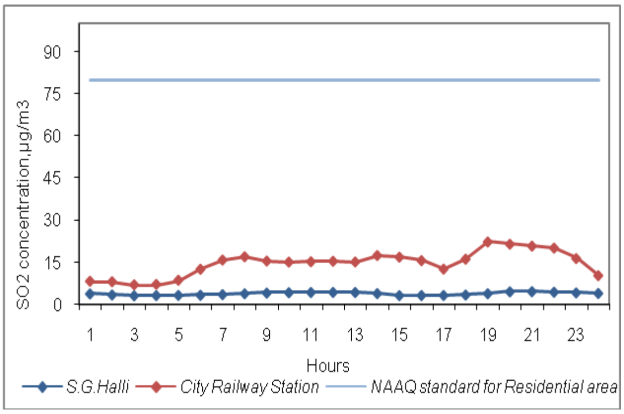

Figure 7: 24-hour SO_2 concentration in residential locations in 2007-08

No particular trend is apparent for SO_2 at City Railway Station and SG Halli RSPM. Low sulphur content of the few diesel vehicles plying to SG Halli, a residential area, is the most probable reason. Similarly, the number of diesel engine trains passing through the City Railway Station is limited. The SO_2 concentrations in Indian cities are generally low except in certain industrial areas where, apart from fuel combustion, it is also emitted from industrial chemical processes. Low SO_2 pollution in Bangalore could be attributed to low sulphur content of fuel. Some experts opine that under Indian climatic conditions SO_2 in gaseous form might get converted to sulphate in particulate matter. Since data on sulphate content in particulate matter is not available, reasons for the low value cannot be substantiated. This warrants future studies and the inclusion of particulate characterisation in ambient air quality monitoring programmes.

1.2.4. Oxides of nitrogen

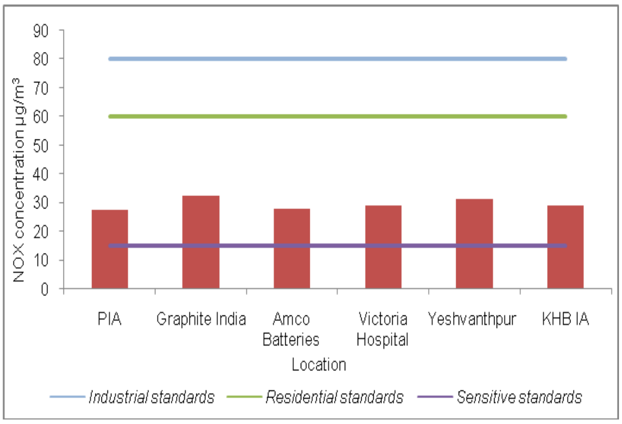

Figure 8: Annual NO_2 concentration in industrial, residential and sensitive areas in 2006-07

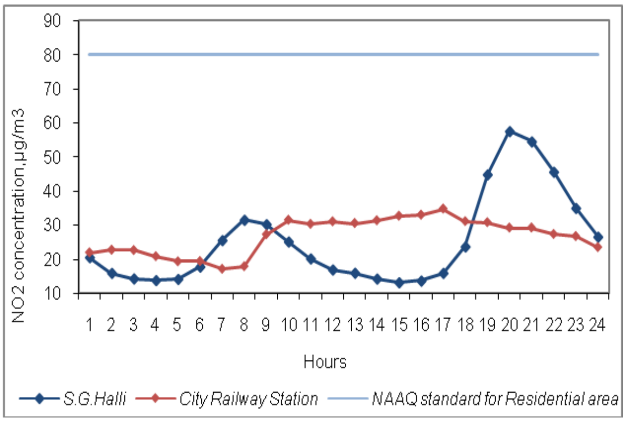

Figure 9: 24-hour NO_2 concentration in residential locations in 2007-08

Figure 8 describes the annual average concentrations of NO_2 in different parts of the city during 2007. Its sources are the same as that of SO_2 namely, industrial process, transportation and domestic combustion. Annual average concentrations are well within the standards except for Victoria Hospital, which needs to be classified as sensitive although it is located in an area dominated by commercial activities and high traffic loads. Therefore it is not surprising that the air quality exceeded the limits for sensitive yet were compliant with the standard for residential areas that is applicable to its neighbourhood.

At SG Halli, a residential area, NO_2 shows a bimodal peak similar to that of RSPM of the same location. This suggests that vehicular emissions are the major source of air NO_2. No particular trend was observable at City Railway Station.

1.2.5. Carbon monoxide

Carbon monoxide (CO) was monitored only at City Railway Station and SG Halli. Highest concentrations were observed at peak hours, i.e. morning 8 am to 12 pm and in the evening between 7 pm to 10 pm.

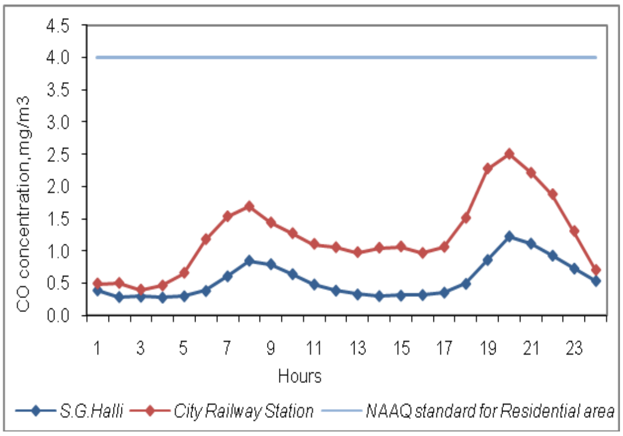

Figure 10: 24-hour CO concentration in residential locations in 2007-08

1.3. DATA OF THE MOBILE LAB

1.3.1. Monitoring at intersections

The mobile monitoring lab of KSPCB analyses immediate parameters in the field itself. The laboratory is recognised by EPA and is currently in the process of obtaining NABL accreditation. The mobile lab presently studies five parameters namely NO_X, CO, SPM, ozone (O_3) and CO at major traffic intersections in the city. Details of concentration of air pollutants monitored through mobile lab are as shown in Table 3. The data shows that NO_X, SO_2 and SPM concentrations at all monitoring stations are well compliant with residential limits. It is alarming, however, that the 24-hour averages for CO have exceeded even the 8-hour standards in more than 90% of the samples. CO is chiefly a product of incomplete combustion and found generally higher in diesel engine exhausts than in petrol. The results point at old or poorly maintained heavy vehicles such as lorries or buses as culprits.

Table 3: 24-hour averages of pollutants at major intersections in 2003-04

Intersection	NO_X in µg/m^3	SO_2 in µg/m^3	SPM in µg/m^3	O_3 in µg/m^3	CO in mg/m^3
Airport Road	37.2	2.4	122.0	4.3	1.7
Mekhri Circle	79.0	2.4	127.0	4.1	2.3
Yeshwanthpur	58.0	3.9	141.9	3.4	3.2
MC Tollgate	73.0	3.6	134.0	3.4	3.3
Indian Express Circle	79.3	4.5	147.9	2.2	4.5
K.G. Circle	47.2	4.4	164.5	2.4	4.6
Town Hall	38.2	4.8	154.1	2.4	4.8
Mahatma Gandhi Road	26.8	4.6	96.5	2.3	5.1
Peenya Industrial Area	19.4	4.8	153.7	2.0	3.5
Victoria Hospital	3.1	3.6	65.2	2.1	2.5
Jayanagar	10.7	3.9	72.0	1.7	3.3
Residency Road	24.0	4.6	115.0	1.9	4.8

Source: KSPCB

Figure 11: Smoke from this lorry exhaust is visible even at idle speed

1.3.2. Monitoring of solvents

CPCB has also monitored benzene, toluene and xylene (BTX) levels in the ambient air at selected locations in Bangalore. Concentrations detected at Rajajinagar residential area during the winter months of 2002-2003 are given in Table 4. Benzene levels show a range of 9-39 ppb. There is no safe level for air-borne benzene and India is yet to notify standards. The UK has set limits for benzene to 5 ppb (15 µg/m^3) and WHO to 5-20 µg/m^3. The WHO limit for toluene is 1 µg/m^3. Both benzene and toluene levels in Rajajinagar are above WHO standards. The average benzene level is more than four times higher than considered safe in the UK. The reasons are attributed to emissions from vehicles, the burning of oil and solvent processes in the nearby industrial area and evaporation from petrol pumps. A significant peak in concentration occurs between 4 pm and 8 pm, the period when most people return from work.

Some facts about benzene

Benzene is a confirmed human carcinogen. It is released into the environment through combustion of gasoline and industrial solvents. Exposure is also linked to genetic changes, increased proliferation of bone marrow cells and occurrence of certain chromosomal aberrations in humans and animals. Outdoor levels are 0.2 µg/m3 in remote rural areas and in industrial centres have been found to reach up to 350 µg/m^3.

Table 4: BTX levels at Rajajinagar residential area in 2002-03

Period of the day	Benzene in ppb	Toulene in ppb	Ethylbenzene in ppb	M.P.-Xylene in ppb	O-Xylene in ppb
00:00 – 04:00 hours	20	46	8	32	1.5
04:00 – 08:00 hours	9	19	4	14	3
08:00 – 12:00 hours	21	48	9	37	11
12:00 – 16:00 hours	20	49	9	36	5
16:00 – 20:00 hours	39	99	19	64	24
20:00 – 24:00 hours	31	78	16	58	22
Average	***23***	***56***	***11***	***40***	***11***

Source: CPCB

1.4. DATA OF THE BANGALORE METRO

Bangalore Metro Rail Corporation Limited (BMRCL) has carried out an environmental baseline study that entailed monitoring of ambient air quality at 17 traffic intersections along the route of the planed metro. The monitoring of air quality extended over the year 2006 and covered all seasons.

The annual average of SPM concentration at these locations ranged from 108 µg/m^3 to 170 µg/m^3. The limits of 140 µg/m^3 were exceeded at Tumkur Road –, Road Ring junction (1. in Figure 12), Yeshwanthpur Railway Station (2.), Majestic near Police Station (4.), Byappanahalli Depot (9.), MG Road (13). Fortunately, RSPM ranged only from 33 µg/m^3 to a maximum of 55 µgm/m^3, below the limit of 60 µg/m^3 for residential areas.

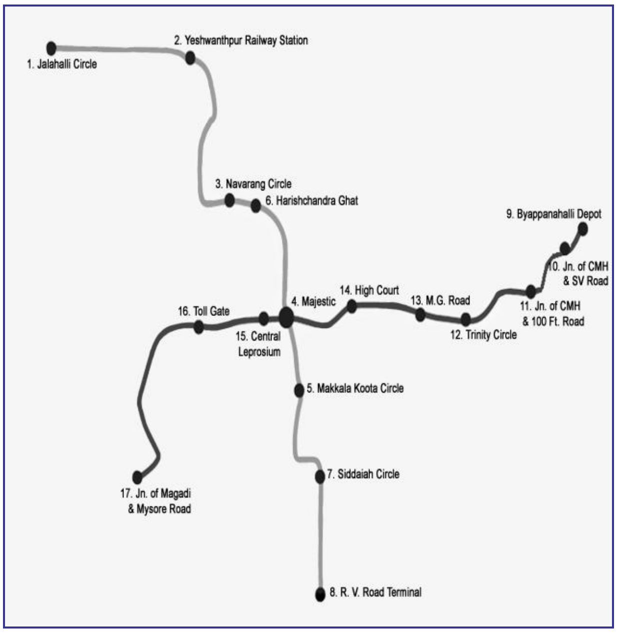

Figure 12: Location of monitoring stations

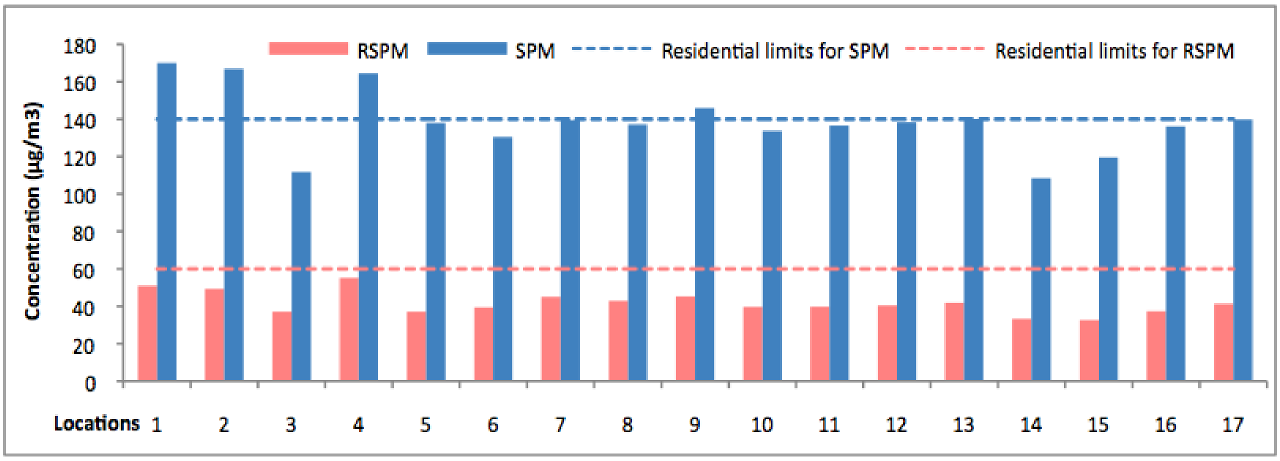

Figure 13: Ambient air quality along the planned metro in 2006

1.5. DATA OF INDUSTRIAL AREAS

Environment Management and Policy Research Institute (EMPRI) monitored the ambient air at Peenya Industrial Area and Dobbaspet Industrial Area in March 2006. Monitoring was conducted on an 8-hour basis for 3 days and samples were analysed by CPCB Southern Zonal Office, Bangalore. The results indicate that pollutants are below permissible limits. Contrary to expectation, SO_2 values for two sites were even below detectable limits (BDL). A possible reason for this could be that monitoring sites were located in the interior of the estate and not in proximity to chimneystacks or roads. The conclusiveness of the study suffered somewhat from limited information about the sampling spots and the short sampling duration while the results were not entirely free from doubt as to the veracity of analysis.

Table 5: 8-hour averages at Peenya Industrial Area

Sampling spot	***SO_2 in µg/m^3***	***NO_X in µg/m^3***	***RSPM in µg/m^3***
M/s John Crane	BDL	22.3	109
M/s Ace Designer	BDL	21.0	138
BMTC Bus Depot	54.0	17.0	145
24-hour limit for industrial areas	***120***	***120***	***150***

Table 6: 8-hour averages at Dobbaspet Industrial Area

Sampling spot	*SPM in µg/m³*	*RSPM in µg/m³*
M/s ANZ International	74.3	49.0
M/s SembRamky BMW Incinera-tion Plant	96.7	63.7
M/s E-Parisaraa	146.0	63.7
KIADB water tank	92.7	53.0
KIADB at Tumkur Road	195.3	51.7
Yedehalli village	124.7	81.7
Geetha English School	96.0	56.3
24-hour limit for industrial areas	***500***	***150***

Self monitoring

Several industries monitor ambient air quality routinely on their premises and report it to KSPCB. Data is submitted in the context of Environment Impact Assessments, environmental statements and, more frequently, to meet the regulatory requirements specified by consent conditions. Such self-monitored data from industries in 15 different locations is shown in Figure 15. Typically, the data does not specify the monitoring period or the averaging method used and so it should be assumed that it represents instantaneous values instead of averages.

The data reported to KSPCB gives no indication of any reason for concern. This is not entirely surprising as it is conceivable that data reported was chosen based on whether it is in compliance with standards and thus "safe". It also seems reasonable to assume that air is monitored primarily in larger enterprises that may have better capacity to act on pollutants than small-scale enterprises that typically do not monitor. The picture presented should thus not be considered representative for air quality in Bangalore's industrial areas.

Figure 14: Smoke above industrial sheds on Mysore Road, presumably without self-monitoring

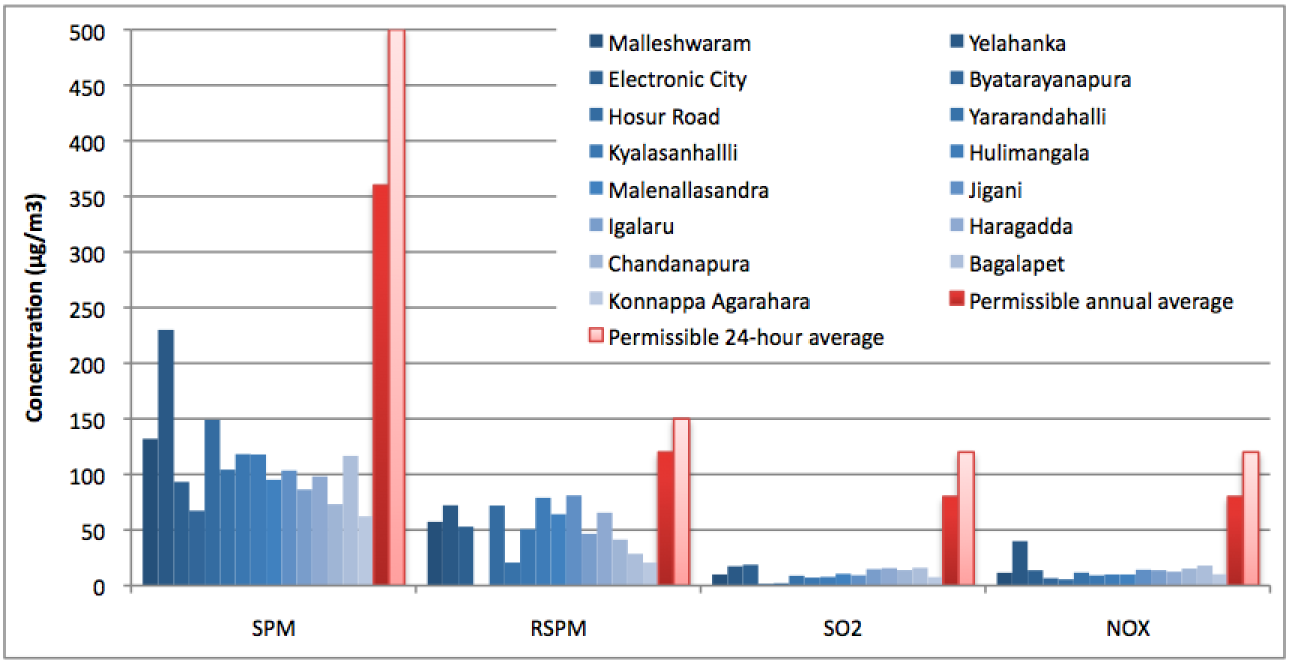

Figure 15: Self monitoring results in selected industrial areas

1.6. AIR POLLUTION TRENDS

The trend lines for particulate matter between 2002 and 2007 are inconclusive. A slight increase is noted for SPM in three out of six monitoring locations. One trend line is declining and the one for Graphite India is steeply rising. The reason for high particulate matter levels include vehicles, engine generator sets, industries, incineration, re-suspension of traffic dust and use of commercial and domestic fuels. As expected, trends for these locations are visible as RSPM concentrations as well. RSPM levels exceed the prescribed NAAQS in most of the industrial areas.

SO_2 levels apparently have not risen in sample locations even though there has been a significant rise in population, industrial activities and registered vehicles since 2002. The reason for this encouraging trend is presumed to be the combined impact of regulatory restrictions on SO_2 emissions and strict enforcement of appropriate heights of industrial chimneystacks. Besides, the sulphur content in diesel has been reduced to 0.05% in steps. Other measures include the implementation of Bharat Stage III emission norms adopted for new vehicles.

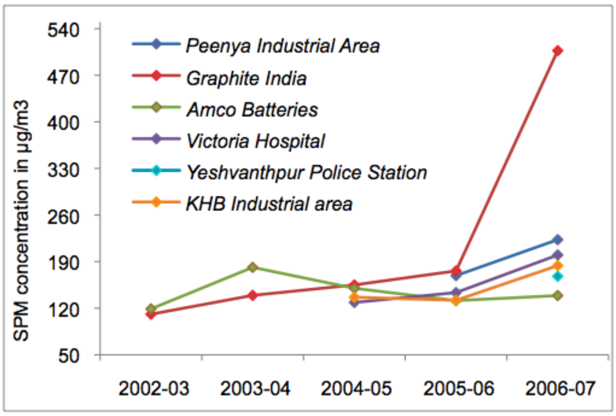

Figure 16: Trend of annual average of SPM

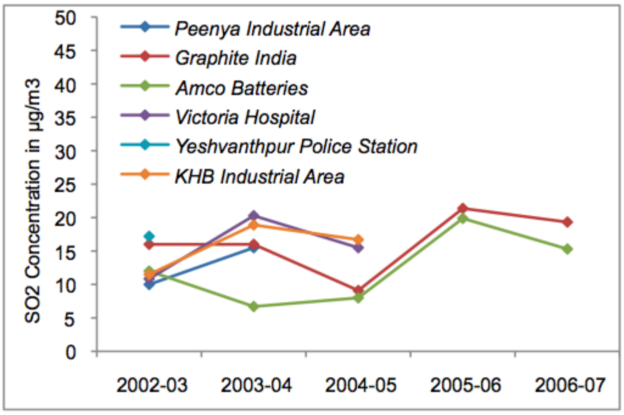

Figure 18: Trend of annual average of SO_2

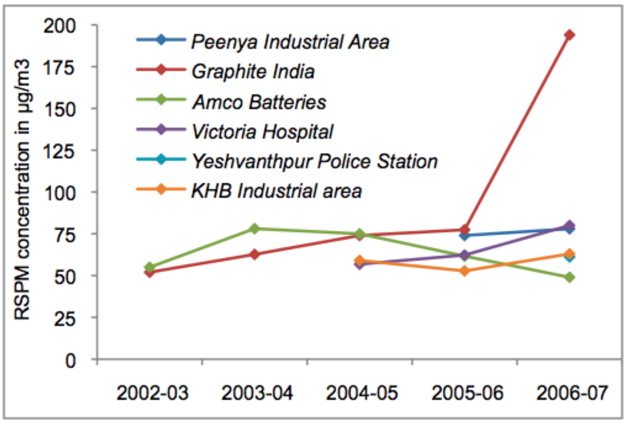

Figure 17: Trend of annual average of RSPM

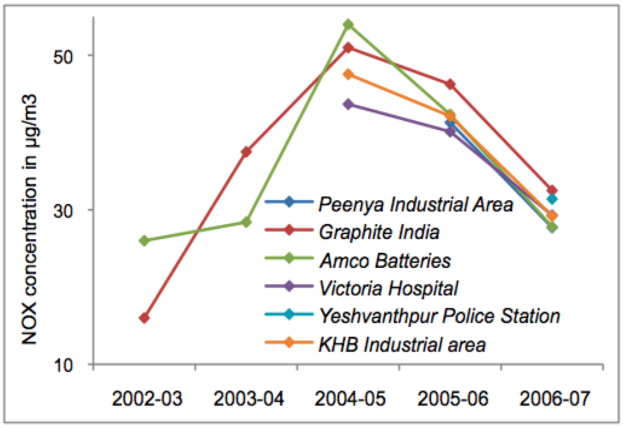

Figure 19: Trend of annual average of NO_X

Also NO_X concentrations as depicted in Figure 19 have shown to decrease in all six selected locations over the past two years. Yet, since the major source of NO_X are vehicle emissions and since their numbers have continued to increase the trend exhibited does not appear plausible. The issue requires further examination than the present data lends itself to.

1.7. AIR QUALITY INDEX

Based on monthly average results of the National Ambient Air Monitoring Programme for 2006-07 an air quality index has been calculated. Table 7 presents the air quality index (AQI) of six locations, covering industrial areas (Graphite India, KHB Industrial area, Peenya Industrial Area), residential areas (AMCO Batteries, Yeshwanthpur) and a sensitive area (Victoria Hospital).

Table 7: Bangalore air quality index (AQI) 2006-07

SPM	SO_2	NO_X	AQI	Rank	SPM	SO_2	NO_X	AQI	Rank	SPM	SO_2	NO_X	AQI	Rank
Graphite India (industrial)					*KHB Industrial Area (industrial)*					*Peenya Industrial Area (industrial)*				
398	23.4	31.4	**124.3**		160	22.1	31.0	**68.5**		210	21.0	31.0	**79.5**	
328	22.9	31.8	**108.2**		173	20.7	30.3	**70.4**		196	20.5	29.0	**74.9**	
222	22.4	32.2	**83.7**		99	19.9	19.9	**46.9**		227	18.8	29.0	**81.2**	
204	19.7	34.0	**79.1**		102	17.5	22.4	**47.7**		336	18.0	23.6	**103.0**	
332	23.8	39.1	**113.5**		129	20.5	28.8	**59.2**		293	18.2	27.4	**95.3**	
525	28.9	24.8	**152.7**		192	15.1	22.8	**67.7**		290	9.9	18.7	**85.4**	
647	15.7	31.6	**176.9**		144	14.9	32.0	**61.4**		171	11.7	21.1	**60.0**	
900	13.8	31.5	**232.7**		236	15.3	32.1	**83.1**		174	13.4	29.6	**66.3**	
1,004	13.8	30.1	**255.2**		209	12.1	30.8	**74.4**		179	12.5	30.0	**67.2**	
590	14.0	32.9	**163.8**		230	14.0	32.3	**81.1**		169	13.6	29.4	**65.1**	
455	14.2	37.3	**135.6**		219	13.8	35.5	**80.2**		208	14.7	32.6	**76.5**	
AMCO Batteries (residential)					*Victoria Hospital (sensitive)*					*Yeshwanthpur (residential)*				
160	22.1	31.0	**38.2**		255	24.1	31.1	**47.8**		218	21.0	29.3	**42.4**	
173	20.7	30.3	**38.5**		225	19.4	26.8	**41.3**		162	21.6	31.2	**38.3**	
99	19.9	19.9	**26.9**		130	15.9	27.6	**31.4**		123	19.8	30.0	**33.4**	
102	17.5	22.4	**27.3**		141	18.3	22.3	**31.2**		151	17.0	20.8	**31.0**	
129	20.5	28.8	**33.7**		165	12.3	25.5	**32.3**		163	21.6	37.2	**40.8**	
192	15.1	22.8	**34.8**		144	17.5	33.1	**35.7**		165	20.0	25.6	**35.5**	
144	14.9	32.0	**34.1**		184	11.4	29.3	**35.2**		136	16.8	29.2	**33.0**	
236	15.3	32.1	**42.8**		167	14.2	27.5	**34.1**		131	13.4	38.5	**35.0**	
209	12.1	30.8	**38.5**		192	13.6	31.3	**37.7**		158	13.4	34.7	**35.9**	
230	14.0	32.3	**41.8**		260	12.8	33.4	**44.6**		248	13.5	32.2	**43.2**	
219	13.8	35.5	**42.1**		245	12.4	33.5	**43.0**		187	14.2	37.8	**40.2**	

Legend

Ranks	> 100	Severe air pollution
	75-100	Heavy air pollution
	50-75	Moderate air pollution
	25-50	Light air pollution

From the data of Table 7 it was inferred that Graphite India is affected by severe air pollution as indicated by very high air quality indices. Peenya fares marginally better, showing average quality levels of heavy air pollution. The situation in KHB Industrial, which on average is moderately polluted, is better as compared to the former two. Only in residential and sensitive areas the air quality is better but still lightly polluted. Looking at the trend over the last four years in Figure 20, it could be inferred that Graphite India, representing an industrial area, shows a sudden change in its air quality from being lightly polluted to severe. The same is the case with KHB and Peenya Industrial Area. However, at Amco Batteries and Victoria Hospital representing mixed and sensitive area respectively shows a gradual change in its air quality from being less pollution to moderate pollution. The data makes the prevailing air pollution apparent.

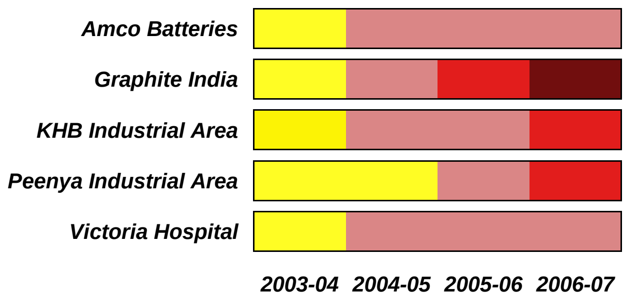

Figure 20: Air quality index trends

2. INDOOR AIR QUALITY

It has been recognised that indoor air pollution due to solid fuel usage is a major health concern, particularly among women and children. As per 2001 Census data, about 79% of rural households in Bangalore still rely on solid bio-fuels for domestic cooking needs. In urban areas there has been a considerable increase in the share of LPG as cooking fuel. Nevertheless, poor households in urban areas still use biomass or kerosene in less ventilated kitchens where the level of pollutants would be much higher. With growth in per capita income and urbanisation, households tend to move on from solid fuels to the more convenient LPG. For the distribution of cooking fuels among households refer to Chapter 9 "ENERGY", section 1.5.

Combustion of biomass fuel emits a considerable quantity of pollutants such as particulates, carbon monoxide (CO), polycyclic organic matter and formaldehyde. As part of the study conducted by Regional Occupational Health Centre (ROHC) in 2005 the indoor air pollution measurements were done among different fuel use categories namely firewood, kerosene and LPG. The study reports high concentration of particulate matter among fire wood users. Total organics (TO) concentration was high among LPG users as well (refer to Table 8). The study also measured volatile organic compounds (VOC) where benzene and styrene levels were especially high among LPG users (refer to Table 9).

Table 8: Concentration of particulate and gaseous pollutants in residential areas

Category	SPM (mg/m^3)		RPM (mg/m^3)		SO_2 (mg/m^3)		NO_X (mg/m^3)		TO (mg/m^3)	
	n	Mean ± SD (range)	n	Mean ± SD (range)	n	Mean ± SD (range)	n	Mean ± SD (range)	n	Mean ± SD (range)
LPG	14	333 ± 239 (ND-833)	14	235 ± 142 (ND- 563)	15	0.82 ± 0.68 (0.10-2.08)	15	6 ± 3 (2-14)	14	6 ± 4 (ND-14)
Kerosene	16	538 ± 324 (103-1146)	16	490 ± 202 (185-890)	16	1.35 ± 0.24 (0.69-1.67)	16	80 ± 54 (2 - 172)	13	4 ± 3 (ND-12)
Firewood	11	1078 ± 897 (66-2784)	11	904 ± 623 (146-1824)	11	0.98 ± 0.67 (0.31-2.56)	11	48 ± 45 (6-135)	10	1 ± 1 (ND-3)

Source: Regional Occupational Health Centre (ROHC), 2005

Table 9: Concentration of volatile organic compounds (VOC) in residential areas

Category	n	Benzene (mg/m^3)		Toulene (mg/m^3)		Xylene (mg/m^3)		Styrene (mg/m^3)	
		n	Mean ± SD (range)	n	Mean ± SD (range)	n	Mean ± SD (range)	n	Mean ± SD (range)
LPG	15	10	168 ± 184 (26- 516)	4	54 ± 32 (19-94)	7	77 ± 80 (18-250)	5	37 ± 35 (13- 95)
Kerosene	16	15	77 ± 50 (19 – 185)	13	28 ± 17 (11 - 57)	10	52 ± 46 (11 – 128)	8	25 ± 18 (11 – 63)
Firewood	13	12	109 ± 64 (44 -223)	6	51 ± 37 (22 - 104)	10	23 ± 15 (11 – 60)	4	23 ± 8 (15 - 32)

Source: Regional Occupational Health Centre (ROHC), 2005

Exposure to high levels of indoor air pollution has serious consequences on health, particularly on women and children as they generally spend more time indoors. WHO pointed out that inhalation of indoor air pollution doubles the risk of pneumonia and other acute lower respiratory tract infections (ALRI) among children below five years and increases the risk of chronic obstructive pulmonary diseases (COPD) among women by three times than women who cook with cleaner fuels (WHO 2006). Some studies have linked the exposure to indoor air pollution to asthma, cataracts, tuberculosis, adverse pregnancy outcomes and interstitial lung diseases (Smith 2000). Indoor air pollution is the third most important risk factor next to poor water and sanitation and malnutrition of ill health and responsible for 17% of all deaths among children under five in India (Smith KR, Mehta S, Feuz M. 2004). Switching from solid unprocessed biomass fuels to more efficient and cleaner fuels such as LPG and biogas can reduce indoor air pollution levels substantially and improve the health of residents. It has been reported that if a household shifts from crop residues to LPG, the indoor PM and CO levels could be reduced by 95% (Smith, Zhang, Uma et al 2000).

Figure 21: Indoor air pollution is not limited to temporary sheds – Construction shed in J.P. Nagar

A recent worldwide analysis of WHO reveals that the provision of LPG, biogas or modern bio-fuels to 100 million homes would reduce the exposure levels of harmful indoor air pollution among 473 million people and save 282,000 pre-mature deaths per year occurring due to respiratory diseases (WHO 2006). In spite of these significant benefits of LPG, there are barriers existing in the widespread use of LPG among poor. The cost of LPG is relatively high when compared to the financial resources available with the poor from their incomes. In remote villages, access to LPG supplies also acts as a constraint. Micro-credit facilities and a targeted subsidy could perhaps help in lowering the financial barrier. The existing subsidy scheme needs to be modified so as to reach the poor.

However, cleaner commercial fuel is understood to remain out of reach for economically weaker sections. Past efforts therefore focused rightly on improving the design of *chulas*, traditional stoves, to optimise combustion. These efforts have achieved commendable reduction of smoke and other pollutants while permitting the continuation of traditional fuel use. Regrettably, no information is available about the actual penetration of improved *chluas* in BMR but improved designs are believed to be widely used across Karnataka.

3. NOISE

Another important polluter of Bangalore is excessive noise. Important sources of noise include traffic, flying aircraft near airports, drilling of bore wells, industries, construction activities, DG sets, public address systems playing loud music during festivals like *Deepavali*, *Ganesha Chathurthi* and other occasions. No continuous monitoring programme is in place for noise. But some studies have been conducted on the subject over the last two decades by both regulatory agencies as well as by major project implementers. But, by and large these studies were of short duration and limited to specific locations. The data available therefore, does not permit the assembly of the overall scenario, neither does it give insight into trends.

3.1. TRAFFIC NOISE

Noise levels and frequencies were monitored by CPCB at important locations of the city to assess the magnitude of noise pollution. The study has revealed that noise levels in a silent zone around Victoria Hospital near City Market are far higher than permissible. The sound levels during the day (6 am to 10 pm) were as high as 64 to 79 dB (A) as against the permissible limit of 45 dB (A). At night (10 pm to 6 am) the levels ranged between 58 and 70 dB (A) as against the permissible limit of 40 dB (A). Noise levels were also recorded inside the wards where they varied from 65 to 70 dB (A). The wards are located a kilometre away from the busy Mysore – Bangalore Road. As such, there is significant movement of traffic to and fro from the market creating noise. More or less the same situation exists in other sensitive zones where hospitals are located. The study also revealed that the noise levels in a sensitive area near National College, Vanivillas Circle and KIMS Circle were far higher than permissible limits. The sound levels during the day (8.30 am 11.30 am) were in the range of 74-80 dB (A). Additional trees and plants would be capable of absorbing noise, which could reduce the levels at least in sensitive areas.

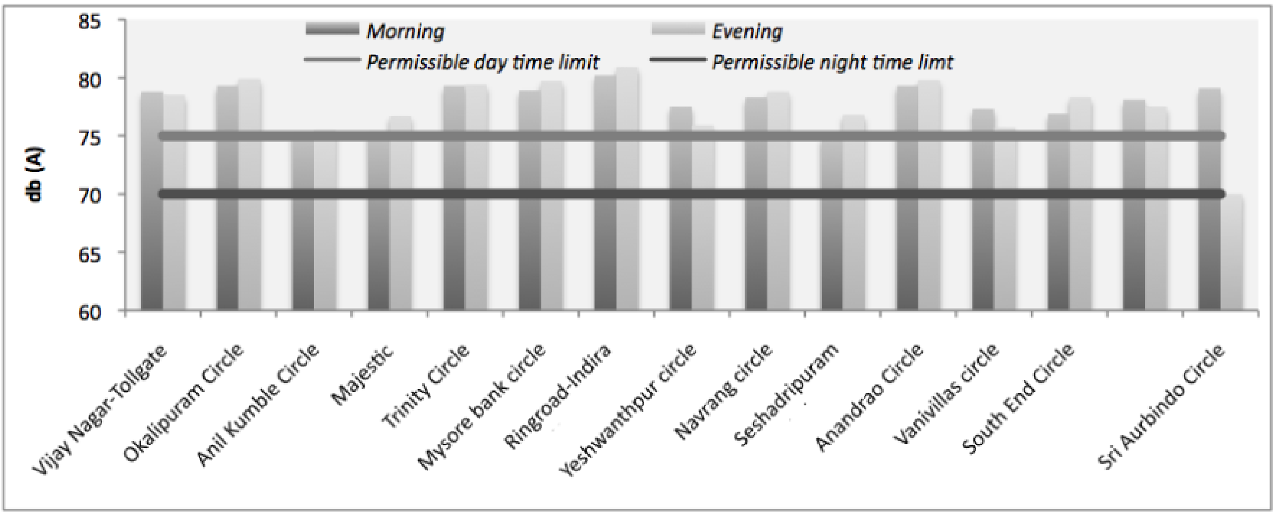

Figure 22: Traffic noise monitored by CPCB

Figure 23: Belching high-decibel two-stroke auto rickshaw, City Market

Also the Bangalore Metro Rail Corporation Limited (BMRCL) has monitored traffic noise in 17 selected locations (see Table 10). In this study the noise levels were monitored during day and night time, concluding alarmingly that noise levels exceed the permissible limits at all times and at all locations.

Table 10: Traffic noise monitored by BMRC

Locations	L_{day}	L_{night}
Tumkur Road – Ring Road junction	80.5	76
Yeshwanthpur Railway Station	76.8	74.2
MKK Road – West of Chord Road junction	76.4	71.7
Majestic Circle	78.9	74.0
KR Road – Albert Victor Road junction	75.7	68.7
Harischandra Ghat on MKK Road	76.5	70.8
Sidaiah Chowk/ Circle	76.0	69.3
South End Road – RV Road junction	76.8	69.7
Byppanahalli Depot near Police Station	76.5	69.1
Road – SV Road junction	76.6	69.3
CMH Road – 100 ft Road junction	76.9	70.5
Trinity Circle	76.0	70.5
Queens Road – MG Road junction	75.3	71.7
Opposite to High Court	75.7	71.6
Central Leprosium – Magadi Road	74.8	69.3
Magadi Road – Chord Road junction	76.4	70.3
Magadi Road – Mysore Road juntion	77.9	73.7

3.2. INDUSTRIAL NOISE

Noise levels were monitored in Jigani Industrial Area in February 2008 and found to be within limits. This data, however, may not be representative for the overall situation in industrial area and in the absence of relevant data no conclusion can be drawn.

Table 11: Noise at Jigani Industrial Area in 2008

Location	Day 06:00 – 22:00	Night 22:00 – 06:00
Location 1	53.5 dB (A)	49.4 dB (A)
Location 2	59.2 dB (A)	51.6 dB (A)
Location 3	55.9 dB (A)	50.9 dB (A)
Location 4	50.4 dB (A)	41.2 dB (A)

3.3. CONSTRUCTION NOISE

Bangalore is expanding horizontally as well as vertically, sustained by construction activities noticeable across the city. Construction activities are believed to contribute a significant fraction of noise levels but data on the same is scarce. Data available for this study is limited to a single unspecified site (not in picture) in January 2009 where noise levels were found above permissible limits of residential areas.

Table 12: Noise at a construction site in 2009

Section of the site	*Max dB (A)*	*Min dB (A)*	*L_{eq} dB (A)*
Core area of project site	66.3	55.2	61.6
South-East of the project site	65.1	60.2	63.2
South of the project site	83.0	55.9	64.8
West of the project site	70.6	54.3	60.5
North-West of the project site	78.0	61.1	67.4

Figure 24: Construction site near M. G. Road

3.4. SEASONAL MONITORING

Over the last decade a change could be observed in the way *Deepawali*, the festival of lights is celebrated. From the once serene and peaceful festival it has turned into a festival of firecrackers with noise reaching unprecedented levels. Among the recent studies, CPCB and KSPCB have monitored the noise levels and frequencies at important locations of the city during the festival. The results are presented below. The findings give reason for concern, a fact that most citizens might agree with.

Table 13: Noise during *Deepawali* festival

Area	*Nature*	*Day*	*Noise levels in dB*			
			2004	*2005*	*2006*	*2007*
Jayanagar	Residential	1	—	63.7	50.7	63.0
		2	—	75.8	56.2	73.0
		3	70.4	62.4	57.2	75.0
		4	68.0	59.2	54.2	71.0
AECS Layout	Industrial	1	60.0	—	46.2	—
		2	85.0	43.2	58.29	—
		3	83.0	17.5	59.21	—
		4	73.0	41.3	49.21	—
Vijayanagar Club	Residential	1	59.8	—	42.3	75.5
		2	83.2	—	69.6	82.6
		3	87.7	—	70.2	95.4
		4	81.7	—	75.2	82.6
Indiranagar	Residential	1	68.8	—	50.1	—
		2	82.5	—	55.6	—
		3	72.1	—	55.4	—
		4	68.4	—	55.9	—
Cubbonpet	Commercial	1	43.7	59.9	—	61.0
		2	79.8	75.4	71.0	78.7
		3	81.4	87.7	74.6	91.7
		4	76.5	84.0	71.2	91.5

4. CAUSES OF AMBIENT AIR POLLUTION

In order to determine appropriate control measures it is essential to have estimates of the contribution of individual source to air pollution. Over the last few decades Bangalore has witnessed a remarkable growth in economic activities, particularly after the 1995 software boom. The transformation from a garden city into a hi-tech city has not only resulted in an enormous increase of vehicles on its roads but also in alarming levels of air pollution.

4.1. TRANSPORTATION

Economic growth promotes the intensification of urban activities including transportation, with consequential traffic congestions, accidents and generation of air pollution. Economic growth accelerates increases in the number of vehicles per capita and generates transportation needs associated with economic growth. Like other mega cities, Bangalore is also facing the challenge of providing for better transportation without incurring the negative impact on the environment.

Figure 25: Exhaust fumes lining Mysore Road

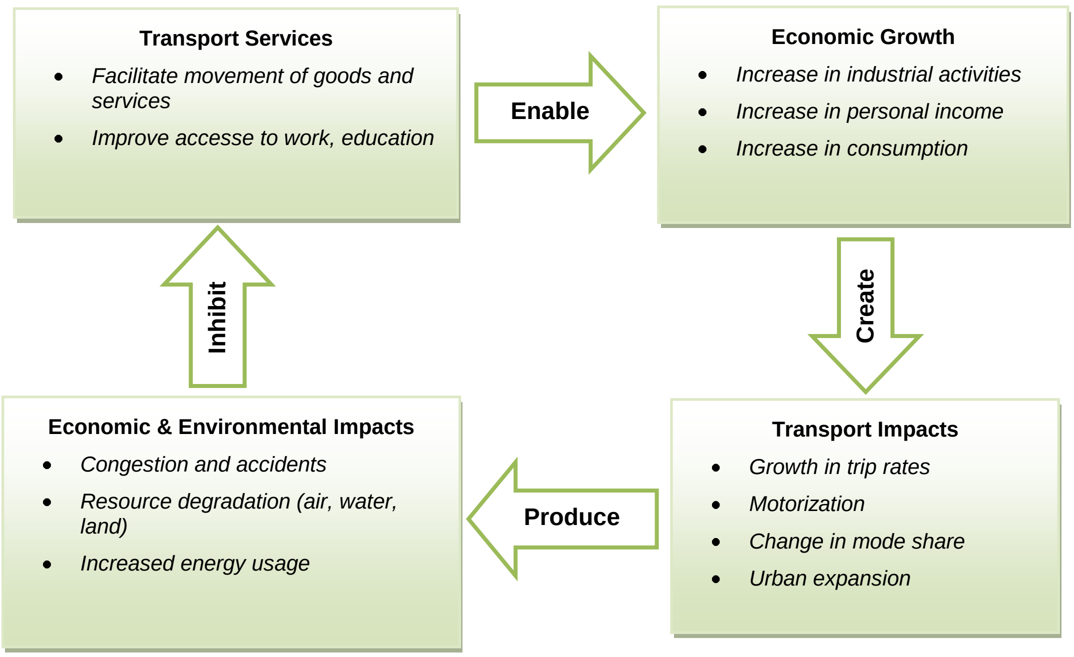

Figure 26: The vicious cycle of growth

The trend of Bangalore's vehicular population from the last two decades shows an increasing number of two-wheelers, indicating the dominance of personal over public mode of transport. The growth of the two-wheeler segment has shown an increase from 0.75 million in 1997 to an astonishing 2.04 million in 2007. The growth in car population indicates a change in the standard of living of citizens and corresponds to growing disposable income associated particularly with the IT and ITES industry. The development of Bangalore's vehicular population over the past three years is shown in Figure 27. The expansion of roads in the core areas of the city has of course not yet been synchronised with this actual increase in vehicle numbers resulting in traffic congestion, low speeds and increased air pollution and noise levels.

With the increase in human and vehicular population the fuel consumption has also increased. The last years have witnessed an increase in the consumption of petrol, diesel and LPG while kerosene is on the decrease.

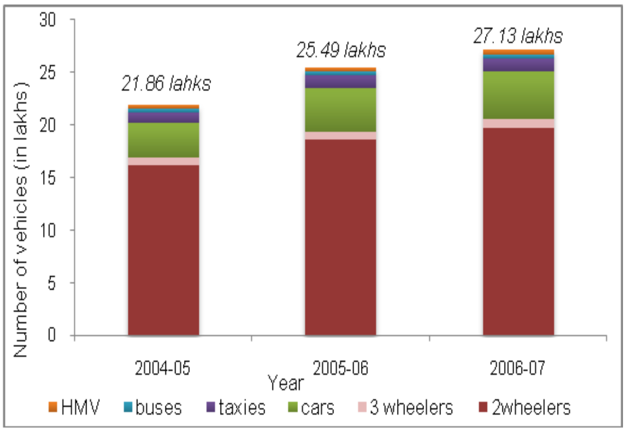

Figure 27: Trend of Bangalore's vehicle population

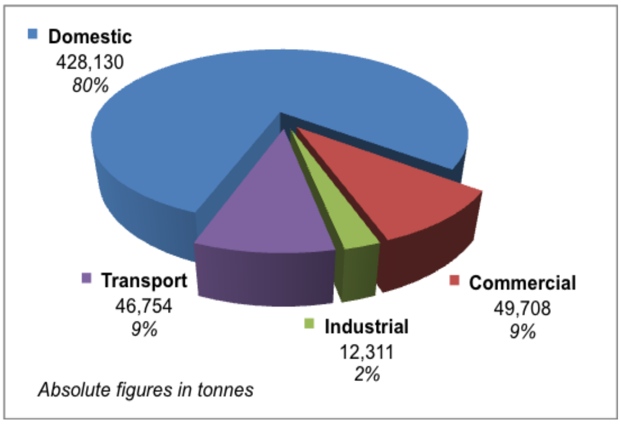

Figure 28: Bangalore's LPG consumers

The increased availability of LPG and its promotion for transportation and domestic needs has unsurprisingly resulted in increased consumption. Out of 72,000 auto rickshaws plying on the roads nearly 62,000 have been fitted with LPG kits, indicating tremendous success of the conversion initiative. Figure 28 shows that 80% of the LPG usage is, however, in domestic sector while only 9% is attributable to transportation. With the efforts of the government to making the conversion of 3-wheelers to bi-fuel mode mandatory, there is a continued shift towards LPG that definitely contributes to improving the air quality, especially in terms of particulate matter. The problem is nevertheless that the rapidly growing number of vehicles offsets these qualitative achievements with ease and so a net benefit for citizens remains elusive. The only exception seems to be SO_2 whose concentration appears to be well in control. Figure 29 shows significant rise in the overall LPG consumption while the kerosene market shows a marginal decline.

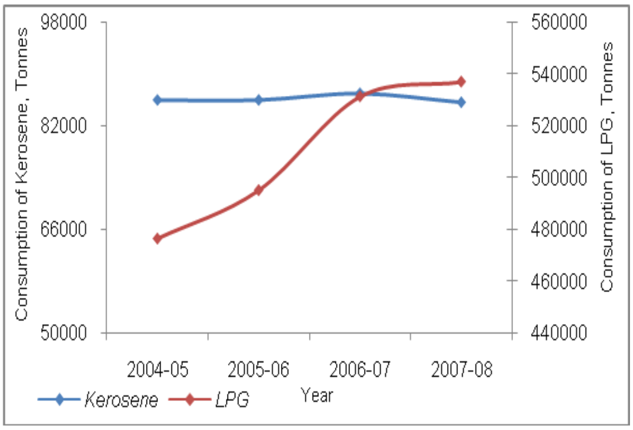

Figure 29: Consumption trends for LPG and Kerosene

Congestion

The growing number of vehicles has caused the saturation of road network in Bangalore. The city's road network has the distinction of having a very large number of intersections per unit length necessitating the introduction of a comprehensive traffic management plan to improve the major and more critical road intersections and consequently improve the traffic flow.

The Karnataka Road Development Corporation Limited (KRDCL) has conducted a study of 106 traffic intersections in five areas of central Bangalore, namely Majestic Circle, Hudson Circle, Minerva Circle, Queen's road and Mahatma Gandhi Road. The study has observed that the majority of intersections recorded peak hour volumes of over 10,000 passenger car units (PCUs). Hudson Circle intersection has recorded peak hour volumes over 20,000 PCUs while the values for other intersections were between 15,000 and 20,000 PCUs. At all intersection two-wheelers were the single largest category of vehicles except the intersections in Majestic Circle where auto rickshaws and buses account for the highest share in traffic. The congestion index exceeds 1.0 in a vast majority of the road links. Both the number of intersections and the density of two-wheelers have increased traffic congestion in the study area. The study also has revealed that the congestion of major roads results in reduced travel speed and increased fuel consumption leading to the problem of air and noise pollution. A survey conducted by BMRCL counted 30,745 vehicles or 54,867 PCUs on Tumkur Road and Hosur Road. Traffic volume was also found to be high on Bellary Road and on Airport Road.

4.2. INDUSTRIAL AND COMMERCIAL ACTIVITIES

Emissions from the industrial sector are associated with fuel combustion and industrial process as well as some emissions from management, transportation and storage of materials and products. Major SO_2 emitters include the chemical, wood and textile industry as well as non-metallic minerals. NO_X emission contributors are non-metallic minerals and metal industries. Chemicals, printing and metal industries are among the major hydrocarbon contributors. With the implementation of the Air (Prevention and Control of Pollution) Act, 1981 and the Environment (Protection) Act, 1986 legislated to protect our resources from pollution in addition to the Motor Vehicle Act 1988, industrial process emissions are being monitored by the state regulatory authorities and reported.

Due to infrastructural deficiencies in the generation of power, load shedding was and is a ubiquitous feature of Bangalore. The need for assured electricity supply in some sectors such as IT and ITES and the growing interest in captive power generation has diesel generators (DG sets) made a major source of emissions of pollutants and greenhouse gases. Across industries and commercial establishments 10,304 DG sets are on the record of the Electrical Inspectorate while CPCB estimates that the actual number could be in the order of 1 lakh.

4.3. OTHER CAUSES

Along with transportation and industry, burning of municipal solid waste, industrial waste and agricultural residues are significant sources of air pollution in the urban environment. Though pollution from burning of agricultural residues is less in Bangalore Urban district, biomass and agriculture crop residues burning in rural Bangalore district can be a major source of particulate matter and other pollutants. In the urban environment open burning of waste is remarkably common in both industrial and residential areas (refer to Figure 30). Depending on the materials being burned which often contain plastics, waste burning may release highly toxic dioxin and persistent chemicals apart from noxious fumes.

Over the past decades Bangalore witnessed a major change in the composition of waste. The IT boom and increasing affordability of televisions, refrigerators and other consumer products led to a large scale introduction of synthetic products and packaging materials. These materials are increasingly found on waste disposal grounds as either components of packaging or discarded product. These wastes are often burnt in an uncontrolled environment typical for waste disposal grounds such as low temperatures from 25 °C to 70 °C and oxygen starvation. Emission released may contain dioxins, furans, volatile organic compounds, metals (antimony, arsenic, barium, beryllium, cadmium, chromium, lead, manganese, mercury, phosphorus, titanium), particulate matter, hydrogen chloride, carbon monoxide and oxides of sulphur and nitrogen.

Figure 30: Every breath counts – Burning waste in Peenya Industrial Area

5. IMPACT OF AMBIENT AIR POLLUTION

5.1. POLLUTION LOADS

An inventory of critical pollutants emitted by non-point (mobile) sources in BMR has been prepared considering the present vehicular population of different vehicle categories. Considering the data of Table 14 as baseline, future pollutions loads have been projected in Figure 31 considering the anticipated increase in the number of vehicles in BMR.

Table 14: Pollution loads from transport

Category of vehicles	Number of vehicles	Average distance in km/d	Total distance covered in km/a	Total emissions in t/a				
				PM	SO_2	NO_X	HC	CO
Motor cycles	2,097,152	13.5	10,420,805,115	365	208	2,814	6,357	17,194
Light duty (G)	188,810	50	3,445,786,150	21	3,032	724	655	9,441
Light duty (D)	90,112	120	4,031,833,800	242	1,572	1,976	1,048	1,210
Heavy duty (D)	147,456	150	8,455,918,500	6,722	12,684	97,243	3,298	102,655

Note: Emission Eestimate based on ARAI emission factors

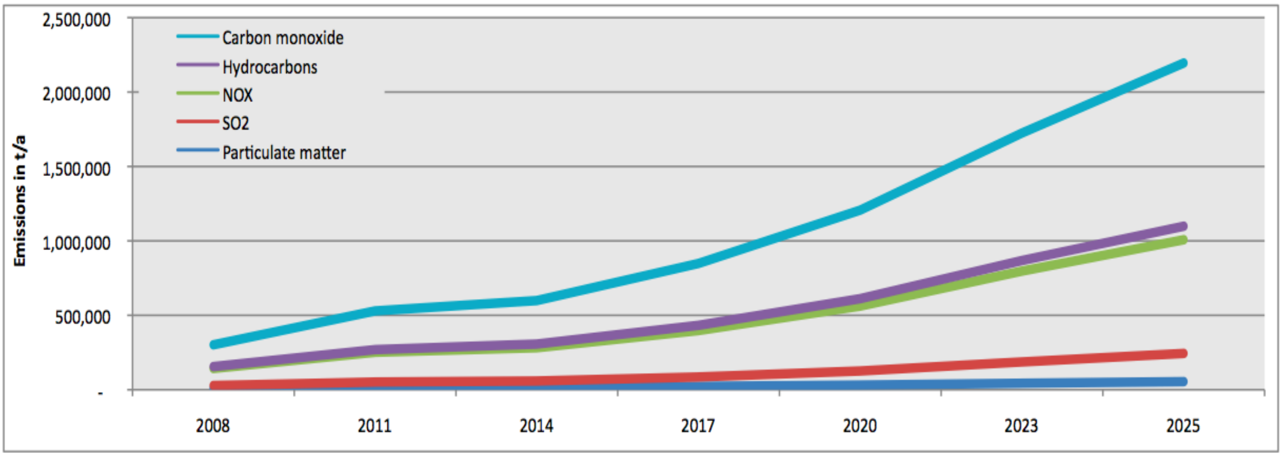

Figure 31: Pojection of pollution loads until 2025

5.2. GREENHOUSE GAS EMISSIONS

An inventory of greenhouse gases has been drawn up considering the consumption of commercial fuels for transportation and industrial operations in BMR in 2007-08. Domestic LPG is not included in this analysis given in Table 15.

Table 15: GHG emissions from commercial fuels

Fuel	Quantity used in t/a (2007-08)	Energy content in TJ	Emissions in t/a			Emissions in t_{CO2eq}/a
			CO_2	CH_4	N_2O	
Gasoline	303,446	1,2702	880,249	419	41	901,921
Diesel	730,790	3,0591	2,266,793	119	119	2,304,851
LPG	536,904	2,6610	1,679,091	1,650	5	1,718,612
Total in t/a						**4,925,384**

5.3. HUMAN HEALTH

The poor air quality has significant short and long-term effects on human health. An in-depth evaluation of the impact of air pollution on health can be found at Chapter 5 "HEALTH", section 3.1.

6. CURRENT POLICIES, PROGRAMMES AND LIMITATIONS

6.1. ACTS AND RULES

The Air (Prevention and Control of Pollution) Act, 1981 and the Environment (Protection) Act, 1986 are the two major acts that seek to protect the atmosphere from pollution in addition to the Motor Vehicle Act, 1988. The Environment Act was enacted with the objective of protection and improvement of the environment. The major objective of the Air Act is to provide for the prevention, control and abatement of air pollution. Section 17(g) of the Air Act 1981 provides for the establishment of limits for emission of air pollutants from industries, automobiles or other sources with the exception of ships and aircraft. Section 20 provides power to the authority in charge of registration of vehicles to ensure compliance with emission standards. Automobile emission standards established by the Central Government are regulated under the Pollution Under Control (PUC) certification programme. Other potential polluting activities such as burning of waste, re-suspended road dust, dust from construction and infrastructure development activities etc. are covered under the City Municipal Laws and Rules.

6.2. AIR QUALITY IMPROVEMENT ACTION PLAN

With the steady increase in vehicular traffic in Bangalore, a multi-department task force was constituted in 2001 for the control of air pollution. The task force was set up with top officials from ten departments and members of some non-government organisations (NGOs). The objectives of this task force were to plan and coordinate the efforts of all stakeholders, including government agencies, NGOs and the public to achieve abatement of pollution. In addition to planning and devising strategies to control pollution, the Task Force is sought to take measures to create environmental awareness. The Task Force has eventually come up with a 14-point action plan known as Air Quality Improvement Action Plan. The action plan had involved five departments — Transport, Food and Civil Supplies, Home, Bangalore Metropolitan Transport Corporation and KSPCB.

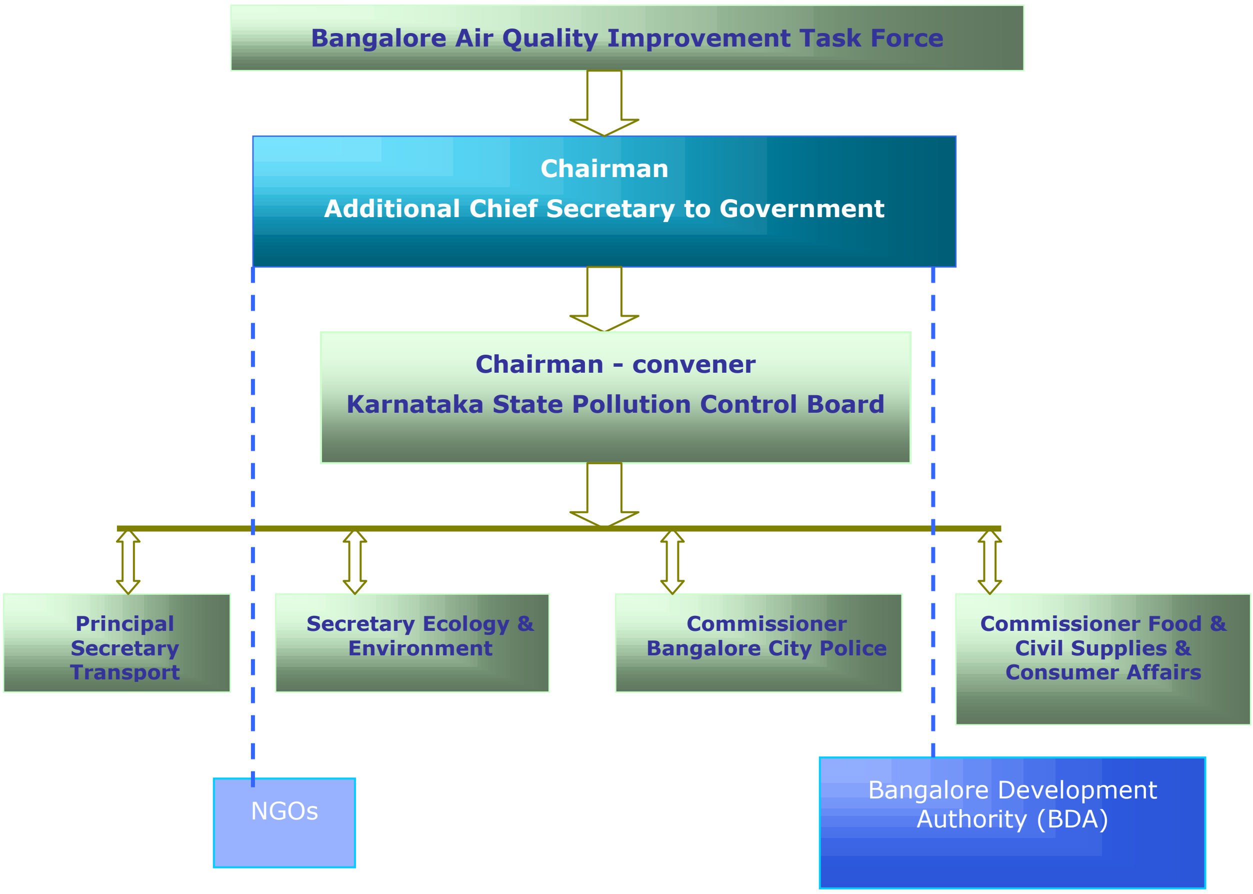

Figure 32: Structure of Bangalore Air Quality Improvement Task Force

One of the main components of the action plan was the conversion of three-wheelers registered after 1991 to bi-fuel mode of petrol and LPG with authorised LPG kits and fixed LPG tanks. The second component was mandatory registration of three-wheelers having bi-fuel mode starting from 2003 and the final component was to take action for conversion of nearly 35,000 auto rickshaws running on unspecified and unauthorized LPG kits and detachable cylinders. Transport Department sources said that in the last four years 62,000 auto rickshaws out of 72,000 have been fitted with authorised LPG kits. Steps were also taken to phase out 4,000 auto rickshaws registered before April 1991 and the remaining will be converted to LPG in stages as per the proceedings of August 2007 Task Force meeting. The Task Force functions by holding meetings of its members and invitees where actions are being reviewed.

To strengthen the objectives of the Task Force, CPCB has taken up a Source Apportionment Study in Bangalore. The major objectives of such study are to identify the sources of air pollution, assessing the contribution of sources identified, prioritising sources that need to be tackled, evaluating options for controlling the sources with regard to feasibility and economic viability and recommendation of the most appropriate action plan. The study is focusing on fine particulates (PM_{10} and $PM_{2.5}$) that are most critical.

6.3. LIMITATIONS IDENTIFIED

- Despite the constitution of dedicated Bangalore Air Quality Improvement Task Force, the structure, mandates and resources for air quality improvement programme remain weak.
- Lack of epidemiological studies relating exposure to particulate matter and respiratory morbidity
- Lack of emission inventories for primary $PM_{2.5}$ and gaseous pollutants for whole of BMR
- Lack of emission factor measurements and source profile measurements for vehicles, as well as for biogenic, industrial and household sources
- Lack of proper frequency and spatial coverage (background monitoring stations) for measurements of criteria pollutants covering all major industrial areas, commercial areas
- Lack of field studies for vehicle emissions
- Lack of incentives to encourage retrofitting vehicles with emission control devices
- Lack of proper zoning of vehicles thereby limiting private vehicles use in heavily trafficked parts of the city
- Lack of coordination between all the current modes of transport to help in better usage of public transport
- Lack of service quality, performance and personal security on the existing public transport system
- Lack of proper promotion of fuel switching to LPG/natural gas and fuel quality as per the road map recommended in Auto Fuel Policy
- Lack of promotion of cleaner production initiatives

Figure 33: Is pollution becoming marketable? Advertisement on Kasturba Road

7. RECOMMENDATIONS

7.1. INTEGRATED FRAMEWORK FOR AIR QUALITY MANAGEMENT

One of the primary challenges in the development of coordinated, robust and cost effective air quality management plans is to address all relevant scientific, technological, political, institutional, economic and administrative aspects. In evaluating the needs of BMR, it is essential to include not only analytical approaches but also the participation and input of the most important stakeholders. It is clear that the research outputs in a number of areas could help in formulating strategies that would pay the large social dividends. Table 16 proposes a framework that seeks to address the issues identified.

Table 16: Framework for air quality management

Action points	*Responsible authority*	*Time frame*	*Indicative budget in INR*
Recommendations for future research in health studies			
Epidemiological studies on exposure to particulate matter and respiratory morbidity	Clinical research institutes, medical institutes, KSPCB, research institutes	3 years	20-40 lakh
Recommendations for future research in air pollution science			
Develop an emission inventory for primary $PM_{2.5}$ and gaseous pollutants	Research and consulting organisations	Yearly basis	5-10 lakh
Develop a coherent energy related database for BMR	Government organisation, research institutes	Yearly basis	5 lakh
Recommendations for air quality measurement studies			
Increase the frequency and spatial coverage (include Installation of Background monitoring stations) of measurements for criteria pollutants and additional pollutants ($PM_{2.5}$, Ozone, CO) covering all major industrial areas, commercial areas, etc	KSPCB, CPCB, research institutes, private organisations	To be initiated within 1-2 years	Initial investment about 25 lakh per monitoring station
Conduct field measurements for vehicle emissions	Pollution Control Board, Transport Department	To be initiated within 1 year	
Reduction of non-point source (mobile) emissions			
Regulations on maximum age of vehicles to ply on road should be enforced	Transport Department	1 year	
Increase registration fee, license and annual ownership tax of older vehicles to gradually phase them out in the city	Transport Department	1 year	
Incentives to encourage retrofitting vehicles with emission control devices and switching to cleaner fuels such as LPG/CNG	Transport Department, insurance companies, manufacturers	1 year	
Limiting private vehicles use in heavily trafficked parts of the city	Transport Department	1 year	
Strengthening of public transport			
Priority to improve and coordinate all the current modes of transport	Transport Department	1 year	
Service quality, performance and personal security on the existing public transport system should be substantially improved	Transport Department	1 year	
Existing inter modal transfer stations should be strengthened to reduce the trip rate and improve the speed of public transport	Transport Department	2 years	
Improvement of fuel quality			
Prevention of illegal vehicle conversion to run on LPG without adequate emission controls and enforcements. Adulteration of fuels should be strictly controlled	Transport department	2 years	
Reduction of non-transport emission sources			
Promotion of Fuel switching to natural gas and fuel quality to be improved as per the Road Map recommended in auto fuel policy	Department of Industries and Commerce	2-5 years	
Introduction of solar energy water heating systems to reduce fossil fuel consumption	Department of Industries and Commerce	2-5 years	
Introduction of clean production and pollution prevention practices	Department of Industries and Commerce	2-5 years	
Modernisation of technology and processes	Department of Industries and Commerce	2 years	
Relocation of high polluters outside the BMR	Department of Industries and Commerce	5 years	

Table 17: Factors to be considered

Policy	Technical	Economic	Institutional
Monitoring Industrial zoning Residential zoning Compliance Traffic management Public transport Land use	Cleaner technologies Fuel improvements End of pipe control devices Cleaner production	Taxes Subsidies Pricing Charges Fines Tradable permits	Emission standards Fuel standards Energy efficiency Maintenance Capacity building Compliance Awareness

7.2. EDUCATION AND CAPACITY BUILDING

The success and sustainability of environmental polices depends on the level of citizen awareness and the active and informed participation of stakeholders. Change in people's attitude and behaviour has to be effected to improve the environment culture through awareness and continued education. It is also essential to improve the capacity of environmental professionals to diagnose the environmental problems so as to plan, execute and evaluate the policies and programs aimed at improving the air quality of BMR. More trained personnel will enhance the performance of government, the private and the academic sectors and non-governmental organisations. The above could be achieved through:

- Strengthening and supporting ongoing government programmes aimed at raising environmental consciousness in the general public.
- Allocation of special financial resources for environment education programmes.
- Supporting air quality research at institutions and universities to strengthen the capacity of environment management formulated by regional and local agencies as well as industrial and academic sectors.
- Developing programmes of applied research and technical training in the fields of prevention and control of atmospheric pollution.

7.3. FUNDING MECHANISMS

Sustainable environmental programmes demand adequate and reliable financial resources. But efforts must be based on the generation of financial resources. For this the society should be aware of the fact that the environmental benefits received from nature are not free and it is necessary to pay to conserve it. The cost of preserving, maintaining and restoring the environmental system should be transferred to the polluter and/or to those receiving benefits.

Chapter 5

Health

CONTENTS

TABLES

FIGURES

1. INTRODUCTION

Aspects of environmental health include the quality of life as determined by physical, biological, social and psychological factors prevailing in day to day life. The relationship between environment and its impact on human health is highly complex. Each of the effects is associated with a variety of aspects of economic and social development. There is no single best way of organising and viewing the development–environment–health relationship that reveals all important interactions and possible entry points for public health interventions. Citizens are exposed to a variety of toxic substances in the environment affecting the human body through skin, respiratory system and gastrointestinal tract that can affect the vital body systems such as pulmonary, reproductive, nervous and immune systems. Dysfunction of these systems could have far-reaching consequences affecting individuals and even their progeny.

To investigate the possible effects of environmental pollutants on human health it is of prime importance that accurate exposure assessment techniques and validated biomarkers are available. It is, therefore, essential to have a comprehensive and accurate environmental health impact assessment procedure in place to undertake application-oriented research such as occupational and environmental cohort studies to define the single or mixtures of pollutants and their impact on health. This would help implementing agencies to devise and revise environmental and industry specific actions. It is also very important to focus on developing a collaborative approach among industries and various research centres together with the implementing agencies of pollution control so as to deal with the issues pertaining to environment and health scientifically.

Children are more susceptible to contracting diseases due to exposure to air pollutants and hazardous chemicals and ingestion of contaminated water and food. These problems are magnified due to lack of access to safe drinking water and sanitation, haphazard disposal of hazardous and bio-medical waste. A growing number of diseases in children have been linked to environmental exposures. These diseases range from traditional water borne, food borne, vector borne ailments and acute respiratory infections to asthma, cancer, arsenicosis, fluorosis, certain birth defects and developmental disabilities. Children from the fetal stage through adolescence are in a dynamic stage of growth as their immature nervous, respiratory, reproductive and immune systems develop. They are more vulnerable to permanent and irreversible damage from toxic substances than adults.

This report documents the available information related to environment and its impact on health, identifies environmental health problems in Bangalore Metropolitan Region (BMR) and suggests recommendations for mitigation of the same.

2. ACCESS TO HEALTHCARE

There are about 850 healthcare facilities in BMR equipped with a total of about 15,000 beds. Major healthcare facilities are listed in Chapter 8 "Waste", section 2. Most of the bigger and super speciality hospitals are located in the urban area. Access to healthcare facilities in Bangalore Rural and Ramanagar districts is deficient. The coverage in BMR as a whole is 1.87 hospital beds per 1,000 persons as against American cities where the number is about 3.2. BMR has only 0.3 doctors per 1,000 persons as against US cities where the number is 2.8 (Source: Parkin et al, 1992). In case of environmental disasters such as the one that struck Bhopal in 1984, accessibility of medical services is very likely to be deficient. Disaster management plans that are prepared for BMR should consider the issue as access to healthcare is critical in cases of environmental emergencies.

Table 1: Healthcare facilities in BMR

Category	*Number of beds*	*Number of hospitals*
Huge	500 and above	11
Extra large	200 and < 500	15
Large	50 and < 200	38
Medium	20 and < 50	63
Small	10 and < 20	102
Very small	1 and < 10	624
Total		**853**

3. HEALTH STATUS

Identifying reliable data for this study was difficult because of the non-availability of outpatient data in the majority of hospitals, lack of uniformity in diagnosis and limited use of the international classification of diseases (ICD) system. There is an urgent need for a large-scale study in BMR to evaluate the current health status of citizens keeping in mind the rise of non-communicable and chronic diseases due to change in lifestyles and increased life expectancy. Moreover, due to inclusion of many peri-urban areas in BMR, poor sanitation and improper disposal of solid waste in these areas has led to a rise in vector borne diseases as evident by recent outbreak of chikungunya fever. There is an urgent need to correlate the effect of environment and its impact on the health of BMR's citizens.

Table 2: Morbidity conditions reported by an urban private hospital

Morbidity condition	Prevalence	
	Male (n=189)	Female (n=420)
Upper respiratory infection	32.8 %	38.3 %
Gastritis	26.5 %	10.0 %
Hypertension	2.7 %	3.6 %
Skin problems	15.9 %	3.1 %
OBG	-	15.5 %

Source: ROHC 2003

In a study conducted by ROHC Bangalore in 2003, the morbidity pattern in one private hospital showed higher proportion of respiratory infections as compared to other illnesses.

Table 3: The occurrence of malaria in BMR

Districts	Number of +ve cases		
	2005	2006	2007
Bangalore Urban	519	97	32
Bangalore Rural and Ramanagar	464	177	264
Totals	983	274	296

Source: RIHFW, Kendriya Sadan, Bangalore

The three-year report of Regional Institute of Health and Family Welfare (RIHFW) on malaria in BMR shows the declining trend. However, the factors favouring transmission of malaria like construction activities leading to collection of fresh water in water tanks and migration of labourers to BMR are abundantly available. With the implementation of National Vector Borne Diseases Control Programme and the ongoing Integrated Disease Surveillance project the reporting of these cases should improve so as to enable the health department to study the trend of these vector borne diseases and correlate them with the changing environment, e.g. rainfall, temperature and humidity.

3.1. IMPACT OF AIR POLLUTION

The effect of air pollution on health has become a major concern for public health in recent years. An in-depth evaluation of air pollution is provided in Chapter 4 "AIR". Although some clinical studies have revealed the mechanism for undesired effects, the relation between urban air pollution levels and increased cardio-respiratory morbidity has, clinically speaking, not been sufficiently explained yet.

Table 4: Health effects due to air pollution

Pollutant	Health effect
SO_2	Irritation of eyes, respiratory problems, increased mucous production, cough and shortness of breath
NO_X	Irritation of pulmonary tract affecting functioning of lungs
CO	Reduction in oxygen carrying capacity of hemoglobin in blood
SPM	Respiratory diseases, reduced visibility may occur on long-term exposure
Benzene	Respiratory problems, CNS, haemopoetic, immune system disorder, causes cancer

Figure 1: Dense traffic and pollution, Jama Masjid

Researchers are currently investigating the importance of the size and chemical composition of particles as a causal factor for many of the respiratory diseases. As the smaller particles penetrate deeper into lungs they are believed to be more strongly associated with adverse health effects. There is some literature on the effect of major air pollutants on health including numerous epidemiological and toxicological studies. According to these studies, the establishment of an association between air pollutants and their effects depends on exposure levels, the background health status of the population exposed as well as their age.

Review of literature

➲ A cohort study of 664 pre-school children conducted by Awasthi et al in Lucknow fortnightly for one year concluded that SPM, SO_2 and NO_2 levels were associated with increased incidence of symptoms of respiratory disease (Shally Awasthi, et al).

➲ Data collected by Dr. Paramesh, Lakeside Hospital, Bangalore) shows increase in prevalence rate of persistent asthma in Bangalore from 1979 to 2004 (Dr. Parmesh, Indian Journal of Pediatrics, 2006).

➲ A comparative study of the respiratory symptom complex, sputum cytology and presence of micronucleus in buccal epithelium in children from Kolkata and those from a rural area in the same state by Lahiri et al found that urban children had a higher prevalence of the respiratory symptom complex and also had significantly increased number of neutrophils, eosinophils and iron laden alveolar macrophages in the sputum (Lahiri et al, 2000).

➲ Exposure to indoor air pollution from contaminated fuels has been linked to at least four major categories of illnesses by epidemiological studies. These are acute respiratory infections (ARI) in children, chronic obstructive pulmonary disease (COPD) such as asthma and bronchitis, lung cancer and pregnancy related problems. Of these, ARI appears to have the greatest health impact in terms of the number of people affected (www.cpcbnvis.nic.in).

➲ There are very few studies that analyse the effects on health from transport related air pollution. Some studies indicate that reduced air pollution may bring down the incidence of acute asthma attacks in children. If there is a long-term decrease in air pollution, there is an associated decline in bronchial hyperreactivity and deaths from all causes in respiratory and cardiovascular diseases (www.euro.who.int).

➲ India contributes to 28% of deaths due to indoor air pollution in the world and this is attributed mainly to the use of firewood as domestic fuel in rural households (World Bank, 2000).

From above studies it is apparent that air pollution has definite implications on health, particularly on asthma in adults and acute respiratory infections among children. But with the exception of the study by the Regional Occupational Health Centre (ROHC), Bangalore, which is presented in the following, no studies specific to BMR have been carried out and it is difficult to assess the exact burden on human health caused by ambient air pollution.

Data on Bangalore

ROHC prepared the "National Environmental Health Profile and Comparative Health Risk Assessment for Bangalore City" for the period 2003-04. The study assessed human health risk associated with air pollution, water pollution and solid and hazardous waste management. It also evaluated environmental concerns on the basis of human health risk and economic risks. The study focused on three distinct locations in Bangalore with different environmental and socio-economic patterns: a residential area (J.P. Nagar), a commercial area (Anand Rao Circle) and an industrial area (Whitefield).

Annual averages show that suspended particulate matter (SPM) levels were found above the limit of 140 $\mu g/m^3$ applicable to commercial and residential areas but within limits of the much higher value for industrial areas of 360 $\mu g/m^3$. Respirable particulate suspended matter (RSPM) levels in all the areas were higher than the limits set by National Ambient Air Quality Standards (NAAQS). The standards are available at Chapter 4 **"AIR"**, section 1.

Not surprisingly, the monitoring of indoor air pollution in residential areas confirmed that SPM and RSPM were higher in residences where firewood and kerosene were used instead of LPG. The study also inferred that external factors such as window, doors and the possibility of cross ventilation have a significant impact on the results. In the absence of standards for indoor air quality, however, it is difficult to benchmark the findings reported.

The study also looked at respiratory morbidity patterns and found that symptoms related to respiratory diseases such as cough in the morning, bringing up phlegm on most days as much as three months of the year was noticed especially among smokers in industrial areas (see Figure 1). 19% of the women in the age group of 45+ years in industrial areas suffered from respiratory disease symptoms. It was also observed that pulmonary function test values were uniformly lower among all the age groups of people living in commercial areas when compared with those living in residential and industrial areas. The observation that the data does not conform to the expectation that incidence should be lowest in residential areas is attributed to the fact that houses in the study area were small and situated on narrow roads, many of them using kerosene.

Table 5: Respiratory symptom comparison of male smokers (S) and non-smokers (NS)

Respiratory symptoms	*Residencial areas*		*Commercial areas*		*Industrial areas*	
	S (n=65)*	*NS* (n=65)*	*S* (n=50)*	*NS* (n=50)*	*S* (n=90)*	*NS* (n=90)*
Cough in the morning	13.8%	3.1%	18.0%	4.0%	23.3%	2.2%
Cough on most days for 3 months of the year	4.6%	0.0%	4.0%	4.0%	20.9%	2.2%
Bring up phlegm in the morning	10.8%	4.6%	14.0%	2.0%	16.5%	3.3%
Bring up phlegm on most days 3 months of the year	4.6%	1.5%	2.0%	2.0%	13.2%	3.3%
Breathlessness while walking at ground level	7.7%	3.1%	2.0%	2.0%	5.5%	2.2%
Wheezing	7.7%	1.5%	4.0%	2.0%	5.5%	3.3%

Source: ROHC

The above difference may be due to mixed pattern of obstructive and restrictive pulmonary conditions resulting from the effect of air pollutants in the area over a period of time. However, in the absence of established baseline information and non-availability of documented community data it should be presumed that air pollution has led to respiratory morbidity such as chronic bronchitis, emphysema and asthma.

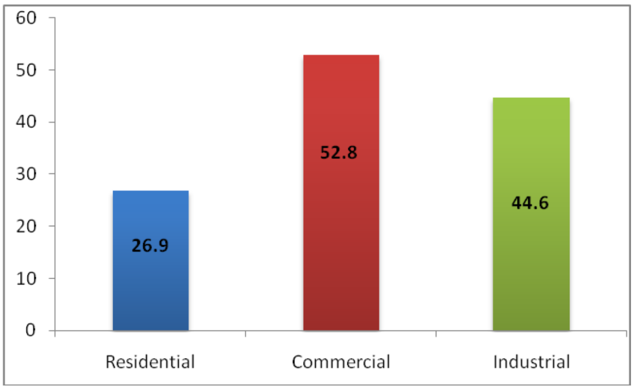

Figure 2: Children who missed school for 2-4 days because of illness

It was found that a higher number of children from commercial areas missed school because of illnesses as compared to industrial and residential areas. This finding appears surprising as industrial areas are generally considered to pose a greater risk. But it is often overlooked that commercial areas often have a considerably denser vehicular pollution.

It was also observed that irritation and watering of eyes, throat, nose and chest problems which are symptoms of upper respiratory tract infections were high among children under 14 years of age residing in commercial areas as compared to industrial and residential areas. However, the results were not found to be statistically significant.

Adverse respiratory health effects of air pollution include the following symptoms:

- Increased frequency of symptomatic asthma attacks;
- Increased incidence of lower respiratory tract infections;
- Increased exacerbation of chronic cardiopulmonary or other diseases reflected in various ways including reduced ability to cope with daily activities, increased hospitalisation, increased physician visits and medication and decreased pulmonary function;
- Increased prevalence of wheezing unrelated to colds, or wheezing on most days or nights;
- Increased prevalence or incidence of chest tightness;
- Increased prevalence or incidence of cough/phlegm production requiring medical attention;
- Increased incidence of acute upper respiratory tract infections that interfere with normal activity;
- Acute upper respiratory tract infections that do not interfere with normal activity;
- Eye, nose and throat irritations that may interfere with normal activities (e.g. driving), if severe.

From the above data it is apparent that air pollution has a major impact on the health of citizens. As very few primary studies have been carried out in Bangalore, it is difficult to assert the magnitude of the impact of air pollution. However, with available literature the issues that seem to emerge as major concerns are respiratory morbidities due to air pollution, prevalence of asthma and acute respiratory infections. These two could in fact be considered as health indicators for studies on air pollution.

It emerges as required to emphasise the need for further and broader monitoring initiatives on these symptoms along with the ambient air quality to study the trends and impacts with a higher degree of certainty that would permit projections and help formulate adequate responses for mitigating the impact of air pollution.

3.2. IMPACT OF NOISE

"A girl's cries for help while she was being raped were drowned in the loud music being played in her neighbourhood. She committed suicide later."

–The Times of India, June 1, 1998

Noise is defined as unwanted sound and unarguably, unwanted sound is a growing problem. The translation of laws into practical results is still out of sight and doubt has been raised whether the standards are actually implementable. The main sources of notice include the transport sector, which cannot possibly be underestimated, the industry and the domestic sector. Especially the last one tends to be overlooked while it entails, apart from TVs and music noisy neighbours and dogs barking while citizens may try to sleep. The key to the answer whether the sound of a music system is enjoyable or plain noise is whether or not it is wanted by the listener and all others compelled to listen. Occupational noise is and remains a serious problem because industrial workers, the traffic police, flourmill operators, drivers and many others have professions that are intrinsically associated with regular exposure to noise at substantial levels over long periods of time. Traffic noise has reached alarming levels in most cities.

Frequent exposure to noise at high levels can result in hearing loss, of which there are two types, both of which are permanent:

- **Sudden hearing loss:** Loss sustained due to impulse noise of very loud intensities where, along with the damage of inner ear there may be damage to the middle ear also. Bomb blasts and firecrackers are capable of causing sudden hearing loss.
- **Chronic hearing loss:** Loss sustained due to long-term exposure to noise where damage is limited to the inner ear. Exposure to industrial noise, traffic noise, etc. may result in this type of hearing loss, which takes a long time to develop.

Although a number of variables such as individual susceptibility, age, exercise, exposure to other toxic agents like lead, carbon monoxide, toxic drugs, etc. might combine to produce noise induced hearing loss, traffic policemen who bear the brunt of noise and air pollution are at a significant risk of hearing loss.

In India people on the whole tend to accept the high noise levels without complaint. One reason is certainly that noise is viewed as a symbol of progress. Another might be that noise has been such a steady companion for decades that its perception has moved to the unconscious. The effects of noise persist, however, whether noise is perceived consciously or unconsciously. Creating awareness is an important step in tackling the problem. There are measures indeed that can be taken to bring noise levels down.

The permissible ambient noise levels in residential areas, as specified by Central Pollution Control Board (CPCB) are 55 dB (A) in daytime from 6 am to 10 pm and 45 dB at night from 10 pm to 6 am. However, in most cities the noise levels are seldom within these limits and Bangalore is no exception as Chapter 4 **"AIR"**, section 3 explains. Indoor noise is contributed by the use of appliances such as mixers, washing machines, cookers and TVs can be reduced by avoiding their simultaneous use and to some degree, by careful purchase decisions.

Figure 3: Ear assault – A two-stroke rickshaw climbing the City Market fly-over

Studies that are indicative of the health effects of noise pollution include the following.

➲ A Japanese study in 1991 reported a possible correlation between noise and blood pressure and also indicated that noise plays a determinative role in hypertension. A set of studies in 1977 examined the effects of airport noise on cardiovascular problems in the neighbourhood. The report suggested that noise constitutes a very serious threat to all forms of public health especially cardiovascular ones (Dr TS Sidhu, 1998).

➲ A sample study of 100 randomly selected traffic policemen out of 1,100 in Chennai in 1997 showed noise induced hearing loss among 21%. The incidence of hearing loss of high tones or frequencies was also found to be around 18% (Prof. SK Kacker, 1998).

➲ In the context of a study on etiology of hearing impairment it was found that 12% of a study group were affected by partial hearing loss but unaware of it. This could be one reason why corrective measure to contain noise pollution get less than needed public attention (Prof. Dr. A. Mukherjee, Calcutta Medical College).

➲ Audiologists of The Institute of Speech and Hearing, Bangalore carried out a noise survey in Bangalore in 1998. Noise levels were fairly uniform across the areas surveyed. The highest levels were recorded in K. R. Market Circle and Richmond Circle. It is evident from the survey that the levels in all the areas are far beyond the permitted limit of 65 dB (A) L_{EQ} specified by CPCB.

➲ The same institute carried out another study funded by Dorabjee Tata Trust in May 1998 to assess the hearing status of traffic policemen. A total of 80 policemen were tested out of which 24 had a mild hearing loss in specific frequencies that clearly pointed to noise as the causative agent. Some of the policemen had been in their jobs for less than two years.

There is an obvious need to gather data on noise induced hearing loss from residential and commercial areas. Intersectoral coordination needs to be strengthened among the concerned sectors to mitigate the impact, especially in view of the threat of hearing loss.

3.3. IMPACT OF WATER POLLUTION

"We shall not finally defeat AIDS, tuberculosis, malaria, or any of the other infectious diseases that plague the developing world until we have also won the battle for safe drinking water, sanitation and basic health care."

–Kofi Annan, Former United Nations Secretary-General

Supply of fresh and clean water in adequate quantities is a basic need. Pollution of fresh water is mainly attributed to discharge of untreated sewage and untreated industrial effluents and runoffs from agricultural fields. An in-depth evaluation on the status of water pollution can be found at Chapter 3 "WATER SUPPLY AND SANITATION", section 1.6.

Exposure to polluted water can cause diarrhea, skin irritation, respiratory problems and other diseases depending on the pollutants in drinking water. Stagnant water and other untreated water provide a habitat for mosquitoes and a host of other insects and parasites which cause different types of bacterial infections. In India acute diarrheal diseases are one of the major consequences of water pollution and deficiencies of sewage management in cities and rural areas. Diseases like cholera, shigellosis, escherichia ecoli diarrhea, poliomyelitis, typhoid and viral hepatitis are generally occurring due to water pollution and contaminated water. Lack of sanitation and personal hygiene contribute to the sufferings of city dwellers.

According to the findings of National Family Health Survey in Karnataka (NFHS, 2005-06) only 71.2% of the urban population use piped drinking water and only 82.7% have access to toilets. The survey also reported that 67.3% of children under 3 years were taken to health facilities for treatment of diarrhea within the past two weeks in urban areas and 38.5% of them had received oral rehydration solution (ORS).

Figure 4: Stagnant water at Church Street

Data in Table 6 shows cases of water borne diseases treated by Epidemic Diseases Hospital, Bangalore. However, the numbers depend significantly on referrals from other health centres and hence cannot be taken as indicators of overall incidence.

Table 6: Water borne diseases reported

Disease	*2005*	*2006*	*2007*
G.E	960	718	592
Cholera	40	22	6
Typhoid	411	2,400	1,209
Viral hepatitis	71	64	5

Source: Epidemic Diseases Hospital

The following studies indicate the effects of water pollution on health:

➲ P. Rajasekaran et al in their study on the incidence of diarrhea and shigellosis among children in rural community in Madurai observed an incidence rate of 21.5 per 100 person years for diarroheal diseases in villages consuming well water, 36.8 per 100 person years in those using street tap, 23.5 per 100 person years in those using taps within the houses. Though the highest incidence of morbidity was found in the children of 1-2 years of age, no sex predilection was reported.

➲ Ashraf S. M. and Yunus M. in their study on water-borne diseases of bacterial origin in relation to quality of water in Uttar Pradesh has revealed that the morbidity was 88.3% among those who used standpipes compared to those who used piped water where it was only 51.8%. Similarly the incidence of different water sources mentioned above was found to be 1.1% and 0.7% for typhoid, 2.7% and 2.2% for bacillary dysentery and 6.1% and 5.1% for diarrhoea respectively.

➲ The "National Environmental Health Profile and Comparative Health Risk Assessment for Bangalore City" for the period 2003-2004 by ROHC also looked at drinking water and assessed its quality based on data of Department of Mines and Geology. While nitrate and iron have clearly been found to be above limits in several samples the study, rather surprisingly, argues that, "in toto, the drinking water supplied by the Bangalore Water Supply & Sewerage Board (BWSSB) is safe and the physical and chemical characteristics of water quality [are] well within the permissible limits laid down by WHO". This conclusion contradicts the finding of microbial contamination of drinking water with E-coli in samples from two divisions of Bangalore of the same study and the conclusions of Chapter 3 **"WATER SUPPLY AND SANITATION"**, section 3.5.

➲ Nitrate levels of water bodies and fluoride levels in ground water have been found to exceed permissible limits in several locations as shown in Chapter 2 **"WETLANDS"**, section 1.3 and Chapter 3 **"WATER SUPPLY AND SANITATION"**, section 1.6. However, no incident of fluorosis has been reported in the BBMP area, neither any case of methhaemoglobinaemia or blue baby syndrome, a disease that is linked to high nitrate levels in water or food.

➲ In the study of Jyothi J. titled "Study of Morbidity due to water borne infections and bacteriological quality of water" with particular focus on diarrhea, poliomyelitis, enteric fever and hepatitis A and E in two areas of Bangalore namely, NTI Layout and Vidyaranyapura which was exclusively supplied by bore well water and Anjanappa Garden which was exclusively served by surface water supply of BWSSB, it was found that the difference in the following practices were found to be statistically significant ($p < 0.05$):

- Exclusive latrine facility for the house
- Hygienic way of handling drinking water

This difference was attributed to the presence of latrine facilities among the residents of NTI Layout as compared to the residents of Anjanappa Garden who used community latrines.

Looking at the years ahead, Bangalore is expected to face a severe drinking water shortage due to unchecked growth of the population due to migration and urbanization. Water shortage and urbanisation will have a clearly harmful impact on human health. A quantification of this aspect does not however, appear feasible. The most vulnerable group would be children below 5 years of age.

Table 7: Potential drivers of pathogens in water

New environments
▪ Climate shifts and deforestation ▪ Water resources development projects such as dams and irrigation ▪ Water-cooled air conditioning plants ▪ Changing industrial and agricultural practices ▪ Increasing number of humanitarian emergencies
New technologies
▪ Water resources development projects such as dams and irrigation ▪ Water-cooled air conditioning plants ▪ Changing industrial and agricultural practices
Changes in human behaviour and vulnerability
▪ Demographic changes ▪ Increasing size of high risk populations ▪ Deliberate and accidental release of pathogens to water ▪ Increasing number of humanitarian emergencies
Scientific advancments
▪ Inappropriate and excessive use of antibiotics ▪ Changing industrial and agricultural practices ▪ Improved methods of detection and analysis ▪ Inappropriate use of new generation insecticides

Source: Emerging Issues in Water and Infectious Disease, WHO, 2003

In is concluded that BWSSB water appears to be by and large safe at the dispatch level but not at the point of consumption. There can be no state of positive health and well being without safe water. Available data shows that much ill health identified is related to deficiencies in the provision of water supply and there is an urgent need to improve its quality. On the other hand, there is also a need to link health data to water data so that the etiological link between unsafe water supply and diarrhoea morbidity can be documented with a higher degree of certainty.

3.4. IMPACT OF LEAD CONTAMINATION

Lead (Pb) and some of its chemical compounds are virtually ubiquitous in the environment. Lead compounds can be found in air, water, soil as well as in the food that we consume. Although lead does not play a role in any known biological function in the body, it nevertheless affects a large number of organs in the human body. Lead should be kept out of human body. The treatment for lead poisoning is expensive and the only way is to regulate the environment and keep the pollution under check.

The major sources of environmental lead are petrol and battery recycling. Lead exposure may occur in drinking water, by use of cosmetics containing lead, chewing lead paints on windowsills and toys in case of children. Lead is used in over 200 industries including those involved in storage and manufacture of batteries, glass manufacture, ship building, printing and potteries, etc. Lead poisoning may occur through ingestion, inhalation or absorption of lead compounds. Much of this lead is of microscopic size invisible to the naked eye. More often than not children with elevated blood lead levels are exposed to lead in their own home. For neurological, metabolic and behavioural reasons, infants, children below 6 years and pregnant women are more vulnerable to the effects of lead than others. Lead poisoning is the number one environmental disease among children in developing countries.

Effects on the body

Short-term exposure to high levels of lead can cause vomiting, diarrhea, convulsions, coma or even death. Long-term exposure to lower lead levels may be less noticeable but are still serious. Anemia is common and damage to the nervous system may cause impaired mental functions. Other symptoms are appetite loss, abdominal pain, constipation, fatigue, sleeplessness, irritability and headache. Continued excessive exposure as in an industrial setting can affect the kidneys. In children, even low level exposure may cause subencepahlopathic neurological and behavioural effects on the central and peripheral nervous system leading to deficiencies in intellectual development, growth and hearing of infants along with impaired cognitive performance and behavioural changes. It shows up as low intelligence quotient (IQ), hyper-activity, lack of attention and learning disabilities among children.

➲ In a survey conducted by Veena Kalra in 1998 from AIIMS Delhi on school children it was observed that the IQ level of children with low blood lead was higher as compared to those having high blood lead. IQ decrements are associated with increasing blood lead levels, a relationship that is clear above 10 µg/dl. The magnitude of the adverse effect on the IQ, as assessed at 4 years and above is a deficit between 0 and 5 points for each 10 micrograms/decilitre (µg/dl) increment in blood lead level. An association between blood lead level and hypertension (blood pressure) has also been reported in this study. The likely order of magnitude is that for a two-fold increase in blood lead level, e.g. from 17 to 34 µg/dl there would be a mean increase in systolic blood pressure 1 mm_{Hg}. The association with diastolic pressure is of a similar but smaller magnitude.

Situation in Bangalore

Along with sobriquets such as the Garden City, Silicon Valley of India, Pub Paradise, Bangalore may soon add the new tag "Lead City". The load of lead in the air becomes apparent in blood samples taken from youngsters. With around 40 µg/dl, Bangalore's lead scenario is among the worst in the country, according to Dr T Venkatesh, Director of the National Referral Centre for Lead Poisoning in India (NRCLPI) at St. John's Medical College Hospital. About 15 years ago only16% of Bangalore's pre-teens showed lead contents of more than 10 µg/dl, today their share has increased to over 40%.

Bangalore has large, unorganised groups of battery recyclers who buy from individual vehicle-owners. The Environment Ministry's new rules that lead acid batteries should be returned to registered manufacturers are yet to be fully implemented. Unorganised recyclers are often beyond the control of the Pollution Control Board.

The five-year Project Lead Free started by the George Foundation with St. John's National Institute of Health Sciences and supported by Admiral O. S. Dawson was started in the year 1997. The National Referral Centre for Lead Poisoning Prevention in India (NRCLPI), a non-profit organisation, was set up at Bangalore with the objective of gradually spreading the message among manufacturers, policy-makers and the lead-user chain. NRCLPI, through the State Level Referral Centre, creates awareness, conducts blood tests and consults with lead-based industries to reduce lead contamination. The National Referral Centre has launched an awareness campaign and a database for Anekal *taluk,* which, along with Mangalore, is a centre of lead industries. The battery industry has also woken up to the cause. The National Referral Centre is coordinating with Exide, Amara Raja and other manufacturers and has mooted a six-monthly screening of blood samples of their workers.

NRCLPI encourages college students to take up short-term research projects on lead. In the recent past students from various colleges in Bangalore have undertaken such projects with the following results:

➲ Students from NMKRV College studied the prevalence of lead poisoning among children studying in 2nd, 3rd and 4th standard aged 6-8 years in Government Model Primary School, Byramangala village of Bangalore. Results showed that 10% of the children had blood lead levels greater than 10 µg/dl. However the lead levels in vegetables and water samples consumed by the children were within permissible limits indicating that these may not be the primary sources of lead in these children.

➲ Results of a study by students from MES College showed that soil samples from near Ragigudda Temple in south Bangalore contained lead levels of 115 µg/dl. They also demonstrated the harmful effects of lead on guppy fish following the immersion of water and oil painted *Ganesha* idols. However, in this case, the immersion of clay Ganeshas did not result in any harmful effect on the fish. A large numbers of *Ganesha* idols are immersed in Bangalore's tanks during the annual *Ganesha Chaturti* celebrations. This tradition contributed to the pollution of water bodies, increasing particularly the levels of lead.

➲ Students from Jyothi Nivas College studied the lead content of water samples in Bangalore from residential areas (Koramangala and BTM Layout) along samples from lakes (Ulsoor, Madivala and Agara). They also included Tilaknagar to represent an area with potential occupational exposure as it has a number of battery recycling units. In residential areas samples from municipal supply were well within the permissible limits but bore wells showed higher lead levels, ranging from 11 to 30 µg/dl. The lead content in water from Tilaknagar area was highest with 33.8 µg/dl. Among the lakes, Madivala showed noticeably high lead levels.

➲ Students from Vivekananda Degree College, Peenya studied the effect of lead on employees working in the paint industry and found that the blood lead levels among the workers in that factory ranged from 9.4 – 26.7 µg/dl.

➲ Another study by Reva Institute of Science and Management evaluated the lead concentration in milk and milk products in various areas including Peenya, Doddabalapur, Hebbagodi, Hessaraghatta, Yelahanka, Hebbal, Devarabeechanahalli, Vijayanagar, Banashankari and Doddaladamara. The results showed that the lead levels in milk were well within the WHO Permissible limits of 20 ppb except in Doddaballapur where levels peaked at 30.4 ppb. This could be due to the large number of dyeing units the area. As a conjecture, their effluents could have contaminated ground or surface water resulting in high lead levels in the milk of animals which feed on this water and graze in fields which have grown in this water. This study also revealed that branded milk products (Nandini and Amul) like ice cream, milk powder and sweets did not show traces of lead.

➲ Students form Government Science College undertook a study to quantify metallic lead in plants. They studied the lead levels in water hyacinth (water weed) which is used as cattle fodder and in edible plants like coriander and a variety of other green leafy vegetables. Results reveal that all the water hyacinth samples collected from Vrishabhavathi valley, Yeshwantpur and Peenya Industrial Area contained lead concentration at an alarming level well above the maximum permissible concentration in foods of 25 mg/kg. The sample from Anchepalya lake showed the highest lead concentration of 102.5 mg per kilogram of plant.

➲ Coriander samples collected from City Market also showed lead concentration above permissible limits. On enquiry, the coriander was traced to Hoskote, Malur and Ganjam near Srirangapatna with the Ganjam samples showing the highest lead levels of 24.3 mg/kg of dry plant mass. On field samples of other green leafy vegetables collected from areas surrounding Byramangala lake and Varthur lake showed lead levels within permissible limits.

➲ HAWA-GTZ carried out a study on the potential occupational health impact of lead on informal e-waste recyclers. The study shows lead values in the air ranging from 50 – 75 µg/m³ for 8 hr TWA (time weighted average) sampling as against permissible limit of 30 µg/m³ and respirable particulate matter (RSPM) as high as 220 µg/m³ for 8 hr TWA as against the permissible limits of 50 µg/m³. The study also reveals associated health effects among workers in the units studied which is clearly indicative of occupational risks associated with e-waste recycling (Malkan Mussarath et al, 2007).

The above studies show that environmental contamination of lead in and around Bangalore is a considerable threat to the health of citizens of BMR. However, most of the studies are designed to study the presence of lead in the environment whereas only one study looked into the presence of lead in human beings. More studies to document the health impact are needed. Since there is an agency that is already in the process of gathering data on lead, policy makers could use this information to reduce the impact of lead poisoning. It is encouraging that Bangalore will soon be the first city in the world to have a lead map. The map will indicate the presence of lead in samples of water, soil, plants, milk, paints, ceramic and plastic articles from different parts of the city.

3.5. BIO-MEDICAL WASTE RISKS

"Hospital waste management is an important subject that needs urgent attention. In most circumstances it is appropriate to consider an incremental approach realiszing that an improvement is of great value even if resources do not allow achievement of highest standards immediately."

–Report of a consultation of medical waste management in developing countries, WHO,1992

Bangalore with a population of 65 lakh has about 850 bedded healthcare facilities and an estimated 750 non-bedded clinics and veterinary clinics. Together these generate at least 1,350 tonnes of bio-medical waste per year (refer to Chapter 8 "Waste", section 2). The handling of bio-medical waste requires specific precautions. Mismanagement of healthcare waste poses risks to healthcare workers, patients, waste handlers, rag pickers and the general public. Most of the data available regarding the quantum of waste is based on estimates.

A study carried out by the Department of Community Medicine, M.S. Ramaiah Medical College, in 1996 identified four problem areas in the management of healthcare waste; they are:

- Lack of awareness,
- Lack of information support,
- Lack of good practices and
- Lack of effective coordination between civic body and healthcare units.

The last ten years saw increased awareness among healthcare settings and healthcare personnel, a fair degree of waste segregation, containment, disinfection before disposal and the establishment of common treatment facilities. Although the Bio-medical Waste (Management and Handling) Rules were legislated in 1998, raising awareness of healthcare personnel in order to ensure safe management of healthcare waste still needs to be strengthened. Various studies have been conducted in Bangalore to substantiate this. However no health impact studies have been carried out in the BBMP area.

Final treatment and disposal of bio-medical waste by individual healthcare units would require additional infrastructure, comparatively high capital investments and trained manpower for operation and maintenance. Common bio-medical waste treatment facilities address these problems and also prevent the proliferation of treatment equipment in the city. Common facilities reduce the cost of treatment and also reduce the monitoring pressure on the regulatory agency, which is Karnataka State Pollution Control Board (KSPCB). The concept of common bio-medical waste treatment facilities has been legally introduced through the Bio-Medical Waste Rules. In keeping with this concept, Bangalore has two common facilities. One is at Dobbaspet Industrial Area, serving the northern region with 622 registered healthcare establishments and about 8,200 beds and the other one at Gabbadi Kaval on Kanakapura Road in Bangalore's south, covering 435 healthcare establishments with about 9,000 beds.

Hygiene strictly prohibits the reuse of syringes because they are highly infectious. With reference to their physical properties, the waste constituted by syringes is known as sharps. Poorly managed, sharps have a considerable risk potential for healthcare workers, waste handlers and the community. WHO has estimated that 32% of all the new infections of Hepatitis B, 40% of Hepatitis C and 5% of HIV are due to injections with contaminated re-used syringes. Injuries from sharps that are not disinfected have the potential to transmit HIV and Hepatitis B to not only to the healthcare professionals but also to the people handling them like waste handlers and rag pickers.

Occupational transmission of HIV

France: In 1992, eight cases of HIV infection were reported as occupational infections of which two cases which had transmission through wounds were said to have occurred in waste handlers

USA: In 1994 the Centers for Disease Control and Prevention (CDC) recognized 39 cases of infections as occupational infections of which 32 were from hypodermic needle injuries, 1 from blade injury, 1 from glass injury (broken glass from a tube containing infected blood), 1 from contact with non-sharp infectious items, 4 from exposure of skin or mucous membranes to infected blood. All cases were seen among nurses, medical doctors, or laboratory assistants.

Source: WHO

Liquid and special healthcare waste

Apart from solid healthcare waste, liquid waste comprising of blood, body fluids, discharges and waste from patients are another critical area. Only a few of the tertiary healthcare establishments in Bangalore have effluent treatment plants to take care of their liquid waste. Primary Health Centres, community health centres, nursing homes, small clinics, dental clinics, laboratory and blood banks generally never possess these facilities. Some of the smaller establishments are not even connected to underground drainage systems. The management of liquid infected waste poses a considerable challenge. It is neither practical nor feasible to have effluent treatment plant in all these places. While disinfection of liquid waste before disposal is a viable solution, close monitoring of the large number of establishments is beyond the capacity of KSPCB. With increase of urbanisation, population and the number of health centres, there is an urgent need to address the problem of liquid waste to reduce the risk of health personnel and the larger community.

Also the management of radioactive waste, cytotoxic waste, expired drugs and plastic waste is a major problem area that remains largely unaddressed. Disposal of mercury, heavy metals, chemicals, are largely neglected and ignored areas. Halogenated plastics such as PVC, if incinerated under low temperatures produce dioxins and furans which are lethal to brain and kidneys.

Conslusion

It is difficult to estimate the potential effects of a no-action scenario in the selected hospitals, since registers are poorly maintained. But the composition of bio-medical waste poses a very considerable risk owing to the presence of infectious agents, toxic chemicals, sharps, which in totality render it highly infectious. The risks are on the staff, medical and paramedical, waste handlers working in healthcare institutions, patients and their attendees, scavengers and rag pickers and, last but not least, the community at large. There is an urgent need to address these challenges to create a healthier healthcare environment in BMR. Solutions would include:

- Strict enforcement of Bio-Medical Waste Handling Rules,
- Creation of greater awareness among stakeholders,
- Strengthening the curriculum of professional education of medical doctors, dental surgeons, nurses and laboratory technicians,
- Carrying out epidemiological studies to assess the impact of needle stick injuries and mismanagement of bio-medical waste on high-risk groups.

3.6. DOG BITE RISKS

Rabies is a zoonotic viral disease of the central nervous system that affects all mammals and is transmitted to humans by infected secretions; in most cases through the saliva of an animal. Most of the exposures occur through the bite, lick or scratch of an infected animal. Dog bites are responsible for the transmission of rabies in more than 90% of the cases. Rabies in India has been a disease of low public health priority both in the medical and veterinary sectors. The disease is mostly affecting the poor who are more exposed and less protected. If timely medical help has not reached the patient, rabies is a 100% fatal disease. Death follows 2-7 days of excruciating torture and untreatable pain, in patients fully alert and aware of their impending fate. This is probably the reason for a large number of rabies cases go undiagnosed or unreported.

Data on Bangalore

Every year there are 50 reported and perhaps 500 unreported or undiagnosed cases of rabies in Bangalore and its surroundings. Table 8 suggests that the stray dog population has remained nearly constant over the last years. However, the general acceptance of stray dogs in the neighbourhood both at household level and in public places is only one third. Though the number of dog bite cases reported is similar, the account reflects only cases reported at BBMP centres and not those reported to general practitioners or nursing homes.

Figure 5: Street dogs on guard

Table 8: Dog population and bite cases in BMP

Source of information	Year	Pet dogs	Stray dogs	Total	Dog bite cases in BBMP per year
16th Live Stock census by Animal Husbandry and Veterinary sciences	1997	46,449	29,118	75,567	*(not available)*
People for Animals	2000	*(not available)*	70,980	70,980	*(not available)*
KIMS	2001	1,25,000	2,00,000	3,25,000	22,905
BBMP	2007	1,43,522	1,83,758	3,27,280	17,798

Source: Kempegowda Institute of Medical Sciences (KIMS), Bangalore, 2007

In Bangalore City, about 16,300 bites were recorded in the period from April 2006 to February 2007. Probably, another half as many cases would have occurred in the seven City Municipal Councils (CMCs) surrounding BMP but no estimates exist. 59% of the reported cases were caused by stray dogs and a surprising 41% by pet dogs

(Source: BMP Health Department Records). This presents an average of 0.14 % of stray dog bites of Bangalore's population of approximately 65 lakh. This is well below the national average of 1.74% of dog bites. Only 6% of dogs found rabid have a reliable rabies vaccine history. 40% of dogs vaccinated only one time have lost most of their humoral immunity 4-6 months later. The National Multicentric Survey found that the majority of animal bite victims belonged to lower economic strata and the use of anti-rabies vaccines was low. It is also seen that the use of rabies vaccination is low and that of rabies immunoglobulins is negligible.

In all municipal acts, control of stray dogs is explicitly and emphatically the responsibility of civic authority, i.e. BBMP. Section 87 of the Karnataka Municipalities Act 1964 as amended in1995 lists as the obligatory functions of municipal councils: "*It shall be incumbent on every municipal council to make adequate provision by any means or resources which it may lawfully use or take for each of the following matters within the municipal area namely, ... arranging for the destruction or the detention and preservation of such dogs within the municipal area as may be dealt with under the law in force relating to police or under Section 222 of this Act and ... providing facilities for anti-rabid treatment and treatment of lepers and mental patients and meeting the expenses of indigent persons undergoing anti-rabid treatment within or outside the municipal limits.*"

The main measures for the control of rabies include:

- Pre-exposure immunisation of pets and their compulsory registration,
- Elimination of stray dogs by humane methods,
- Extensive health education to public to procure their cooperation in fulfilling the above mentioned objectives.

The above measure should be coupled with providing an adequate supply of vaccines and anti-rabies serum for immunisation of dog bite victims. Citizens should also be educated regarding first aid measures for animal bites especially treatment of wounds by washing with plenty of soap and water. The efforts for rabies prevention and control are meeting stiff resistance from animal rights activists. In addition, the city's budget for vaccination of dog-bite patients and treatment of rabies victims is a mere INR 15 lakh a year.

It is also noted that the dog is the host for many more zoonotic diseases (brucellosis, tuberculosis, echinococcosis, leishmaniasis among others). Better control of stray dogs is an issue that needs to be treated with greater priority. Also a scientific estimation of the dog population and a proper method to enumerate dog bite and rabies cases is needed.

3.7. CLIMATE CHANGE RISKS

Climate change is a significant newly emerging threat to public health and changes the way we must look at protecting vulnerable populations. The most recent report of the Intergovernmental Panel on Climate Change (IPCC) confirmed that there is overwhelming evidence that human activity is affecting the global climate and highlighted a wide range of implications on human health. Climate variability and changes bring about death and disease through natural disasters such as heat waves, floods and droughts. In addition, many important diseases are highly sensitive to changing temperatures and precipitation. Climate change already contributes to the global burden of disease and this contribution is expected to grow in future.

The impact of climate change on human health will not be evenly distributed around the world. Developing country populations, particularly in small island states, arid and high mountain zones and in densely populated coastal areas are considered to be particularly vulnerable. More information on climate change can be found at Chapter 7 **"INDUSTRY",** section 2.4.

Direct effects of climate change on health

- Effects caused by projected higher temperatures leading to increase in illness and death from heat stroke and dehydration more frequent and severe heat waves.
- Effects caused by the projected increase in extreme weather such as tornadoes, hurricanes droughts, floods and winter storms leading to injury, illness, death and stress related disorders associated with social disruption and environmentally forced migration.

Indirect effects of climate change on health

- Altered spatial distribution of infectious disease vectors resulting in increased transmission of diseases such as malaria, dengue and yellow fever.
- Increasing temperatures anticipated with climate change can serve to magnify the effects of pollutants already in the air.
- Increase in illness from allergic respiratory disease, particularly asthma, emphysema and chronic bronchitis due to increase in trees and other vegetation that give rise to allergenic pollens and mold spores

which grow more profusely in a warmer climate, combined with smog and other atmospheric pollutants.

- Changes in quality and quantity of drinking water as water sources in some areas become threatened by drought. Increase in health disorders related to environment and water contamination by bacteria, viruses, protozoa and parasites could also increase.
- Millions of people all over the world will experience increased water stress and the per capita water availability will drop drastically
- Changes in the amount and distribution of wildlife, fish and vegetation.
- Increase in healthcare costs, the need for various adaptation strategies such as expanded vigilance and medical services, health monitoring, environmental management, disaster preparedness and improved water and pollution control.
- Crop productivity and potential for food production will fall. Increase in the frequency of droughts and floods are projected to affect the local crop production negatively.
- Even modest rise in sea levels will cause coastal erosion, flooding and economic disruption in densely-populated mega-deltas.
- Increase in malnutrition and consequent disorders with implications on child growth and development.

No studies have been found that attempt to correlate the impact of climate change with its health implication for the Bangalore Metropolitan Region.

Table 9: Diseases that may increase due to environmental changes

Environmental change	Disease
Dams, canals, irrigation projects	Schistosomiasis Malaria Onchocerciasis Helmninthiasis
Agricultural changes	Malaria Viral Heamorrhagic fevers
Urbanisation, overcrowding	Cholera Dengue Cutaneous leishmaniasis
Deforestation and changes in land use	Malaria Visceral leishmaniasis Tick borne encephalitis Kyasanur forest disease
Reforestation	Lymes disease
Ocean warming	Toxic algal blooms
Elevated precipitation	Rift valley fever Hanta Virus pulmonary syndrome
Air pollution	Asthma COPD URTI
Water pollution	Cholera and other water borne diseases
Noise pollution	Deafness Auditory fatigue

4. HEALTHCARE AND ENERGY

Energy consumption in healthcare settings is not a very popular topic. However, in the wake of climate change this is an important area to consider According to a 2008 report of the consultancy firm Hosmac India Pvt. Ltd., Bangalore hospitals rank second in energy consumption after Mumbai, according to a four-city hospital survey. Bangalore hospitals spend an average of INR 459 per bed per day on energy. There is potential for saving 27% of the energy through simple effective practices alone. The bigger and technologically better equipped a hospital is, the heavier is its electricity bill. High-end tertiary-care hospitals with 300 beds and more spend nearly 60% of their power expenditure on services directly related to patient care in the out- and in-patient departments, intensive care units, radiology and diagnostic services. There is great potential for energy savings in Bangalore's hospitals, particularly considering the presence of more than a dozen super speciality hospitals.

5. EXISTING PROGRAMMES

Several programmes and schemes of the government exist that have a direct impact on health of citizens. The most prominent ones are listed in the following table. Apart from these, there are a very large number of initiatives that accrue health benefits indirectly through improvement of livelihoods, one example being the newly legislated National Rural Employment Guarantee Act.

Table 10: Relevant government programmes

Rural programmes	Urban programmes
National Rural Health Mission Accelerated Rural Water Supply Programme (ARWSP) Integrated Wastelands Development Programme (IWDP) National Watershed Development Rural Sanitation Programme Rural Water Supply Programme	Jawaharlal Nehru Urban Renewal Mission Accelerated Urban Water Supply Programme Mega City Scheme

6. RECOMMENDATIONS

6.1. MONITORING NEEDS

The ongoing monitoring process of key environmental parameters is sought to be strengthened so as to correlate changes in the environment to morbidity trends. Currently monitoring is ongoing for various environmental parameters such as SO_2, NO_2, SPM, RPM, lead and CO for air quality; lead, nitrate, fluoride, pesticide and bacteriological quality for water quality. These parameters should be linked with suggested epidemiological studies to acquire a higher degree of certainty about human health impact. Currently the monitoring being carried out is too limited and health impact studies are not being undertaken.

Existing wards could be distributed between institutions such as medical colleges, ROHC and specialised and NGOs of high repute. KSPCB would be an adequate agency to monitor air quality monitoring, BWSSB could be proposed for water supply quality and the Institute of Speech and Hearing in association with KSPCB for noise. BBMP has an Urban Family Welfare Centre in each ward with Lady Health Visitors. These centres should regularly collect data on respiratory, gastro intestinal and malnutrition morbidities and forward the same to ROHC, this could strengthen health impact studies, which are to be carried out annually.

6.2. STUDY NEEDS

Studies are sought to be carried out based on primary data in order to correlate the environmental impact on air, water and noise pollution to human health. Some of the required studies are outlined in the following table.

Table 11: Recommended studies

Specific study areas	Agencies to be involved	Specific study areas	Agencies to be involved
Air pollution		**Animal threats**	
Assessment of the relationship between respiratory morbidity and air pollution among traffic policemen in BMR Assessment of sickness and absenteeism due to respiratory morbidity among school children in BMR	KSPCB, BBMP, Department of Education, Department of Ecology and Environment	Census of dogs or scientific estimation of dog population Studies on more effective municipal licensing of pet dogs and awareness campaign for better and responsible dog care and management practices	BBMP and Institute of Veterinary Sciences
Water pollution		**Noise pollution**	
Assessment of the relationship between incidence of diarrhoeal diseases among under 5 year olds and bacteriological quality of water in BMR Assessment of the prevalence of fluorosis and levels of fluoride content in drinking water in BMR Development of an effective health information system to monitor water borne diseases and bacteriological quality of water	BWSSB, BBMP, and DGHS	Assessment of the prevalence of noise induced hearing loss among high-risk groups (traffic police, school children, industrial workers, etc) in BMR Assessment of the incidence of Hepatitis B among healthcare workers	BBMP, Institute of Speech and Hearing, Dept of Education BBMP, medical colleges, Department of Ecology and Environment, KSPCB

6.3. COORDINATION NEEDS

There should be regular coordination and exchange of information between all stakeholders, including Department of Medical Education, ROHC, medical colleges, BBMP, KSPCB, BWSSB and specialised NGOs. To ensure coordination a working group consisting of these agencies should be established to advise and act on health needs. ROHC could act as nodal centre for compilation of monitoring reports and carrying out area-wise health impact studies and linking these with the monitored parameters. Findings of health impact studies should be utilised to strengthen monitoring and evaluation of parameters and also to estimate the training and capacity building needs.

6.4. HEALTHCARE SERVICES COVERAGE IN DISASTER MANAGEMENT PLANS

The Disaster Management Plans prepared by the office of the DCs of Bangalore Urban and Bangalore Rural districts should focus on the adequacy of healthcare facilities available, especially in the impact zones of industries. The environment management plans prepared by industries in these areas as part of EIA reports should be compiled for the district and their adequacy be determined. As part of the implementation, industries should be made to contribute to set up the healthcare infrastructure in its impact zone. Health surveillance and environmental monitoring in the impact zone should be made mandatory for the industry.

6.5. EPIDEMIC DISEASE TASK FORCE

The epidemic disease task force is to be revitalised in order to enhance the capacity of BMRDA health personnel to strengthen disease surveillance mechanisms. The epidemic disease task force should be made fully functional by BBMP with adequate funds and logistics so that it can strengthen the ongoing disease surveillance system and can play an important role in linking the reported outbreaks with the environmental surveillance data or carry out epidemiological investigations to substantiate the same. The epidemic task force should act as a link between environment and health departments with equal access to records of both these departments. The epidemic task force should also involve the existing medical colleges in carrying out epidemiological studies.

6.6. ENHANCING OUTREACH

Awareness levels need to be raised in areas of environmental protection such as open burning of solid waste, household waste, littering, open defecation, wastage of water, utilisation of available health services and national health programmes. This could be achieved through recurring incentive-based awareness programmes by concerned government agencies such as KSPCB, BWSSB and BBMP. Community participation, a factor vital to the success of health programmes, is sought to be enhanced.

Chapter 6

Transport

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1. CURRENT SCENARIO

1.1. ENERGY EFFICIENCY AND CLIMATE CHANGE

The current transportation activity is overwhelmingly driven by internal combustion engines powered by petroleum fuels. The total transport sector which includes road, rail, aviation and water navigation, the energy consumption in India was 31.14 million tons of oil equivalent in 2003-04 with the share of petroleum fuels 98% and electricity 2% (MoPNG, 2005). Of the total petroleum products consumed, the share of high-speed diesel (HSD) was highest 71%, gasoline 27% and all other fuels less than 1%. Demand for gasoline and HSD has grown at 7.4% and 5.7% per year respectively between 1980-81 and 2003-04. Consequently, the use of energy by transport sector and CO_2 emission closely track the growth of transportation activity. The total CO_2 emission from transport sector in the country in 1994 was 79.88 million tonnes (MoEF, 2004). The transport sector contributed around 12% of the country's total CO_2 emission as a part of its total energy activities (i.e., 680 million tonnes of CO_2 in 1994). Among the transport sub-sectors, road transport is the main source of CO_2 emission and accounts for nearly 90% of total emissions.

In India, GHG emissions from the road transport sector are expected to soar. In 2000, the vehicles in India emitted nearly 81.3 million tonnes of CO_2 and in 2005 it went up to about 130 million tonnes. Similar to the fuel demand growth rate the total CO_2 emission is also likely to go up over nine-fold in the low GDP growth (6%) scenario (127.7 million tonnes in 2005 to 1160 million tonnes in 2030) and about thirteen-fold (134-1,700 million tonnes) in the high GDP growth over the next 25 year period between 2005 and 2030. This increase has been fuelled by the rising demand for mobility, as economies would continue to grow.

Figure 1: Victim or hero? Cyclists are overexposed to safety risks and pollution they do not cause, Queens Road

Despite the rapidly increasing contribution to CO_2 emission likely to grow at an average annual rate of 9.2% with GDP growth at 6% and 10.7% with GDP growth at 8%, there has been no initiative so far in addressing the cost-effective emission reduction strategies in India. Although with advancement of automobile and fuel technologies the fuel efficiency of transport vehicles will continue to improve but these improvements will be more than offset by a combination of increase in the number of personal vehicles (with a shift towards vehicles with more powerful engines) and their increasing utilisation levels. Public transport and alternative fuels such as ethanol are needed to reduce the energy intensity of transport sector in India.

1.2. VEHICULAR GROWTH IN BMR

With the increase of population and economic growth in Bangalore, the Bangalore Metropolitan Region (BMR) has seen an exponential growth of transportation vehicles in the past decade. In the last three decades, owing to easy accessibility, flexibility and reliability the share of both freight and passenger traffic has experienced a rapid shift from rail to road. However, the capacity of road has not been able to keep pace with the increasing demand. In terms of rail-road modal mixes, the freight traffic carried out by road transport is estimated to have increased from roughly 35% in 1970-71 to 70% in 2003-04 whereas the passenger traffic has increased from 67-85% in the same period.

The Bangalore city population officially stood at 5.6 million, a jump of 1.5 million from the previous census. The compound average annual growth rate of population between 1981-91 and 1991-2001 was 3.4% and 3.7% respectively. Vehicular population growth in Bangalore has continuously increased during the last decade particularly after the 1995 software industry boom in Bangalore when the two-wheeler vehicle population saw an exponential increase. Along with increase of human and vehicular population, the fossil fuel consumption has also increased. The mix and the growth in automobile population determines the contribution of auto emissions of CO, HC, NO_X and PM.

The burden of urban bane like poor infrastructure, traffic congestion and inadequate public transport has started taking a toll on the city. The public transport system operated by the BMTC has a fleet of 5,000 buses and there is a plan to augment the fleet size to 10,000 buses within the next three years in a phased manner. It has dedicated services to the newly opened Bangalore International Airport and Ring Road services to cater to the high-density population areas of Bangalore city with inter connections to and from the Ring Road. This is largely evident from Table 1, which shows the share of personalised mode of transport as compared to public transport system (buses) which is 0.5% of the total vehicle population and carried 46% in the year 2007 out of the total commuters and of the share of two-wheelers being 72% carrying 36%. Hence, there is need to shift from private mode to public mode of transportation (high capacity buses).

Figure 2: Inhalation inevitable, City Market

Further, the rapid pace of urbanisation and an even faster pace of motorisation measured as the growth in ownership and use of motor vehicles have exerted heavy pressure on the urban transport system of metropolitan cities and second order cities like Mysore. One noticeable feature about the growth of vehicles is an abnormal increase in the number of two-wheelers followed by cars and auto rickshaws. The importance of transport energy use and emissions within the overall energy scene has grown substantially in recent decades in response to a series of public policy objectives such as energy security, human health, safety, local environment and climate change.

Appropriate designing of new infrastructure and introduction of the best practice operating technology could significantly lower the emissions growth rate while increasing mobility, improving air quality, reducing traffic congestion and lowering transport and energy costs. However, just the technology is not enough; the measures are required to limit the road traffic growth by better-directed land use planning, stricter demand management and greater use of public transport.

BMTC, Bangalore's public transport operator at a glance

- Operates 4,886 schedules
- Fleet of 4,929 buses
- Performs 68,273 trips covering 10.8 lakh service kilometers
- Caters to 38 lakh passengers, earns around INR 244 lakh and
- Pays INR 13.4 lakh/day to Government towards motor vehicle tax

Public transport highlights

- Public transport occupies 2% of road space to commute 50% of the population. Whereas cars occupy 80% of the road space and cater to less than 20% of the population; hence, a need for peak hour service only with priority for public transport.
- BMTC has submitted the augmentation plan to the government.
- Operation of grid routes.
- Operation of bus terminals and traffic management centres.
- Improvement of existing bus terminals, upgradation of bus stations and traffic and transit management centres under JNNURM scheme.

Table 1: Vehicle population in Bangalore City as of June 2007

Vehicle category	Number	Percentage
2 wheelers	2,101,174	72.9%
Light motor vehicle (LMV)	434,428	15.1%
Auto rickshaw	91,899	3.2%
Heavy transport vehicle (HTV)	77,842	2.7%
Heavy goods vehicle (HGV)	94,921	3.4%
Others	82,300	2.7%

Table 2: Trends in modal split in BMR

Vehicle category	1982	2003	2006
Car	3.5%	5.4%	7.2%
Two-wheeler	12.1%	36.3%	32.0%
Public transport	55.0%	48.9%	45.7%
Intermediate Public Transport (IPT)	13.3%	7.3%	12.6%
Cycle	16.1%	2.0%	2.4%

Table 3: Year wise distribution of vehicle population

Year	2-Wheelers	Cars	Auto rickshaws, taxis	Others	Total
1980	0.97	0.30	0.10	0.31	1.68
1985	1.89	0.47	0.11	0.30	2.77
1990	4.01	0.71	0.15	1.41	6.28
1995	5.94	1.07	0.34	0.62	7.97
1996	6.69	1.21	0.39	0.71	9.00
1997	7.58	1.38	0.47	0.80	10.23
1998	8.39	1.52	0.54	0.84	11.29
1999	9.10	1.64	0.55	0.94	12.23
2000	9.94	1.84	0.58	1.01	13.37
2001	10.92	2.07	0.62	1.12	14.73
2002	11.83	2.26	0.64	1.23	15.96
2003	13.23	2.53	0.69	1.37	17.83
2004	14.44	2.77	0.76	1.53	19.50
2005	16.71	3.51	0.81	1.69	22.72
2006	18.96	4.06	0.82	1.73	25.57

Source: Bangalore Traffic Police Web Site and RTO, Bangalore

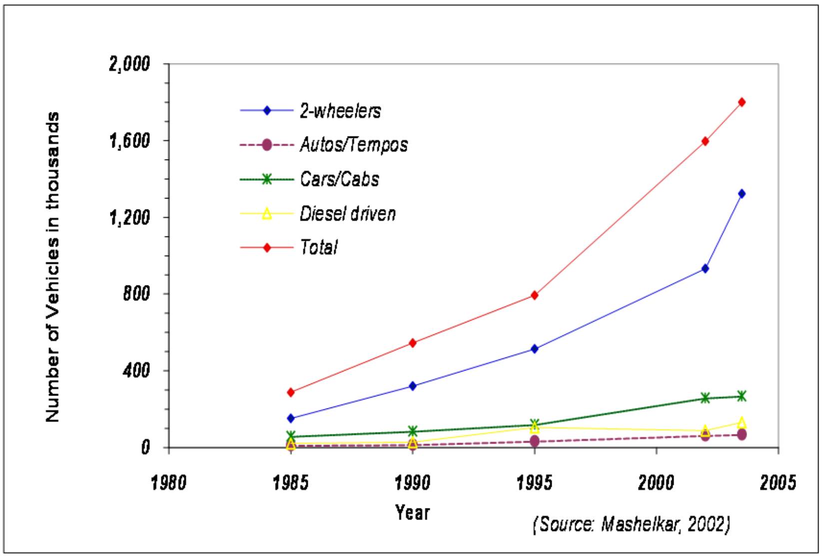


Figure 3: Growth of Bangalore's motor vehicle population

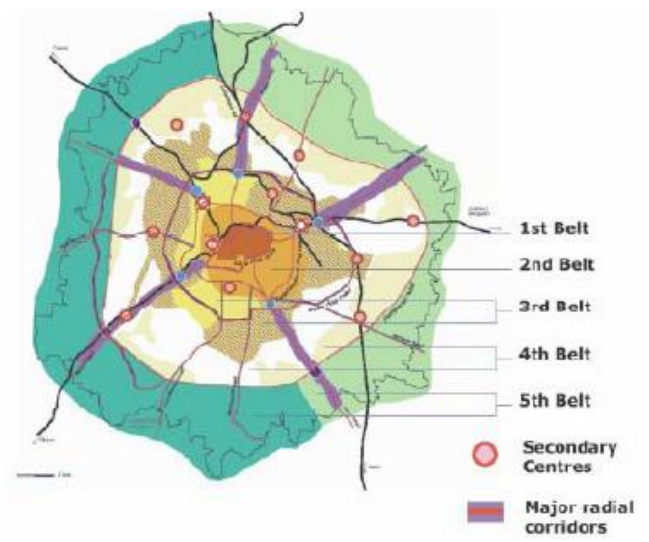
Bangalore is endowed with a radial pattern of road network converging towards the core area of the city. The road network in the central part of Bangalore city has developed organically over the last few centuries and has inadequate rights-of-way of small lanes and footpaths which were later converted into roads. The Bangalore city roads with many intersections and conflict points besides poor geometry in the old areas and central business district (CBD) are considered as the traffic hot spots causing severe traffic congestion. There is an Outer Ring Road of about 62 km cutting across various radial roads and an Intermediate Ring Road has been constructed in fragments e.g., At south-east between Koramangala and Airport Road.

Figure 4: India's diversity reflects on her roads

1.3. DEVELOPMENT AUTHORITIES

There are five agencies with the responsibility and authority for carrying out spatial, structural and transport planning schemes with implications and management powers in BMR. The Bruhat Bangalore Mahanagara Palike (BBMP), Bangalore Development Authority (BDA) and Bangalore Metropolitan Region Development Authority (BMRDA) are responsible for planning and development of road infrastructure while the Bangalore Metropolitan Transport Corporation (BMTC) and Karnataka State Road Transport Corporation (KSRTC) are the user agencies.

1. ***Bruhat Bangalore Mahanagara Palike***: The Bangalore Mahanagara Palike (BMP) became BBMP by absorbing seven City Municipal Councils (CMC) and one Town Municipal Council (TMC), which is the greater Bangalore municipal body.
2. ***Bangalore Development Authority***: BDA is entrusted with the task of preparing a Comprehensive Development Plan (CDP) subject to revision once every ten years. It is also responsible for planning, implementation and monitoring of plans in the Bangalore Metropolitan Area where as the BMRDA is responsible for the surrounding area.
3. ***Bangalore Metropolitan Region Development Authority***: It is responsible for developing the outer regional development beyond BDA. It has an overseeing role over BDA with authority to control and reject the plans as it takes care of the local planning authorities for the planned development of BMR.
4. ***Bangalore Metropolitan Transport Corporation***: BMTC is responsible for city and sub-urban bus operation and management and to improve the movement of bus network in the city.



1st Belt	*The core area, the administrative centre and the CBD*
2nd Belt	*Older planned residential areas surrounding the core area*
3rd Belt	*Extensions of city on both sides of the Outer Ring Road, a portion of which lacks services and infrastructure facilities*
4th Belt	*New layouts with vacant plots and agricultural land*
5th Belt	*Green belt and agricultural area including small villages*

1.4. TRANSPORT NETWORK

Bangalore has a network of 4,300 km of road out of which 252 km is arterial roads including 81 km in the eastern sector, 76 km in the western sector and 95 km in the southern sector. National and state highways entering the city add another 100 km to the arterial roads carrying most of the vehicular traffic. The different types of roads in Bangalore city are Ring Roads - Core Ring Road (CRR), Outer Ring Road (ORR), Peripheral Ring Road (PRR), Intermediate Ring Road (IRR), Satellite Township Ring Road (STRR) Expressways- Airport Link Road, Highways - National Highways, State Highways, Arterial Roads, Sub-Arterial roads and other link roads.

The road networking has not been scientifically planned, as the city did not expect the unprecedented growth of population. There is no provision for expansion or for widening of roads therefore, wherever possible the road widening work has already been carried out. The recent development of outer, inner and satellite ring roads are expected to provide some respite to the current traffic woes. Traffic planning is left with the only choice of one-way systems. The construction of underpasses and flyovers may provide some relief to the high-density traffic of city roads.

The present road network consists of ring roads and major radial corridors. A number of proposals have already been included in the Master Plan 2015. In addition, quite a few proposals are being implemented by government agencies like National Highways Authority of India (NHAI), State Public Works Department (PWD), BMC, BDA, BMRDA and Bangalore Mysore Infrastructure Corridor Area Planning Authority (BMICAPA) along with private sector through PPP model. It is necessary to integrate / superimpose all these proposals in the light of projected travel demand for road traffic and confirm that they are in conformity with each other and there is neither conflict nor duplication. As the radial road corridors are expected to have high traffic volume, these corridors have been proposed to be strengthened instead of isolated improvements. The road improvement proposals include road widening, new roads (bypasses and other roads), ORR realignment, grade separators (road flyovers, road over bridges (ROB), road under bridges (RUB), Integrated Freight Complexes, etc.

Fly-overs and grade separators: For de-congestion of traffic in Bangalore city, the government has constructed fly-overs and construction work still going on in some junctions.

Table 4: Emission limits of petrol vehicles

Limits	*Vehicle class*	*CO in g/km*	*HC in g/km*	*NO_X in g/km*
Prior to July 2007	Displacement <150cc	2	0.8	0.15
	Displacement ≥ 150 cc	2	0.3	0.15
Since July 2007	V_{max} <130km/h	2.62	0.75	0.17
	V_{max} ≥130km/h	2.62	0.33	0.22

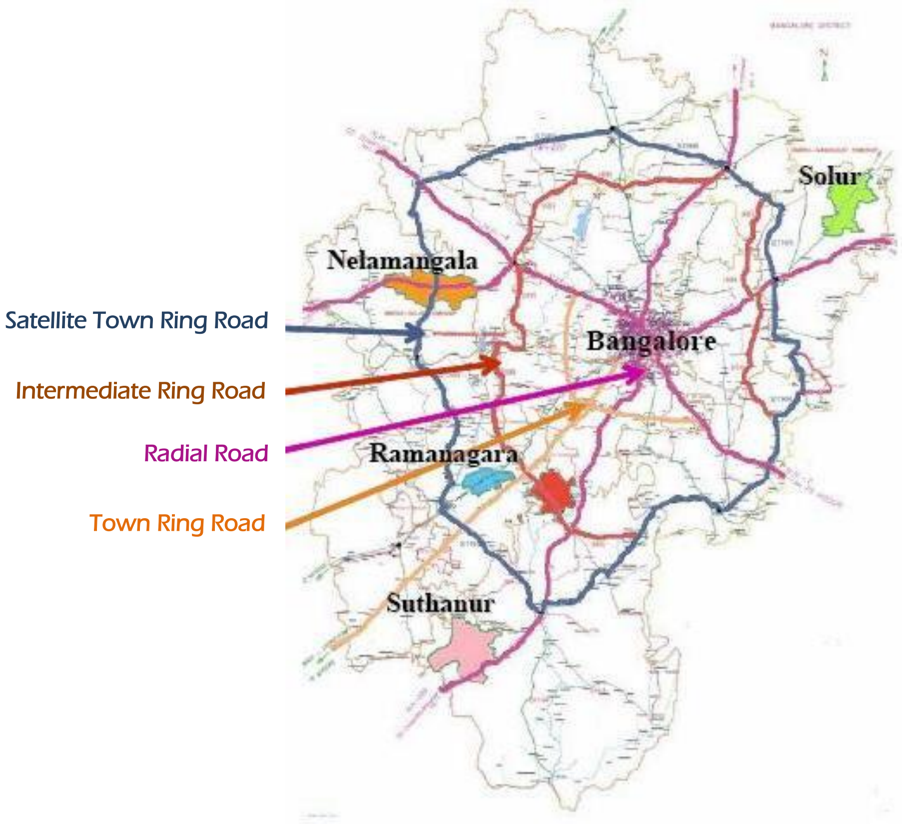


Figure 5: Road network of BMR

Vehicle emissions of BMR

Bangalore has steadily lost its reputation as the "Garden City". The rapid growth of city in the last two decades has crippled its infrastructure and polluted its air, water and soil. About 1.8 million vehicles registered in Bangalore are plying on its roads. Bangalore consumed 2,250,000 metric tons of diesel and 500,000 metric tons of petrol during the financial year 2002-03. The air pollution levels in the city of the future are comparable to that of an industrial-age steel works town. The PM10 levels (160-180 µg/m^3) are almost three times that of the Indian National Ambient Air Quality Standards (INAAQS) for exposing 5.7 million people of Bangalore to unhealthy levels of this pollutant (Source KSPCB).

Vehicle emissions from the transport sector contribute 51,221 tonnes of carbon monoxide (CO) and about 2,467 tonnes of particulate matter (PM) annually.

Table 5: Pollution load of Bangalore

CO in Mt/d	*NO_X in Mt/d*	*HC in Mt/d*	*PM in Mt/d*
207.0	29.7	117.4	8.1

2. ISSUES

2.1. AIR POLLUTION

Bangalore's population has been growing at a rate of 3.25% per year in the last decade. There has been a phenomenal growth in the population of vehicles. The number of motor vehicles registered has already crossed 28 lakh. In the absence of adequate public transport system, people are using personalised modes of transport which is not only leading to congestion on limited road network but also increasing the pollution load. An average Bangalorean spends more than 240 hours commuting every year. (refer to Executive Summary of CTTP Report for Bangalore). Such delays result in loss of productivity, reduced air quality, reduced quality of life, increased cost of services and goods besides unquantifiable health cause.

Some of the common issues encountered in the Bangalore city traffic are:

- Per capita emission of two-wheelers and four-wheelers is high as compared to buses.
- Health risks due to air pollution are on the rise and reaching alarming levels as evidenced by the number of respiratory diseases and allergic cases reported in Bangalore city. This is predominant among vulnerable road users like pedestrians, traffic police, shop owners, vendors and auto drivers.
- "In the last 20 years, Bangalore has seen the rising levels of pollution from vehicle exhaust and industrial toxins. This is leading to increase in the number of asthma, bronchitis, allergic rhinitis cases and other respiratory problems in the city. From studies that we have done, we found that in 10 years between 1994 and 2004, the cases of chronic asthma had gone up from 20% of the population to 36.5%" as per the report of H. Paramesh, paediatric pulmonologist and Director of Lakeside Medical Centre and Hospital.

  On an average a person inhales up to 10,000 crore suspended particulate matter (SPM) mostly from vehicular exhaust, industrial pollutants, construction material and waste in a day on the streets of Bangalore. It does not take more than 30 seconds for these tiny particles to enter the bloodstream. It means that some of the respirable suspended particulate matter (RSPM), especially those less than 2.5 microns can easily get into the respiratory system, cause extensive damage to the lungs and blood vessels. In a sensitive area such as Victoria Hospital the SPM and RSPM have been found to be considerably above the permissible limits (refer to Chapter 4 **"Air"**, section 1.2. An in-depth evaluation of health risks can be found at Chapter 5 "**Health**", section 3.1.
- Vehicle mix: Vehicles of different size, capacity and speed occupy the same road space and fight for mobility. This leads to higher fuel consumption and higher emissions.
- Ten-year old bus pollutes hundred times more than a new bus (Volvo report at Sustainable Mobility Conference on 04-02-2008).
- Vehicle density and road space is a critical concern.
- Integrated transport system - inter connectivity with inter-modal changes are the only options as the studies have also shown that the transport sector contributes to 16% (Source: Handbook of Statistics 1998) of GHG emissions and therefore, needs clean and green technologies.
- Bangalore city is suffering from poor infrastructure, lack of resources, chaotic traffic, lack of traffic discipline, rampant building rule violations, etc.
- Poor roads, indisciplined drivers, poor traffic management, lack of proper infrastructure.
- Noise pollution due to operation of vehicles is assuming critical stage. Victoria Hospital junction tops in noise pollution in the city with the noise level recording between 82-86 decibels, while the permissible limit for sensitive areas is 50 decibels. The results of analysis suggest that the noise pollution in K. R. Circle, S. M. Junction Peenya, Silk Board junction are noise hotspots with levels exceeding 100 decibels.

Table 6: Checks conducted by Transport Department

Details	2005	2006	2007
Defective silencer	6,823	39,819	14,364
Emitting black smoke	13,420	23,170	12,539
Shrill horn	16,871	38,931	41,660

2.2. FUEL AND TECHNOLOGY

- Despite the fact that Bangalore city has been on the radar of highly polluted cities in the country, the effort to blend ethanol at 5% as per mandatory norms is not implemented in total due to lack of willingness of the petroleum marketing companies.
- The higher Bharat Stage Norms have poor fuel efficiency.
- Auto rickshaws continue to pollute as they use poor quality/adulterated lubricants.

- The auto giants have not made sustained efforts to develop the R & D of renewable alternate fuels like bio-fuels, fuel cell technology, electric vehicles and alcohol engines.

2.3. ROAD UTILISATION

- The average speed of vehicles in Bangalore city that was 13 km/h has been reduced to 11 km/h causing adverse impact on emission levels. The optimum working speed of vehicles is 35 to 40 km/h besides, the stop and go of vehicles will result in higher emissions and higher fuel consumption.
- The location of roadside bus stop leads to traffic snarls during peak hours and further reduces the average speed of vehicles. The encroachment of hawkers in market places further aggravates this problem. The location of auto rickshaw stands in busy intersections and crowded market places adds to the existing woes of traffic problems.
- The poor land use planning, location of important offices and business activities located in the CBD adds to further congestion.
- Road network capacity is grossly inadequate. Most of the major roads are with four lanes or less with small scope of their widening. This indicates the need for judicious use of available road space.
- Traffic composition on roads indicates a very high share of two-wheelers. The share of cars is also growing. This indicates inadequate public transport system.
- GHG emissions are increasing most rapidly in the transportation sector. A major issue of global concern at present is the increasing contribution of transport sector to CO_2, the main GHG produced from the use of fossil fuels-and its consequences on global warming and climate change.
- There is high pedestrian traffic in the core area. Footpaths are generally not adequate and their condition is deteriorating. Therefore, up gradation of facilities is a high priority.
- Parking is assuming critical dimensions in Bangalore that needs to be augmented substantially.
- Share of bicycle traffic has declined over the years. This mode of transport needs to be promoted by providing exclusive cycle tracks at least in the newly developed layouts.

Volume to capacity ratio

Ideally, the Volume to capacity (V/C) ratio should be less than 1. If it is 0.2, the level of service (LOS) is excellent; if it's 0.4, the LOS is good; if it's 0.6, it's average but, 0.8 is bad and 1 is worse. Even 1.2 is allowable under extreme circumstances, as say, when a rock concert gets over and all the vehicles spill over the roads at once. When it crosses 1.2, a road is virtually dead.

Table 7: Volume to capacity ratio of city roads

Road	*Volume capacity ratio*
J.C. Road	1.81
Hosur Road	2.62
Airport Road	2.34
M.G. Road	1.11
Cubbon Road	0.92
Nrupatunga Road	1.94
Old Madras Road	2.06
Chord Road	0.74
Museum Road	0.69
Raja Ram Mohan Roy Road	0.80
Residency Road	1.96
Richmond Road	2.01
Sampige Road	2.61
Margosa Road	1.86
Infantry Road	1.88
Race Course Road	2.46
Peenya	2.94
St. Mark's Road	2.09
Bull Temple Road	1.36

Though the ideal V/C ratio is 0.2, these ratios are far from reality on Bangalore roads as shown in Table 7. The air pollution on these roads is abnormally high with the ratios that are above 2.0. The interventions like flyovers on Hosur Road and the "magic box" for decongestion on Sankey Road are short-term solutions. Reducing the V/C ratio through infrastructural interventions are very tough measures. The existing bottlenecks on city roads have further worsened because of the Metro construction work. The only way to reduce V/C ratio is through reducing the vehicles and shifting the private mode to public mode of transport with efficient, accessible and comfortable public transport.

2.4. PEDESTRIAN TRAFFIC

Figure 6: Pedestrians negotiating for walking space, Jama Masjid

There is rightly an increasing demand for better pedestrian facilities. The increase in vehicular traffic has given rise to widening of carriageway to accommodate the vehicles resulting in the reduction of footpath space. While footpaths exist in most areas they are often obstructed by utilities (see Figure 7) or used for temporary storage of building materials or dug up or encroached upon. Not seldom all of these concur. There are very few footpaths without bottlenecks and pedestrians are typically forced to circumvent obstacles by using the road at least at some point. To picture the severity of the implications one should consider a mother with one or two small children, entering a road that carries rush hour traffic, in the dark and sometimes in the rain. Footpaths very rarely are an invitation. Walking spaces that connect without obstructions are missing. This situation results in increased vehicle–pedestrian conflicts. In addition, at many places footpaths are narrow and many do not have proper surfaces to walk on.

Zebra crossings are rare on busy roads. Sufficient facilities, particularly for crossing, have not been provided for pedestrians. At some locations foot bridges were constructed but these are not being fully used due to the inconvenience of climbing and descending. This is an aspect which needs consideration. Facilities like subways or skywalks with lift facilities may be a better option.

Figure 7: Many pedestrian obstacles are carefully engineered, Jayanagar

2.5. PARKING

Vehicle parking is a major problem in the city. Parking demand is increasing with increasing vehicles and street parking space is almost exhausted in the city centre. Enforcing parking restrictions on the roads will require provision of alternatives in the form of multi storeyed lots and alternative pricing mechanism as a disincentive.

Parking surveys carried out at some important locations like bus terminals and commercial areas have indicated a huge parking demand. Some of the roads like J. C. Road, Sampige Road, M. G. Road, Brigade Road, Commercial Street, CMH Road, Jayanagar 4th Block, Shivajinagar and K. G. Circle are attracting a large number of vehicles especially during peak hours, weekends and holidays. Sufficient provision has been made for parking at KSRTC bus terminal and railway station. Parking lots have been constructed on J. C. Road and K. G. Road. However, the demand for parking is so heavy that the parking lots have not been able to cater to the increased demand.

Figure 8: Surprise beneficiaries of the metro construction, M. G. Road

Future plans

The future plans on the anvil initiated by the urban local bodies (ULB) are increased pay and park systems, new Multi storeyed (MS) parking lots by BMP, BMTC and more conservancy parking. Parking is causing traffic obstruction. A comprehensive parking survey needs to be undertaken covering the entire city and parking plan to be prepared indicating on street and off-street parking locations along with suitable parking policy suitably devised for the city.

3. IMPACT

3.1. EMISSION IMPACT ON HEALTH

It is estimated that every year 800,000 people die prematurely from lung cancer, cardiovascular and respiratory diseases caused by outdoor air pollution and 150,000 of these deaths occur in South Asia alone (Cohen, et al. 2003). Proportionally, about 630 Bangaloreans die prematurely every year due to outdoor air pollution.

The World Bank, in 1998 has conducted an assessment on impact of human exposure to particulates on society and on the economy. According to this assessment the health damage from exposure to high level of particulates in 126 cities worldwide where the annual mean exceeds 50 µg/m^3, in which India represented by 12 largest cities in the sample lost 12 disability-adjusted life years (DALYs) per 1,000 residents. These health damages, in monetary terms, are 9% of the respective income (GDP/capita), implying that the costs to the society, part of which is direct productivity loss due to air pollution in the twelve largest Indian cities are as high as nearly 10% of the income generated in these cities from all economic activities (Lvovsky 1998). In addition, the study estimates based on an analysis of a subset of the sample that social costs worth USD 3 billion is incurred due to air pollution, of which 64% is due only to health costs. The costs due to global climate change are the largest portion of the non-health costs (28%), but are less than half of the health costs.

While, considering the effects of nano particles (particles of size 10 nanometers) and the air toxics (organics in ambient air), in addition to PM10, CO, NOx and SO_X, the ambient air in Bangalore city is a potent cocktail for more premature deaths.

The impact of transport activities on environment is categorised as below:

1. Direct impact
   - Pollution of air, noise, water and soil.
2. Indirect impact
   - Disposal of scrap generated from vehicle maintenance, used oil and fuel filters.
   - Fuel quality and adulteration.
   - Spillages and leakages leading to impact on water bodies and soil pollution.
   - Generation of hazardous waste like used oils, scrap batteries, used tyres etc.
   - Negative impact on species due to high pollution load and high noise levels.
   - Damage to fragile ecosystem.
3. Cause and effect relationship
   - Modification of auto richshaw's silencers leading to high noise levels.
   - Noise due to traffic activity and vibration effects due to engine operation at low, high and abnormal operations.
   - High degree of noise level results in hearing disabilities, sleeplessness, higher stress levels and blood pressure.
   - Noise level limits to be implemented and enforced by concerned authorities.
   - Studies have reported that noise pollution will lead to permanent deafness if exposed to the noise exceeding the permissible limits. (Permissible limit is 55- 65 decibels for residential areas and sensitive places like schools and hospitals, while it is 90 decibels for industrial areas). The major noise polluters in the city are auto rickshaws whose noise level crosses 85-90 decibels. The noise levels of shrill horns used are in the range of 90-100 decibels.
4. Loss of biodiversity
   - Loss of biodiversity due to development of transport infrastructure, clearing of vegetative cover, shift in area of activity.
5. Dust
   - Dust due to traffic operation and generation of particulates of PM 2.5, PM 10 and above.

3.2. ROAD ACCIDENTS

Accident data for the past 6 years is shown in the table below. The table shows that a large number of road accidents take place and claim many lives every year. It shows that the numbers of accidents are on the rise due to high congestion, increased vehicle population, pedestrian traffic and other vulnerable road users.

Table 8: Road accidents of Bangalore city

Year	Fatal	Killed	Non fatal	Injured	Total
2001	668	703	8,358	6,929	9,026
2002	783	820	9,073	7,577	9,856
2003	843	883	9,662	7,980	10,505
2004	875	903	8,226	6,921	9,101
2005	796	836	6,782	5,899	7,578
2006	880	915	6,681	6,048	7,561
2007	957	981	7,469	6,591	8,426

Source: Traffic Police Department, Bangalore

Most of the traffic accidents result from careless behaviour of road user's viz., drivers or pedestrians. The probability of accidents and the severity of accidents can be reduced by proper application of traffic control devices, good road way design features and traffic road management measures.

Table 9: Distribution of trips by mode of travel

	Public transport	Two wheeler	Intermediate public transport	Car	Cycle	Walk	Total
Trips in thousand	**2,634**	**1,845**	**726**	**416**	**139**	**524**	**6,286**
Shares considering walking	*41.9%*	*29.4%*	*11.6%*	*6.6%*	*2.2%*	*8.3%*	*100%*
Shares not considering walking	*45.7%*	*32.0%*	*12.6%*	*7.2%*	*2.4%*	*0.0%*	*100%*

The distribution of trips by purpose and trip length indicate that 38% of home based work trips are performed within 10–20 km distance while 53% of education trips and 57% of other trips are performed within 10–20 km distance. Table 10 shows the distribution of trips by purpose and trip length.

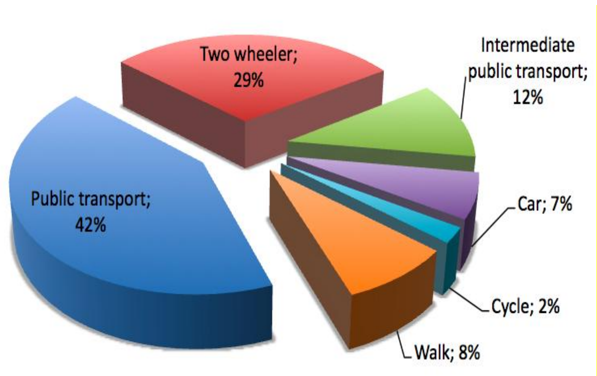


Figure 9: Distribution of trips by mode of travel

Table 10: Distribution of trip length by purpose of travel

Trip length	Home to work	Home to school/college	Home to elsewhere	Trips not starting at home	Business	Return trips	Total
0-2 km	327,907	137,356	28,133	4,852	1,681	223,144	723,074
2-5 km	278,904	78,626	120,412	17,595	1,712	458,116	955,365
5-10 km	433,673	73,612	87,537	26,870	1,371	579,279	1,202,342
10-15 km	422,495	235,376	222,539	21,646	3,759	891,636	1,797,451
15-20 km	281,664	156,917	148,359	14,431	2,506	594,424	1,198,301
20-35 km	95,176	55,422	41,802	2,939	675	200,621	396,636
>35 km	0	1,490	954	4,013	43	6,011	12,511
Total	**1,839,819**	**738,800**	**649,737**	**92,346**	**11,747**	**295,3230**	**6,285,680**
Average trip length in km	*9.3*	*10.9*	*11.5*	*11.0*	*10.7*	*11.1*	*10.6*

It is seen that the trip lengths for education is unusually high, even higher than that of work trips. This can be attributed to the probability that most of the education trips undertaken are for higher education and most of such institutions including Bangalore University is located on the periphery of the city. The percentage of education trips is comparatively low indicating that lot of education trips at primary and secondary level are intra zonal, due to availability of such schools within most zones. Overall, the average trip length observed is 10.6 km.

The distribution of trips by mode and trip length is as shown in Table 11 reveals that 68% of bus trips are made for covering distances varying from 10–20 km while it is 47% in case of car trips and 33.5% in case of two -wheeler trips for the same distance. Nearly 30% of bicycle trips are performed for a travel distance of up to 5 km while it is 43% for distance of up to 2 km by bicycles.

Table 11: Distribution of trips by mode and trip length

Trip length	*Bus*	*Car*	*Two wheeler*	*Three wheeler*	*Cycle*	*Walking*	*Total*
0-2 *km*	197	46	142,633	0	59,137	521,061	723,074
2-5 *km*	117,434	27,809	482,306	279,891	45,390	2,536	955,365
5-10 *km*	134,333	151,603	725,082	165,814	25,509	0	1,202,342
10-15 *km*	1,429,620	152,409	316,173	192,265	6,560	0	2,097,026
15-20 *km*	612,694	65,318	135,503	82,399	2,811	0	898,725
20-35 *km*	329,555	17,627	43,779	5,675	0	0	396,636
>35 *km*	10,639	1,492	0	381	0	0	12,511
Total	**2,634,471**	**416,304**	**1,845,476**	**726,425**	**139,407**	**523,597**	**6,285,680**
Average trip length in km	*15.0*	*11.6*	*8.0*	*8.6*	*3.9*	*1.0*	*10.6*

3.3. TRAVEL COST

Table 12: Average travel cost by purpose of travel

Purpose	*Average travel cost in INR*
Work/business	7.49
Education	2.73
Business	5.74
Others	6.04
Return	6.12
Non-home based	8.74

The average travel cost for various purposes of travel reveals that the cost for non-home based trips is high as compared to work trips. The employee business trips cost INR 5.74 per km. The per capita trip rate (PCTR) refers to the number of inter-zonal trips made by an individual per day. Accordingly, PCTR has been calculated purpose wise for the BMA as presented in Table 13.

Table 13: Per capita trip rate by purpose

Trip purpose	*Trips*	*Share*	*PCTR*
Work	1,839,818	29%	0.271
Education	738,799	12%	0.109
Others	649,737	10%	0.096
Non home based	92,347	1%	0.014
Business	11,748	0%	0.002
Return	2,953,228	47%	0.434
Total	***6,285,677***	***100%***	***0.924***
Total population	*6,800,000*		*0.924*

4. PUBLIC AND MASS TRANSPORT

4.1. METRO RAIL

The first phase of Bangalore Metro consisting of two corridors of electrified double line will cover a total of 33 km. Out of the 33 km covered, 6.76 km will be underground near City Railway Station, Vidhana Soudha, Majestic and City Market and the rest will be elevated. It has been designed for a capacity of 40,000 PHPDT. The number of passengers expected to travel on the metro everyday is estimated at 10.20 lakh in 2011 and it would be 16.10 lakh in 2021 (BMRCL statistics).

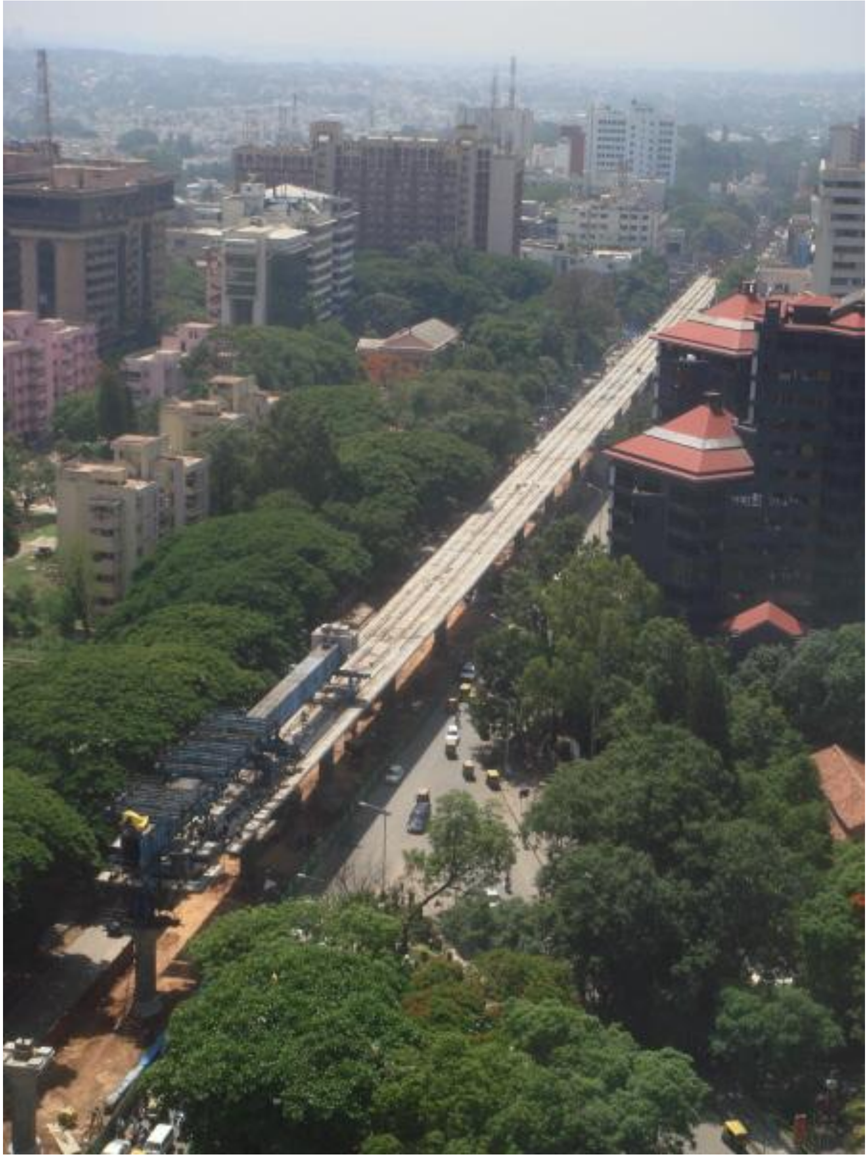


Figure 10: New horizons – Metro in the making, M. G. Road

4.2. BUS RAPID TRANSIT SYSTEM

The road network infrastructure in Bangalore is characterised by comparatively narrow roads. Many intersections have poor and inefficient design. Lack of continuity is an increasing problem as it creates bottlenecks which unnecessarily lowers the capacity of corridors. The heterogeneous composition of traffic adds to the complexity of traffic situation.

The only feasible way to provide the public transport system is through dedicated road space to high and medium capacity buses. If public transport is to be accepted as an alternative to personalised transport, it must be reliable, fast, punctual, comfortable, accessible and operate at higher frequency. The feasibility study carried out by Swedish International Development Co-operation Agency (SIDA) has proposed a traffic system management by restructuring and simplifying traffic calculation and improving intersection design at critical points such as Hudson circle, Minerva circle, Richmond circle, etc., to increase the capacity and to find ways of providing dedicated bus lanes in the central area. Besides these changes in the traffic circulation, improvement of infrastructure in terms of upgrading links have also been proposed. These changes make it possible to implement a network of physically protected bus-ways in the central area. The detailed location of bus lanes in the road varies from place to place depending on the local context and the following three different design principles have been used.

- Two-way bus lanes in the road midst.
- Two-way bus lanes at one side of the road.
- One-way bus lane at the right hand side for links with one-way operation and with limited road width.

4.3. ROUTE NETWORK STRUCTURE

4.3.1. Originally proposed structure

The bus route network proposed by the SIDA report has the trunk route network covering an area with a radius of around 6 km from Cubbon Park. The trunk routes operate through the central area between 8 external terminals. At each terminal a network of feeder routes connect the trunk route. Additional local routes serve the areas and provide connections not covered by the basic network of trunk route terminals and feeder routes. Suburban services form a separate network which connect the trunk route terminals and terminate at the City Bus Stand. The trunk routes form the base in the newly proposed network and were proposed to have a total length of about 67 km with 380 articulated buses operating. The proposed strategy was to connect each of the 8 terminals to the other terminal except the nearest ones. In this way, 5 trunk routes will operate from each terminal with a total of 20 different routes connecting the 8 external terminals. To maximise the availability to the central area, each route operates with different links within the area. Each trunk route was proposed to be operated with headway of 6 minutes. With 5 routes the frequency at each terminal would be 50 departures per hour.

To each of the 8 trunk route terminals, a net of feeder routes is connected. Besides being a feeder to the trunk routes, this route network would also function as a local bus system creating accessibility within the local communities. To maximize this local accessibility and to minimize the size of terminals the feeder routes would pass through the terminals and have their turning points at the fringe of the local area. It was estimated that 50-60 feeder routes would serve the 8 terminals with an average interval of around 10 minutes.

Areas that are not served by the trunk/feeder route network would be served by additional local routes. The density of trunk routes is not adequate to provide the service with acceptable walking distances to everybody. A complementary local network is needed and it has to be carefully planned during the course of the project so as to achieve the necessary coordination and integration. Other types of local service are inter-district routes which connect the different trunk route terminals and also provide service in tangential directions. These services can have a favorable impact on the land use since they facilitate the development along ring roads between radial corridors. The estimated number of local bus routes is 130 with an average service interval of 15 minutes.

4.3.2. Revised approach

The route network proposed was based on the strategy to provide an acceptable frequency during the whole day all over Bangalore within an acceptable walking distance. This implied a considerable reduction of the number of routes and a new strategy with trunk routes and feeder routes. The number of transfers within the route network would increase but a higher frequency and a ticketing system with free transfers would compensate. Also the design of bus stops would facilitate the transfers. The BMTC however, felt the need to modify the route network from the hub-and-spoke scheme as the passengers in Bangalore are used to a destination oriented system that means changeovers are disliked. If the new Metro-bus system is to be accepted, it would be necessary to keep the number of changeovers to a minimum. Also of concern to passengers is the distance travelled, travel time and waiting time at bus stops.

Keeping these points in mind a route network following the grid pattern instead of the hub-and-spoke principle was developed; as it would address the core problem of the passengers. In order to increase the frequency of services and to provide the direction oriented services in place of the present destination oriented services about 27 high-density trunk corridors have been designed. Extensive work has been done to identify the 27 highly potential trunk routes. These 27 routes are planned to run in horizontal, vertical and diagonal directions and also to include two circular routes, one in the CBD area and the other at the outer ring road area. No separate feeder network is proposed though local and suburban services would continue.

Route surveys conducted by the BMTC indicate that the space is available in 27 trunk corridors for dedicated bus lanes. Exclusivity for buses would be to the extent of about 15% of the available road space. Kerbstones will be used to create the bus lanes. These stones would allow the bus to leave the bus-lane but prevent other road users from entering it.

4.4. IMPLEMENTATION OF BUS RAPID TRANSIT SYSTEM

Following are the advantages which help providing

- Efficient public transport system
- Increase of speed
- Better environment
- Better infrastructure facilities through well-designed bus stops and traffic signals
- Discouraging personalised mode of transport
- Influence on the growth of city

Advantages of Bus Rapid Transit System (BRTS)

- Can operate at speeds nearly twice as fast as conventional buses
- Flexible vehicles that can operate on designated roadways
- Have capital and operating costs substantially lower than rail
- More accessible to seniors and people with disabilities than traditional bus service
- Can take advantage of compressed natural gas (CNG) and other clean technologies, thus helping to improve our environment
- Can be developed incrementally allowing the systems to be installed over a period of time as needs and demands change.
- BRTS is particularly appropriate on congested urban corridors

4.4.1. Bus stops and depots

For the trunk route system, the bus way infrastructure with dedicated bus lanes, closed bus stops with level entrance to the bus have been recommended in the SIDA report. The passengers enter the bus stop by a ramp from the street level up to the level of the bus floor which is approximately 85 cm. The bus stops are proposed to have computerised ticketing systems issuing destination based tickets.

4.4.2. Bus fleet

The existing bus fleet is a mix of two different brands with a typical capacity of 82 passengers. The BMTC has also introduced about 40 articulated buses on certain routes. The bus fleet proposed is to be environmentally friendly, provide high comfort and safety of passengers. Two basic types of buses proposed are metro buses and standard buses. The metro buses of 215 passenger capacity are 3-axle single articulated buses with normal floor height using specially designed platforms at bus stops. Bi-articulated buses of the same design could later be introduced. The standard buses of capacity 115 passengers are 2-axle buses which can have either low floor or normal floor height or alternatively, be designed with a low entry. These standard buses were proposed for local buses, feeder buses and suburban buses to be imported.

4.5. DEVELOPMENT OF TRANSPORT INFRASTRUCTURE

The presence of public transport is demonstrated by the fact that it carries 46% of the total demand in spite of the fact that the emissions per passenger km, road space occupied per passenger km is the lowest for a public transport operation with high capacity buses. It is evident that the public transport has the advantages of low emissions per passenger km and road space occupied per passenger km. Therefore, the priority on public transport has to be subsidised to extend the benefit of mass transport and ensure a shift of privatised mode of transport to public mode of transport. It is evident that the infrastructure in terms of Inter Modal Connectivity with sufficient parking facility would promote the use of public transport to larger an extent, as there is scope to improve the share of public transport from the existing 46%.

4.6. SOCIAL OBLIGATIONS

BMTC through its buses indicating destination in red board and operation of city services to core areas with buses having destination in black board connects all villages under the jurisdiction of BMR.

BMTC operates limited stop buses to save the time of commuters by providing comfort oriented fast moving 'Pushpak' buses chartered services to industries, schools and colleges, subsidised travel to the deserving sections of the society, passes to various segments of the society. It also issues passes to the operation of Eco-friendly 'Parisara Vahini' and high capacity 'Vestibule' buses, and 'Mini' buses to provide transport to remote sub urban areas. BMTC introduced 106 'Volvo' buses in the city, 140 Vayuvajra and Suvarna branded services to Bangalore International Airport and City sightseeing 'Curitiba' buses. Special services to cater to the needs of ladies, shopping, hospital and malls are introduced. Special buses with the facility of daily, monthly and students pass are introduced. Monthly and daily passes issued are about 2.5 lakh and 1.6 lakh respectively.

Longer distance access, low frequency and high travel time combined with longer waiting times have caused lower patronage of bus transport. Majority of commuters are reluctant to walk more than a quarter kilometer to the bus stop or from bus stop to destination. All these have caused a number of commuters who would have otherwise travelled by bus to prefer a two-wheeler for travel. Thus, over the years the number of private vehicles on roads have gone up causing congestion of roads which in turn has further reduced the average speed of buses making them less attractive. This trend can be seen from Table 2 which gives the change in the modal split. It also shows that over the years the share of trips by cars has increased due to rising car ownership levels and inadequate and unattractive public transport system. Share of trips by two-wheelers has also gone up significantly. Of late two-wheeler users have been switching over to cars due to rising income levels. Share of public transport has declined to some extent although in terms of absolute numbers it has increased. Share of trips by cycles has declined.

The experience of developed nations and the outcome of studies conducted have also indicated that mass transport through rail has higher efficiency in terms of emissions, energy, space occupied per passenger km than the road based transport operation; it also has an edge over the land use requirement as compared to the road based transport system. This system may not be feasible for a fully developed city like Bangalore due to high capital cost and shift of traffic during the design, planning, construction and implementation period.

Therefore, the best choice of transport is to have inter modal transport system for Bangalore city with provision of road based mass transport system with a feeder system of metro and mono rail having excellent interconnection of railways to neighbouring cities such as Mysore and Tumkur.

A multi-layered traffic management approach

- Traffic management through regulations and restructure
- Traffic infrastructure in terms of grade separators and subways
- Intelligent Transportation Systems (ITS) by use of Automated Traffic Control System
- Synchronised Signalling System
- Automated enforcement through PDAs

Intelligent Transportation System

- GPS based system
- GPS based operation management
- GPS based passenger information system
- E-ticketing
- Smart cards

Intelligent Transport System (ITS) and Passenger Information System (PIS)

- Bus stations, stops and terminals
- Buses for the BRT system
- User terminals (electronic kiosks, billboards, websites, etc)
- Central information centre

Figure 11: To go or not to go? – Defective traffic signal, Raj Bhavan Road

Effect of Intermediate Public Transport (IPT)

The shared modes of transport by autos and taxis are prevalent in BMR in the absence of sufficient trips by public transport-high capacity buses and hence a means to link to remote areas in BMR. The system reduces the per capita emission as compared to personalised modes of transport to a notable level. These modes of transport which help remote and poorly connected places to be serviced may be encouraged by the Government through subsidies. There should be a mechanism to restrict these modes to the remote areas only.

Productivity improvement of public transport

There is a presence of factory/IT/BPO's owned buses plying in the city and BMR which operate empty one way to pickup their staff. These vehicles clandestinely pick up passengers compromising safety. However, schools, colleges and factories in BMR have to be encouraged to use the services of BMTC which has a wide spread service in the BMR through its well connected depots and infrastructure.

5. DEVELOPMENTAL ACTIVITIES

5.1. INFRASTRUCTURE AND MANAGEMENT INITIATIVES OF BMTC

5.1.1. New proposals by BMTC

A. **Core Inner Ring Road services:** Concept being implemented by BMP; it envisages improved connectivity between important commercial, administrative, educational and other land marks within the core CBD's such as Yeshawanthapura, Rajajinagar, Magadi Road, Trinity Circle, Coles Park, J.C. Nagar and Indian Institute of Science. The corridor is expected to be 28 km long. The proposed corridor which is to come up on the existing roads through induction of additional infrastructure such as grade separators, fly-overs, etc., which would ensure uninterrupted traffic. BMTC has prepared a plan to introduce a core inner ring road service.

B. **Augmentation of Metro/Grid services:** BMTC is operating 89 schedules on 25 grid routes. To improve the frequency and connectivity, there is an augmentation plan for induction of 230 buses.

C. **Introduction of Branded Peak Hour service:** To improve the frequency during morning and evening peak hours the BMTC has plans to induct 320 additional buses which will take the total peak hour service to 500.

D. **Hospital Special Service:** These services are being introduced on 3 routes which provide connectivity to 22 important hospitals from Kempegowda bus station.

E. **Ladies Special Service:** BMTC is operating dedicated services to lady commuters.

5.1.2. Public relations for effective transport management

- Public grievances are addressed at depots, bus stations, control room, etc.
- Two exclusive telephone lines are operational in BMTC call center.
- Enquiry counters, Public Address System: These information centers function between 0600 to 2200 hours.
- Public Address System: Public address system has been installed at all the major bus stations.
- Interactive Voice Response System (IVRS): Interactive voice response system will enable the public to get information about operations through telephone.
- Citizens' Charter

5.1.3. Technology for effective transport management

- Internet based bus route operation details
- Monitoring of bus operations using GPS
- Online registration of complaints
- Electronic display system in the buses
- Electronic ticketing machine (ETM)

5.1.4. Vehicular air pollution management

The entire fleet of BMTC is subjected to emission checks every month and corrective actions taken immediately. To facilitate this work all the depots have been equipped with emission testing units. The year wise smoke check details conducted on BMTC vehicles is given in the following table.

Table 14: Emission checks conducted on BMTC's fleet

Year	Number of checks	Average checks /day	Number of defects	% of defects
1997-98	7080	19.40	1102	15.56
1998-99	12298	33.69	1494	12.15
1999-00	21480	58.85	1323	6.16
2000-01	26567	72.79	687	2.59
2001-02	27868	76.35	168	0.60
2002-03	28589	78.33	59	0.21
2003-04	30070	82.38	24	0.10
2004-05	36040	98.74	45	0.12
2005-06	41049	112.46	91	0.22
2006-07	39018	116.82	47	0.12
2007-08	44641	121.97	193	0.43
2007-08 till May	9538	159.00	81	0.85

Control of suspended particulate matter: The BMTC has equipped diesel particulate filter (DPF) developed by M/s. BHEL on trial.

5.1.5. Road safety management

- Regular in-house training programme is conducted on aspects pertaining to road discipline, traffic rules, best behavior quotes, de-addiction drives, etc.
- BMTC has recruited drivers by testing their skill through the driving track. The drivers are trained in BMTC training center for induction and refresher courses.

A. Infrastructure development of BMTC through TTMCs at 5 locations

- Jayanagar at a cost of INR 10 crore
- Domlur at a cost of INR 8 crore
- Yeshwantpur at a cost of INR 25 crore
- Kengeri at a cost of INR 20.7 crore
- Bannerghatta at a cost of INR 5.1 crore
- TTMC's provide integrated park and ride facility.

B. Brand wise introduction of services

- Air-conditioned Volvo Vajra Services with kneeling mechanism for smooth exit and entry options and convenient for physically challenged.
- Chartered services

5.1.6. Development of Intra Modal Transit Centre

- *Yelli Iddira* facility of premium Volvo services

Total number of scrap generated and method of disposal: BMTC scraps around 200 buses every year and these buses are not allowed to operate in the city as they are auctioned as non-runners without valid registration certificate.

5.2. EFFORTS OF BDA, KSRTC AND BMTC

Figure 12: Fly-over in the making, Wheeler Road

BDA has done pioneering work in addressing the environmental issues and familiarising the use of recycled water. The first major initiative to make non-potable recycled water available in a big way has been initiated by BDA within the city.

The tertiary treatment plant at Lalbagh is now in a position to meet the non-potable water requirement to an extent of nearly 15 lakh litres per day with its fully automated dispensing units. These customer friendly contraptions in position have attracted the attention of both users and environmentalists alike. This is a giant step in promoting the use of recycled water and conserving potable water.

Encouraged by this success the BDA has ventured into another tertiary treatment plant in the biggest lung space of Bangalore City viz., Cubbon Park and the work is progressing round the clock. The park extending over 300 acres of land had no dedicated water source. The plant is at the completion stage and has a capacity of recycling 15 lakh litres of sewage per day. Both these recycling plants treat raw sewage and the final product is clearer than the bottled potable water. Customer satisfaction in use of non-potable water is something that is to be seen to be believed. KSRTC has commissioned 15 treatment plants and 10 rain water harvesting units and BMTC has also commissioned 7 water treatment plants and 5 rain water harvesting systems. All the depots will be equipped with water recycling plants by December 2008 and in all the buildings the rain water will be harvested as a policy.

KSRTC and BMTC should endeavour to use the treated wastewater from these tertiary treatment plants for vehicle washing, toilet flushing and other non-potable use in all its bus depots and bus stands.

Goals of BMTC

- To promote sustainable transportation and mobility by providing 24 X 7 services
- To reduce emissions and introduce eco-audits
- Upgradation of technology to increase the passenger load factor by IT based solutions
- To bring in zero accident tolerance to reduce the level of accident rate from the present 0.16 to 0.08 (by 50%) per lakh km travelled by public transport vehicles
- To reduce the two-wheeler and four-wheeler population growth by 50%
- To increase the modal share of BMTC from 40% (with walk trips) or 32 lakh commuter trips per day to 65% or 57 lakh commuter trips per day by 2012.

- To enhance the average speed of buses to 22.5 km/h from the present 11 km/h
- To popularise the direction oriented services through grid system by replacing the present destination oriented services
- To bring the Clean Development Mechanism (CDM) into practice
- To improve the service standards to ISO 9001 and environmental standards to ISO 14001.
- To quantify non-potable water requirements and make an action plan for reuse of treated water for vehicle washing, floor mopping and toilet flushing in bus depots and bus stands.
- To quantify the incinerable hazardous waste, filters, used tyres etc from each of its depots.
- To construct public toilets with water facility at each of its bus stands.
- Awareness programmes and suitable deterrent physical guards to discipline commuters from spilling on to roads. Bus drivers not to allow people to board who do not stand in queue.

6. ACTION PLAN

6.1. TECHNOLOGY DEVELOPMENT

- Battery powered cars
- LPG vehicles (with bi-fuel mode)
- End of the pipe treatment for in use vehicles

KSRTC towards greener operations

Fuel switch programme with alternate fuels

- Ethanol blending @ 7.7% ethanol
- Bio-diesel blending @ B10 and B20

Technology Improvement

- Piston groove modification
- Research and development towards 6 stroke engine and rotary engines
- Jala Shakti engines (Crude prices reaching USD 145 a barrel)

Table 15: Technology progress of 4-stroke engines for 2-wheelers

1996	2000	2005	2010
Improved carburetor, improved porting and scavenging, optimisation of air-fuel ratio and ignition timing	Further improved scavenging, oxidation catalytic converter and/or secondary air injection	Further improved carburetor, improved oxidation catalytic converter and/or secondary air injection	Air assisted direct injection oxidation catalytic converter electronic engine management

6.2. TRAFFIC MANAGEMENT

- Traffic management through regulations and restructure
- Synchronised Signal Systems
- Traffic infrastructure in terms of grade separators and sub-ways
- Automated Enforcement through PDAs
- Intelligent Transportation System (ITS) – use of Automated Traffic Control Systems

6.3. STRATEGY FOR INTEGRATED TRANSPORT DEVELOPMENT

- Extension of mass transport system to provide wide coverage and transport integration with other modes of transport.
- Providing large network of medium level mass transport system such as BRTS to cover the areas beyond Metro network and in over loaded corridors.
- Land use adjustments and densification of corridors along mass transport corridors wherever possible.
- Use of existing railway line network around Bangalore for intra city travel, such as Kengeri, K.R. Puram, Yeshwanthpur, Majestic.
- Rationalisation and augmentation of local bus system.
- Improvement of traffic management through Transportation System Measures (TSM).
- Special facilities for pedestrians within the entire network especially in the core areas. 'Pedestrians Only' in selected shopping streets inside the core

area going to be served by Metro. Provision of pedestrian sky walks/subways, footpaths and road furniture along the roads wherever necessary.

- Diversion of traffic to Peripheral Ring Road by providing transport hubs at the junction of Peripheral Ring Road with important radials such as the National Highways and other heavily loaded roads.
- Improving primary, arterial and other important roads (particularly radial and ring roads) by providing grade separation, junction improvements, adding missing links, widening and other roadside facilities wherever necessary.
- Option of revival and improvement of rail transport services i.e., from City Railway Station to Kengeri Upanagara, Yelahanka, Vimanapura and Whitefield to ease traffic congestion.

6.4. DECONGESTION AND REDUCING AIR POLLUTION

- Promoting alternate travel modes like walking and cycling.
- Developing integral townships, housing the place of work within the township.
- Decentralising and shifting important places of power enforcement.
- Satellite towns to avoid commuting to CBD.
- Promoting the use of IT to reduce commuting of distance, time and congestion.
- Creating awareness on the effects of air pollution and noise pollution.
- Offering incentives for the use of public transport by education institutions through display of badges promoting public transport and reducing pollution.
- Imposing heavy parking / toll fee for commuting to and from the CBD.
- Discouraging private vehicle ownership through increased taxation for highly polluting vehicles and also impose green tax on the concept of polluter shall pay.
- Intensify pollution under control (PUC) checks for all vehicles and ensure 100% compliance for PUC checks and networking the centers.
- Ensure transparency in certifying at PUC centres.
- Encourage only 4 stroke engine vehicles and ban all 2 stroke engine vehicles irrespective of age, condition and application of use, etc.
- Vehicle actuated, signaling system through radio-frequency identification (RFID) or infrared sensors instead of time based traffic signals.
- Banning parking on roads, evacuation of hawkers occupying road space and footpath
- Implementation of carless day, car cooling
- Ban on two-wheelers, IPT's, cars during peak hours to promote public transport and decongest the city
- To penalise littering
- To stagger working hours of offices and schools
- Weekly off on week days
- Plant saplings on either side of road
- Heavy penalties as part of enforcement of traffic rules like seizing driving license and imposing hefty fines
- Deployment of trained traffic volunteers
- Marking of lanes on roads to impose traffic discipline
- Ban on heavy commercial vehicles/trucks within the city from 8 am to 10 pm
- Construction of underpasses and case study of magic box under pass
- Awareness and publicity of ill effects of vehicular air pollution through print and electronic media, seminars and traffic week
- Incentives by the Government for encouraging commuters on public transport
- Activities
  - a) Coordinated enforcement like footpath clearance
  - b) Traffic management scheme
  - c) Parking scheme
  - d) Obstruction removal/relocation of poles/trees/bus stops
  - e) Junction improvement
  - f) Construction of flyovers / ring roads
  - g) Road humps
  - h) Introduction of dedicated bus lanes
  - i) Rationalisation of bus stops
  - j) Road cutting
  - k) Antipollution drive
  - l) BATF coordination
- Welfare
  - a) Health camps
  - b) Green booths
  - c) Pollution mask
  - d) Reflective jackets
  - e) Cats eye (flickering buttons)
- Traffic management
  - a) One-way systems – the unfinished task
  - b) Ban on entry of lorries
  - c) Parking ban on arterial roads

d) Improved road marking
e) Lane system
f) Road traffic signals

- Create awareness in public places and silence zones like hospitals, schools and place of worship about the adverse effect of shrill horns while trying to promote no honking days. Severely punish violators in this regard.
- Special tax could be introduced on vehicles which are not fuel efficient.
- Poorly maintained old vehicles are also a major contributor to the high emission levels. Phasing out of old vehicles, inspection and maintenance for meeting the emission norms to improve the air quality.
- Use of cleaner fuels like CNG, LPG blending of ethanol or bio-diesel to be encouraged especially in public vehicles like buses and 3-wheelers as this will considerably reduce the emission levels.
- Bhurelal Committee recommendations to be implemented
- Mandatory conversion of in-use 3-wheelers registered after 01-04-1991 onwards to bi-fuel mode (such as LPG and Petrol) in a phased manner with authorised LPG kits and fixed on board LPG tanks.
- To take action for conversion of 35,000 auto rickshaws, which are running with unauthorised LPG kits and detachable cylinders.
- Register only new 3-wheelers having bi-fuel mode (such as LPG and petrol) only.
- Introduction of "No Pollution Under Control Certificate – No Fuel" scheme in petrol/diesel dispensing stations.
- Setting up of electronic emission testing centers (ETC) in each petrol bunk to be introduced wherever feasible.
- Increase sales tax and to impose entry tax on white kerosene - Superior Kerosene Oil to curb adulteration with petrol.
- Strengthening strict vigilance and surveillance action in order to check the adulteration of fuel.
- To make it mandatory for kerosene whole sellers to register themselves and produce the End Use Certificates before Civil Supplies Department.
- To establish 5 Auto LPG Dispensing Stations (ALDS) in Bangalore city.
- To convert 5 roads into one-way by Home Department.
- To construct two flyovers and one railway under pass as proposed by the concerned departments.
- To increase the fleet of BMTC buses.
- KSPCB to install online ambient air quality monitoring station.
- KSPCB to take action to promote the use of cleaner fuels used by major industries in DG sets and boilers.
- Funding through JNNURM for rolling stock
- City traffic plan to be expedited from KUIDFC
- Trial of dedicated lanes on pilot basis for high density road
- Peak hour priority for public transport vehicles
- Traffic hot spots
- Location of bus stops away from road junctions
- Bus bays to be provided at all new layouts and existing bus stops of Bangalore city
- Improvement of road geometry.

Chapter 7

Industry

CONTENTS

TABLES

FIGURES

1. CURRENT STATUS

1.1. INDUSTRY PROFILE

1.1.1. Industry base

A complete record of industries in Bangalore Metropolitan Region (BMR) does not exist. Six government agencies maintain their own records of which the ones of District Industries Centres (DICs) and Karnataka State Pollution Control Board (KSPCB) were found to be the most relevant. The scope and coverage of each record differs considerably. They cannot be combined and must be interpreted separately. Table 1 presents the number of industries according to these agencies. A total of 70,000 operating industries was adopted as a baseline for this study based on an estimate by Karnataka Small Scale Industries Association (KASSIA). Figure 1 illustrates the size and overlaps of these records while a closer look at each is taken in the following.

Table 1: Registered and estimated number of industries in BMR

Agency	*Number*	*Category of industries*
KSPCB	7,257	Operating industries registered under the Water Act or Air Act.
Department of Industries and Commerce, DIC	79,301	Industries and a section of non-industrial service providers up to INR 3 crore investment registering voluntarily
Department of Industries and Commerce, DIC	161,986	Industries and a section of non-industrial service providers up to INR 3 crore investment who registered voluntarily with DIC (79,301) plus estimate of unregistered industries (82,685)
KIADB and KSSIDC combined	5,577	Industries in general on state-developed industrial areas of KIADB's (3,488) and KSSIDC (2,089)
Department of Factories and Boilers	5,971	Factories registered under the Factories Act
Estimated total	***70,000***	***Operating industries***

Source: Agencies as mentioned, 2008; KASSIA 2008

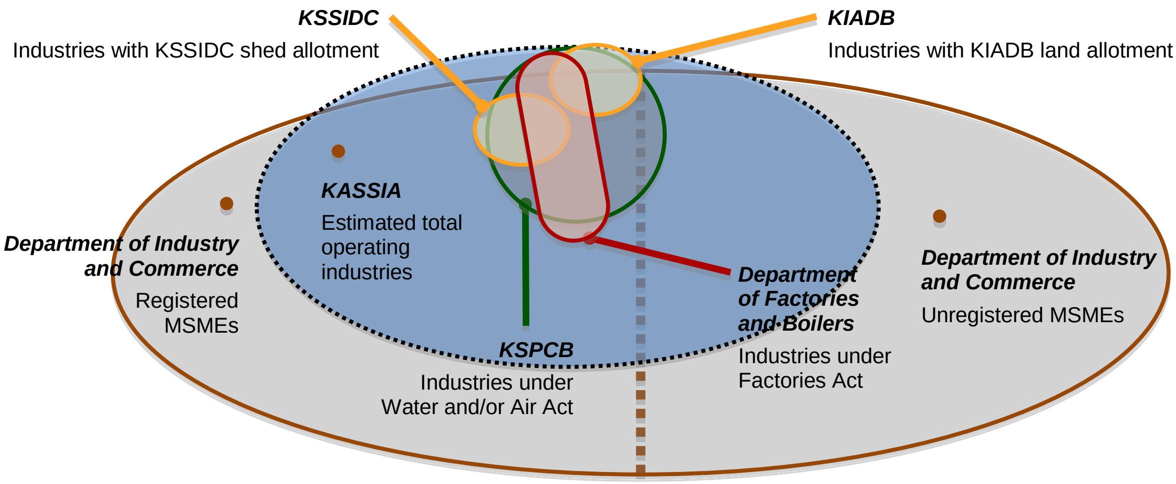


Figure 1: Indicative size and relationship of data sets

KSPCB maintains a consent register of nearly 7,300 operating industries currently in BMR falling under the Water Act and/or Air Act. The Water Act requires industries (or processes or municipalities) that discharge sewage or effluent to seek consent for establishment and operation from KSPCB. Similarly the Air Act requires consent for generation of emissions through, for instance, furnaces, diesel generator (DG) sets or boilers. Considering the inclusion of sewage generation as criterion, the criteria laid out appear to cover the entire gamut of industrial activities. Nevertheless, a comparison with KASSIA's estimated total of 70,000 industries shows that, in reality, only about 10% of operating industries are registered with KSPCB while a much larger share is not.[1] While it should not be assumed that industries not registered with KSPCB are environmentally harmless, the group of 7,300 forms the most critical group to be evaluated because of the significance of their individual and collective environmental impact. Apart from industries KSPCB also registers other entities such as offices, housing complexes and healthcare establishments under the Air Act, Water Act, Hazardous Waste Rules and Bio-Medical Waste Rules.

DIC's record shows about 79,000 voluntarily registered micro, small and medium enterprises (MSMEs) in BMR as of 2007. This excludes industries with an investment exceeding INR 3 crore. In addition to that the most recent census of 2001 estimates that there are around 83,000 unregistered MSMEs in the same region, pushing the total of MSMEs thus to nearly 162,000. This number surpasses KASSIA's estimate of 70,000 industries grossly. A closer look reveals that the department's records are substantially overestimating the size of the industrial sector.[2] This data has therefore not considered as baseline.

KIADB and **KSSIDC**, the state-owned industrial areas development agencies, show a combined register of less than 6,000 industries in BMR. This represents industries to which developed land has been allotted by these agencies. By contrast to the estimated total of 70,000 operating industries, this number is clearly too small to serve as reliable pointer to the magnitude of industries overall.[3]

According to **Department of Factories and Boilers** less than 6,000 industries are classified as factories in BMR. This number makes only a fraction of the estimated total of 70,000 and although it appears to correspond to the data of KIADB and KSSIDC in terms of order, the purview of these data sets differ by definition. Overlaps as might exist are rather a coincidence than a provision. Industries that are defined as 'factories' by the Factories Act are mandatorily required to register with this department. The Factories Act defines factories much more narrowly than KSPCB, DIC, or KASSIA would define an industry.

It was anticipated that the share of cottage industries in BMR could be estimated based on information from **Khadi and Village Industries Board (KVIB)**. KVIB is running cottage industry employment generation programmes across a range of industry sectors. However, no estimates for the magnitude of cottage industry sector are available. The board's records hold only entrepreneurs who are or were financially supported, numbering about 1,500 in BMR.

Table 2: Criteria for registration of industries

KSPCB
• Industries as well as non-industrial establishments that fall under the Water Act by operating processes or disposal systems which are likely to lead to discharge of sewage or trade effluent into a stream, well or sewer or on land. • Industries as well as non-industrial establishments that fall under the Air Act by emitting any kind of emission or air pollutant in air pollution control areas. Note: Entire Karnataka has been declared as air pollution control area. Micro enterprises operating from tiny workshops without sanitary facilities, cottage industries as well as merchants and traders are generally not being registered.
Department of Industries and Commerce
MSMEs with an investment not exceeding INR 3 crore register with the department through the District Industries Centres (DICs) • when seeking services or financial assistance from any of the designated state industries development or finance corporations; • when seeking allotment of developed industrial land from KIADB or a shed in an industrial area developed by KSSIDC; • on voluntarily registration; • Start-up entrepreneurs participating in any of the department's entrepreneurship development programmes.
KIADB
• Industries which have received an allotment of KIADB-developed land for industrial purposes based on an application approval process. Registration requires prior registration with DIC.
KSSIDC
• Industries which have received an allotment of a shed for industrial purposes in an industrial area developed by KSSIDC based on an application approval process. Registration requires prior registration with DIC.
Department of Factories and Boilers
• Industries falling under the Factories Act by having at least ten workers perform regular work with the aid of electric power or 20 or more without. Registration requires prior registration with DIC.

[1] *This group of unregistered industries would include (a) micro enterprises not engaged into activities that pollute air or water operating in tiny spaces without sanitary provisions, (b) cottage industries, and (c) unauthorised establishments that evade the consent process and have not been identified by KSPCB.*

[2] *Several factors contribute to this: (a) the department also registers industries working on a seasonal/casual base; (b) DIC's definition of industries spans a broader scope of activities including even photocopy shops; (c) incentives offered by DIC through entrepreneurship programmes are believed to have resulted into false registrations; (d) once registered, industries remain registered until closure is identified by a census of high inaccuracy. From the census arises also an average delay of 6.5 years between avergae closure and record updation.*

[3] *This also indicates that developed land has been allotted to only 8% of all industries. However, as chapter 1.2.1 explains, industries acutally operating on developed land are estimated to be in the order of 13%.*

1.1.2. Sectoral breakup

Only the Department of Industries and Commerce is systematically documenting the allocation of industries to sectors. However, data of the department has certain limitations. For once, the methodology applied for registration and record keeping implies inaccuracies as has been pointed out in 1.1.1. Secondly, sector wise data for years prior to 1996 is unavailable. The evaluation thus relies on the assumption that the registration details of more than 34,000 industries during the past 12 years can provide for a sufficient approximation of the overall sectoral distribution.

In order to permit an understanding of the magnitude of individual industry sectors, DIC's limited data has been extrapolated against the baseline estimate of 70,000. Table 3 presents the original data and the estimated sector total based on linear extrapolation. This data should be looked at as on approximation. The fact that each sector has had its own growth pattern makes it evident that the assumption of a collectively linear growth is a simplification devised to substitute for the lack of reliable data.

Table 3: Sector breakup of industries in BMR

Industry sectors	*Number of industries*			
	Subsectors	*Sectors*		
		DIC registrations 1996-2008	*Sector share*	*Estimated total (extrapolated)*
General engineering		6,540	19.1%	13,387
Textile		6,086	17.8%	12,458
Textile wet processing units thereof	*above 60*			
Other services		3,580	10.5%	7,328
Information technology (IT) industry thereof	*2,100*			
Biotechnology (BT) industry thereof	*200*			
IT-enabled services (ITES) sector thereof	*245*			
Job work		3,190	9.3%	6,530
Electricals and electronics		2,706	7.9%	5,539
Miscellaneous products		2,671	7.8%	5,467
Quarries thereof	*1,800*			
Stone crushers thereof	*around 350*			
Brick kilns thereof	*27*			
Mines thereof	*around 5*			
Printing and stationery		1,731	5.1%	3,543
Wood and wood products		1,597	4.7%	3,269
Rubber and plastics		1,400	4.1%	2,866
Food and beverages		1,384	4.0%	2,833
Chemicals		1,244	3.6%	2,546
Basic, ferrous and non-ferrous metals		740	2.2%	1,515
Glass and ceramics		491	1.4%	1,005
Leather and leather products		484	1.4%	991
Automobiles and transport equipment		353	1.0%	723
Total		**34,197**	**100%**	**70,000**

Source: Department of Industries and Commerce 2008; KASSIA 2008; EMPRI 2008; Department of IT, BT, Science and Technology 2008; Textiles Committee 2006; Department of Mines and Geology 2008

The table above also shows some selected subsectors in *italics*. This information obtained from sources other than DIC seeks to address the shortcoming that the available DIC data does not segregate activities of different nature within a given sector. Even important emerging sectors such as IT and ITES have not been allotted a category by DIC. Figure 2 illustrates the size of industry sectors detailed in Table 3. 'General engineering' and 'Textile' emerge as BMR's largest sectors, each one occupying nearly one fifth. The next largest sectors, 'Other services' and 'Job work' occupy together almost another fifth. While the latter cannot be understood as to its exact nature, "Other services' accommodates, among other things, recently established subsectors such as IT, BT and ITES.

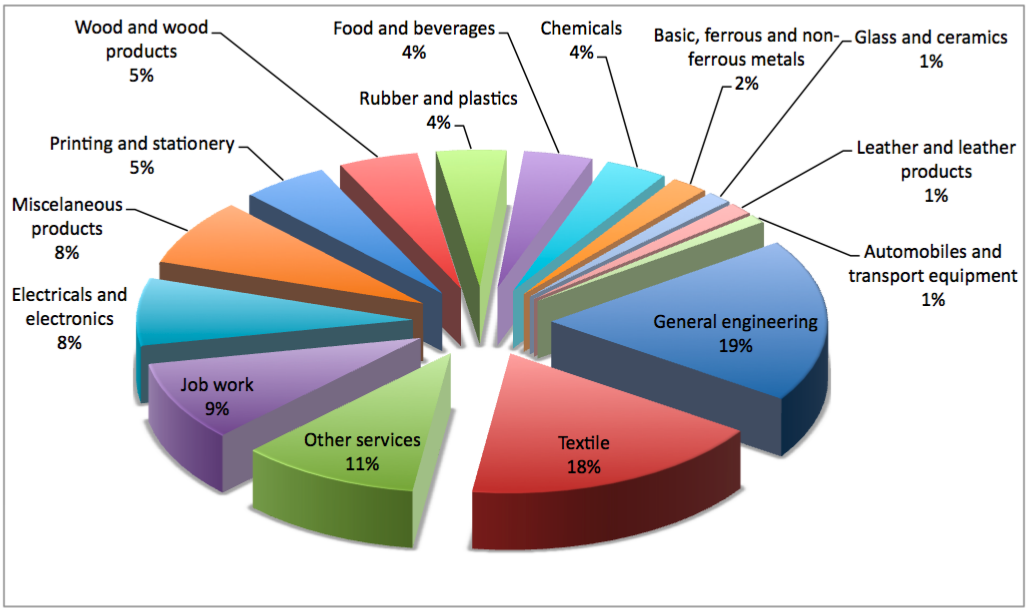


Figure 2: Sector breakup of industries in BMR

If a sizable number of industries belong to the same sector and reside in the same locality, the locality is considered a cluster of that particular sector. According to a UNIDO survey in 2003, Bangalore is a small and medium enterprise cluster of machine tools manufacturers, light engineering, foundries and electronics. Going by survey data of Textiles Committee, the number of garment stitching units and power-loom units recommends their recognition as cluster. Also, relatively young sectors have acquired significant dimensions, suggesting that Bangalore has emerged as cluster for IT, ITES and BT industries.

> **The IT/ ITES industry** continues to be one of the fastest growing sectors in BMR. The environmental impact of 2,345 industries is not immediately apparent. Yet the sector has an estimated 325,000 employees, the majority belonging to higher income strata. Housing requirements, transportation needs, the capacity and inclination to afford cars and the general consumption pattern place IT/ITES employees at the higher end of the resource consumption scale. The impact does not end here as yet. The attraction of these salaries and lifestyles are key forces fuelling the rapid migration Bangalore is witnessing.
>
> More details on the bane of the IT/ITES boom in terms of urbanisation and environmental impact are available at chapters URBAN PLANNING and SOCIO-ECONOMIC DEVELOPMENT.

Outside the definition of industrial activities are other commercial activities of environmental significance. The construction of buildings for instance is a quasi-industrial activity given the temporary nature of these undertakings. In 2008 there were 119 apartment and commercial complex construction sites registered with KSPCB through consent application though the overall number of construction sites may go into a few thousands. Worth mentioning are also healthcare establishments such as hospitals and clinics, nearly 1,000 of which are registered with KSPCB because of the generation of bio-medical waste.

1.1.3. Environmental classification

Central Pollution Control Board (CPCB) classifies 17 industry sectors with a severe adverse impact on the environment as "highly polluting". These occupy a centre stage from the perspective of concern and pollution control efforts. Of the total of about 130 highly polluting industries in Karnataka registered in December 2007, 21 are located in BMR.

Table 4: Highly polluting industries in BMR

	17 highly polluting industry sectors	*Number of industries*
1.	Aluminium smelting	-
2.	Basic drugs and pharmaceuticals	17
3.	Caustic soda	-
4.	Cement (200 tons per day and above)	-
5.	Copper smelting	-
6.	Distilleries (excluding Sugar)	1
	Distilleries and Sugar	-
7.	Dyes & dye intermediates	-
8.	Fertilisers	-
9.	Integrated iron & steel plants	-
10.	Leather tanning and processing	1
11.	Oil refinery	-
12.	Pesticide formulation and manufacturing	1
13.	Pulp and paper (30 tons/day and above)	-
14.	Petrochemicals	-
15.	Sugar (excluding Distilleries)	1
16.	Thermal power plants	-
17.	Zinc smelting	-
Total		**21**

Source: KSPCB 2007

CPCB and KSPCB further classify registered industries based on the pressure they exert on environment, which depends, first and foremost, on the activity and processes undertaken by industries seeking consent for establishment (CFE) or operation (CFO) are classified as highly polluting ('Red'), moderately polluting ('Orange') or less polluting ('Green'). Table 5 shows the classification of operating industries registered with KSPCB in BMR. Industries belonging to the 17 highly polluting sectors profiled above are part of the Red category. Apart from operating industries KSPCB's records also show 535 industries whose operation is yet to commence.

Table 5: Classification of operating BMR industries registered with KSPCB

Size	Red	Orange	Green	Not yet classified	Total	Share
Large	278	199	617		1,094	15.1%
Medium	272	243	823		1,338	18.4%
Small	1,406	502	2,910		4,818	66.4%
Not yet sized				7	7	0.1%
Total	**1,956**	**944**	**4,350**	**7**	**7,257**	
Share	27.0%	13.0%	59.9%	0.1%	100%	

Source: KSPCB 2008

Nearly 40% of the registered operating industries are classified as Red and Orange. Together these two groups comprise 2,900 industries accounting for the major polluters in BMR. Green category industries make up the majority with 60%. The 66% operating small-scale industries (SSIs) registered with KSPCB still understate the overall magnitude of the SSI sector. Apart from the fact that the great majority is not registered, the portion of registered would be greater if KSPCB would apply the same criteria for classification that the Ministry of Micro, Small and Medium Enterprises (MMSME) defined, namely investment cost not exceeding INR 5 crore in plant and machinery. KSPCB, by contrast, adds to the investment also the capital equivalent of a ten-year tenure for rented or leased properties, which lifts a sizable share of SSIs to the medium tier, at least on the record of KSPCB.

1.1.4. Spatial breakup

Industries are unevenly spread across BMR. With 78%, the great majority is in the central most district of Bangalore Urban. The surrounding districts Bangalore Rural and Ramanagar accommodate only 10% and 12% respectively. Among *taluks* of the same district the distribution is surprisingly even. Table 6 presents estimates for each *taluk* along with the raw data it was derived from.

Table 6: Taluk wise distribution of industries in BMR

District	Taluk	Newly registered industries (raw data)					Taluk share	Estimated taluk total (extrapolated)
		2004-05	2005-06	2006-07	2006-07	4-year total		
Bangalore Urban	Anekal	1,329	97	185	923	2,534	24%	16,516
	Bangalore North	-385*	798	870	1210	2,493	23%	16,249
	Bangalore South	1,267	704	719	625	3,315	31%	21,606
	District subtotal					**8,342**	**78%**	**54,371**
Bangalore Rural	Devanahalli	67	75	75	9	226	2%	1,473
	Doddaballapur	110	100	74	71	355	3%	2,314
	Hoskote	91	80	67	36	274	3%	1,786
	Nelamangala	80	80	54	31	245	2%	1,597
	District subtotal					***1,100***	***10%***	***7,169***
Ramanagar	Channapatna	61	71	69	63	264	2%	1,721
	Kanakapura	79	114	73	83	349	3%	2,275
	Magadi	70	96	67	142	375	3%	2,444
	Ramanagar	87	80	64	79	310	3%	2,020
	District subtotal					**1,298**	**12%**	**8,460**
BMR total		***2,856***	***2,295***	***2,317***	***3,272***	***10,740***	***100%***	***70,000***

** Negative growth resulted from subtraction of 2003-04 data from 2004-05 as published by Department of Statistics. It is assumed that this reswult it is either the consequence of purging records from closed industries upon conclusion of the 2001 census or an error.*

Source: Department of Statistics 2004-07; DIC 2007-08

As *taluk* totals were not available, the data of nearly 11,000 DIC registrations of the past four years was used for analysis. In order to permit an understanding of the magnitude, the data has been extrapolated to the baseline estimate of 70,000. While *taluk* totals might not be accurate they are considered to match reality in terms of magnitude. Figure 3 illustrates the estimates shown in Table 6, highlighting the strong presence of industries in the *taluks* of Bangalore Urban district contrasting the weaker presence in the surrounding two districts.

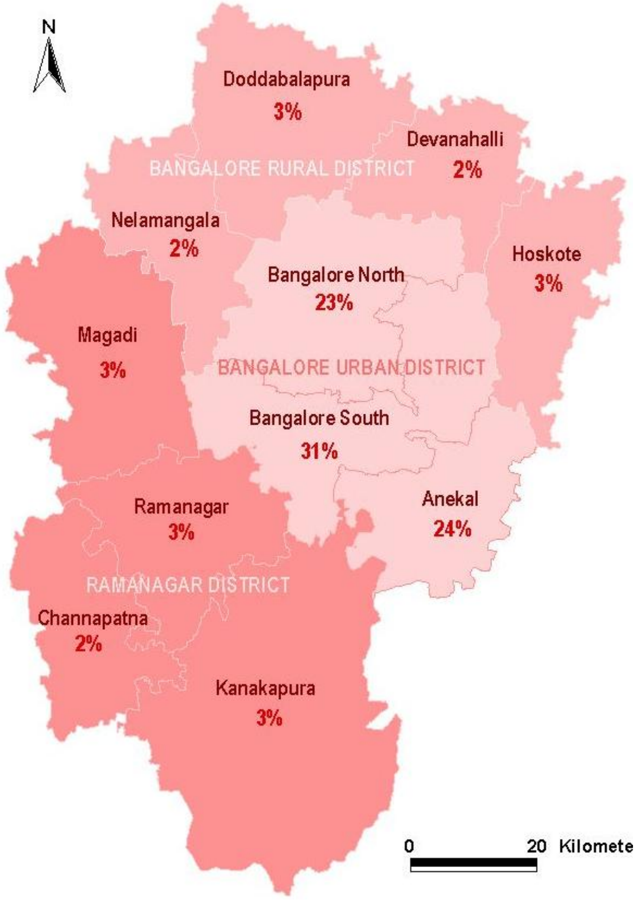


Figure 3: Taluk wise distribution of industries in BMR

1.1.5 Employment and income

According to the Department of Statistics and Economics there were about 3.2 million workers in BMR in 2007. This number includes not only industrial workers but also those employed at trade establishments and offices that are outside the purview of this chapter on industry. For a manufacturing hub such as Bangalore, it appears plausible to assume that about half of the overall workforce is employed in industries. This assumption would peg the estimate of industrial workers at 1.6 million. This number corresponds well to 1.6 million employees in registered and unregistered enterprises identified by the 2001 census of Department of Industries and Commerce.

According to Department of Statistics the annual income from industrial activities is estimated to be INR 12,800 crore (INR 128 billion) in 2005. The average income of industrial workers would therefore amount to about INR 77,000 per annum.

1.2. PROFILE OF INDUSTRIAL AREAS

1.2.1. Developed industrial areas

Land and allotment

In the 1950s the state begun to assume an active role in industrial development. The first industrial areas established were Ramanagar in 1957 and Rajajinagar in 1959. These two areas being small in size, the development was followed by substantially larger areas in Dyavasandra in 1968 and in Peenya Phase I to IV in 1971. Today BMR is home to 26 industrial areas developed by the state as detailed in Table 7 with land allotted to 5,478 industries. KIADB allots its share of land at 11-year lease-cum-sale agreements to applicant industries upon clearance. On completion of the term the lease is converted into sale of the property if certain conditions are fulfilled. KSSIDC is allotting sheds or plots to industries on either rental or lease base while the agency does not relinquish ownership at any point of time. Post allotment, both the agencies retain a monitoring role to ensure that industrial areas are used for the intended purpose. In the two urban *taluks* Bangalore North and Bangalore South allotted 'inactive land' does not account for a significant share. High demand and close vigilance of the development agencies ensure effective utilisation. Yet outside the urban centre the portion of inactive land assumes significant proportions, roughly estimated to be in the order of 10%. A report stating there is some slackening of vigilance has already prompted the government to direct KIADB to initiate corrective action (Deccan Herald June 27, 2008).

Table 7: Developed industrial areas in BMR

Developed industrial areas	*Developing agency*	*Approx launch*	*Area (acres)*	*Approx KSPCB registrations*	*Prominent sectors*
Bangalore Urban district			**7,133**	**3,250**	
Bangalore North taluk			***2,889***	***1,740***	
1. EOIZ	KIADB	1992	14	75	Software
2. EPIP I & II	KIADB	1996	597		Software
3. Kadugodi - Sadaramangala	KIADB	1983	539	40	Engineering
4. KHB Industrial Area Yelahanka	KIADB	1989	9	15	Engineering
5. Peenya, Phase I - IV	KIADB	1971	1,187	1.565	89% Engineering, 4% Garments
Peenya, Stage I - III	KSSIDC	1975	298		
6. Sadaramangala	KIADB	1985	239	30	60% Engineering, 20% Chemicals, 20% Flour mills
7. Yelahanka	KSSIDC	1982	6	15	53% Engineering, 33% Garments
Bangalore South taluk			***1,287***	***690***	
8. Dyavasandra I & II[4]	KIADB	1968	525	165	50% Engineering
Dyavasandra, Doddanekundi I & II[5]	KSSIDC	1977	30		
9. Electronics City (Keonics)	KIADB	1971	10	165	70% Software
Electronics City II	KIADB	1998	307		100% Software
10. Kumbalgodu I	KIADB	1979	143	45	45% Engineering
Kumbalgudu II	KIADB	1979	218	50	50% Engineering
Kumbalagudu	KSSIDC	1985	16	65	60% Engineering
11. Rajajinagar	KSSIDC	1959	37	200	Majority engineering
Anekal taluk			***2,958***	***820***	
12. Attibele	KIADB	1981	250	- - -	Engineering
13. Bommasandra I - III	KIADB	1977	904	130	90% Engineering, 10% Electroplating
Bommasandra IV	KIADB	1998	214	90	70% Engineering, 30% Electroplating
Bommasandra I	KSSIDC	1985	25	120	Majority engineering
Bommasandra II	KSSIDC	2000	10	25	Majority engineering
14. Jigani Phase I & II	KIADB	1981	615	260	Granite cutting, polishing
Jigani - Bommasandra Link Road	KIADB	2003	712		
Jigani Stage I	KSSIDC	1994	18	- - -	
Jigani Stage II	KSSIDC	1997	16	- - -	
15. Veerasandra	KIADB	1981	107	75	Majority engineering
Veerasandra	KSSIDC	1981	14	95	90% Engineering, 10% Electroplating
Veerasandra II	KSSIDC	2001	10	25	13% Oil refinery, 13% Plastics
16. Yarandahalli	KIADB	2006	27	- - -	
Yarandahalli - Kachanayakanahalli	KIADB	2006	35	- - -	
Bangalore Rural district			**1,583**	**335**	
Nelamangala taluk			***339***	***35***	
17. Dobbspet	KIADB	1995	277	35	Majority automobile engineering
Dobbspet II	KIADB	2005	62	- - -	Glass manufacturing, TSDF
Doddaballapur taluk			***820***	***125***	
18. Doddaballapur - Virapura	KIADB	1983	331	125	60% Engineering, 30% Weaving, Chemicals
Doddabalapur - Yalupura	KIADB	1995	5		
Doddaballapur - Basettahalli	KIADB	1995	12		
Doddaballapur	KSSIDC	1984	20		
19. Doddaballapur Apparel Park	KIADB	2004	187	- - -	
Doddaballapur Apparel Park II	KIADB	2006	265	- - -	
Hoskote taluk			***424***	***175***	
20. Hoskote	KIADB	1980	402	150	Majority automobile engineering
Hoskote	KSSIDC	1985	22	25	Majority engineering

[4] *Also known as Mahadevapura Industrial Area*
[5] *Also known as Vishweshwaraiah Industrial Estate*

Developed industrial areas	Developing agency	Approx launch	Area (acres)	Approx KSPCB registrations	Prominent sectors
Ramanagar district			**1,551**	**42**	
Magadi taluk			***14***	***20***	
21. Magadi	KSSIDC	1986	14	20	Engineering
Ramanagar taluk			***1,260***	***21***	
22. Bidadi	KIADB	1997	1,192		
Bidadi - Bannadur	KIADB	2005	13	21	Majority automobile engineering
Bidadi - Abbanakuppe	KIADB	2005	50		
23. Ramanagar	KSSIDC	1957	5	- - -	
Channapatna taluk			***15***	***1***	
24. Channapatna	KSSIDC	1997	15	1	Toys
Kanakapura taluk			***262***	***-***	
25. Harohalli	KIADB	2005	250	- - -	
26. Kanakapura	KSSIDC	1985	12	- - -	
Grand total			**10,267**	**3,627**	

Source: KIADB 2008, KSSIDC 2008, KSPCB 2008

Data on the number of industries residing in these areas is limited. While only about 3,627 industries are registered with KSPCB there are 5,478 bona fide allotees of land. The number of occupants is assumed to be even higher. In case of Peenya Industrial Area/Estate where relatively accurate data is available, bona fide allotees account for only 62% of all occupants. Some industries are assumed to enter through subletting of portions of premises or buildings to other entrepreneurs. Extrapolating Peenya's occupant–allotee ratio to all developed industrial areas suggests that the total of industries occupying developed land could be in the order of 9,000 as shown in Table 8. Comparing this with the estimated total of 70,000 operating industries in BMR it is concluded that developed industrial areas are occupied by no more than 13% of industries. This estimate is probably optimistic because subletting may not enjoy the same prominence outside the urban centre.

Table 8: Estimate of industries occupying developed industrial areas

Number of allotees/ occupants	Peenya Industrial Area/Estate	Share	BMR
KIADB allotees	798		3,389
KSSIDC allotees	1,048		2,089
Total allotees of KIADB and KSSIDC	1,846	62%	5,478
Estimate of occupants	**3,000**	100%	**8,902**

Source: KIADB, KSSIDC and Peenya Industries Association, 2008

69% of developed industrial land is in Bangalore Urban district. Apart from Electronics City which caters to the electronics and IT industry, today's industrial areas are not sector specific. The prevalence of certain sectors has evolved from organic rather than planned growth. Engineering industries have a towering presence in nearly all areas.

Infrastructure and maintenance

KIADB and KSSIDC aim to provide ready-to-occupy land through a single window. The development purview includes roads, water supply, sewerage systems and extends to electricity supply. In addition KSSIDC provides also industrial sheds and/or godowns keeping in mind the needs of particularly small-scale industries. All industrial areas have been equipped with a network of tarred roads. Connections to the rail network or port facilities have not been created anywhere, limiting the means of transport of cargo to road alone. Main roads tend to be in reasonable conditions but not everywhere. Interior roads, however, are in a state of neglect more often than not, even in prime industrial areas. Rajajinagar appears to be the sole exception to the case.[6]

Figure 4: Disintegrating road, Peenya

[6] *The state of neglect prompted Peenya Industries Association (PIA) to launch Peenya Infrastructure Corridor Upgradation Project (PICUP) in private-public partnership to upgrades 48 km of roads.*

Within the limits of Bruhat Bangalore Mahanagara Palike (BBMP), which covers a large part of the *taluks* of Bangalore North and Bangalore South, water is supplied by Bangalore Water Supply and Sewerage Board (BWSSB). Outside the BBMP area KIADB and KSSIDB provide water supply from on-site bore wells stored in overhead tanks. The number of additional private bore wells and frequently plying water tankers indicate that water supply is insufficient. Sewerage facilities have been provided and are maintained by BWSSB in most of the BBMP areas. By and large maintenance appears sufficient. Outside BBMP no facilities exists and entrepreneurs generally discharge sewage into soak pits on the premises. The fact that the great majority of entrepreneurs on developed industrial areas have to deal with sewage disposal individually is a rather surprising fact. Though KIADB and KSSIDC kept land margins aside for common facilities, these have not been created in any developed industrial area.

No infrastructure has been created for the collection and segregation of industrial solid waste. The number of unauthorised waste disposal sites is a telling indicator of this shortcoming. For example, eight such sites were indentified in Peenya Industrial Area/Estate in 2006. Private initiative is intervening here in one case with promising prospects.[7]

Figure 5: Waste dump in Peenya Industrial Area

Buffer zones and green belts are highly neglected aspects in the development of industrial areas. It is a well established fact that certain species of trees and plants are able to absorb certain pollutants and also act as screens between industrial zones and surrounding areas (refer to Chapter 1 "FOREST AND BIODIVERSITY"). Table 9 summarises the key elements of infrastructure and facilities provided in developed industrial areas.

Table 9: Key infrastructure elements and facilities of developed industrial areas

Infrastructure elements	*Development agency*	
	KIADB	*KSSIDC*
Road construction	Main and interior roads	
Access to rail link	none	
Access to water transport	none	
Sheds constructed	None	2,222
Water supply through	BWSSB in BBMP limits, outside bore wells/ tankers	
Drainage system	UGD in BBMP limits, outside individual soak pits	
Common STPs, ETPs	none	
Waste management	none	

Source: KIADB 2008; KSSIDC 2008; EMPRI 2008

1.2.2. Private industrial areas

Land and allotment

The rapid growth of demand for industrial land appears to have outpaced availability, leading to the establishment of private industrial areas. In BMR 118 of such areas were identified and 83 (70%) of them were inspected in a rapid assessment conducted by EMPRI in 2008. This list as presented in Table 10 gives an account of confirmed areas while a further 10-30 areas could potentially exist. Private industrial areas are located primarily in the urban *taluks* of Bangalore North and Bangalore South, suggesting a shortage of developed industrial land in the centre of Bangalore. Land is not allotted but acquired by entrepreneurs from respective owners at market rates. The process of conversion into industrial land is completed in many but not in all cases. Some establishments operate still on agricultural land, rendering their status legally weak. A significant number of residing industries were found registered with KSPCB though.

Given that estimates are available for 70% of private industrial areas, an extrapolation has been attempted. Extrapolating 1,547 acres and 4,306 industries pertaining to these 70%, one obtains 2,210 acres as estimate for the total land area and 6,151 for the number of industries. Private industrial areas are therefore estimated to accommodate at least about 9% of the total of 70,000 industries in BMR. This estimate is conservative as it takes into account only known areas. The sector composition does not show significant differences from developed industrial areas. Frequent coexistence with residential buildings or even schools indicates nevertheless that private areas are not as clearly demarcated by purpose as developed ones.

[7] PICUP is currently developing a waste collection system and handling centre in PPP for Peenya Industrial Area/Estate at a projected investment of about INR 1 crore (10 million).

Table 10: Private industrial areas in BMR

	Private industrial areas	Approx size in acres	Estimate of residing industries	Prominent sectors
Bangalore Urban district		**1,546**	**4,301**	
Bangalore North taluk		**1,059**	**2,733**	
1.	Industrial Suburb Yeshwanthapur	250-350	500-600	Engineering, Textiles, Plastics
2.	Doddanna Industrial Estate	100-150	300-350	Engineering, Plastics
3.	Nadekerappa Industrial Estate	90-100	200-210	Engineering, Plastics, Stone cutting
4.	Byraweshwara Industrial Estate	50-60	200-220	Engineering, Industrial gases
5.	MS Ramaiah Industrial Estate	35-45	70-80	Engineering, Plastics, Printing
6.	Pete Channappa Industrial Estate	30-40	250-260	Engineering, Plastics, Weaving
7.	Shiva Farm	30-35	55-60	Plastics, Engineering, Paints
8.	Patel Channappa Industrial Estate	25-30	50-60	Textile, Stone cutting
9.	Keinoics Layout	20-30	35-40	Engineering, Plastics
10.	Maruthi Industrial Estate	20-30	40-45	Engineering, Plastics
11.	Sri Muneswara Industrial Estate	20-30	30-35	Engineering
12.	Kempe Gowda Industrial Estate	20-25	50-60	Engineering, Optical cables
13.	Jai Bharath Industrial Estate	15-20	20-25	Engineering, Chemicals, Rubber
14.	Patel Puttaiah Industrial Estate	15-20	80-90	Engineering, Electricals
15.	Badrappa Industrial Estate	15-18	35-45	Engineering, Textiles, Plastics
16.	Byregowda Industrial Estate	10-20	15-25	Paints, Engineering
17.	Nanjappa Industrial Estate	12-14	30-35	Weaving, Printing, Engineering
18.	Karihobanahalli Industrial Estate	10-12	20-22	Engineering, Packaging
19.	Pantharapalya Industrial area	10-12	30-40	Plastics, Engineering
20.	Rama Mandira Layout	10-12	45-55	Weaving, Plastics, Engineering
21.	Karimsab Layout	8-12	15-20	Engineering, Stone cutting
22.	Sri Krishnappa Industrial Estate	8-12	40-45	Engineering, Plastics
23.	Chennigappa Industrial Estate	8-10	40-45	Engineering, Weaving, Plastics
24.	Kamakshipalya Industrial Estate	8-10	35-40	Weaving, Plastics, Printing
25.	KCG Industrial Estate	8-10	40-45	Engineering, Plastics
26.	Kulle Gowda Industrial Estate	8-10	15-20	Engineering, Plastics
27.	Raja Industrial Estate	8-10	8-10	Textiles
28.	SLV Industrial Estate[8]	8-10	25-30	Engineering, Electricals
29.	BM Shankarappa Industrial Estate	7-8	40-45	Engineering, Plastics, Stone cutting
30.	Kale Gowda Industrial Estate	5-7	20-22	Plastics, Engineering, Weaving
31.	Raghavendra Layout	5-6	20-22	Textile, Plastics
32.	Kempa Chennaiah Industrial Estate	4-5	40-45	Weaving, Textiles
33.	Kempamma Layout	4-5	20-23	Engineering
34.	Ravi Industrial Estate	4-5	3-5	Stone cutting, Food processing
35.	Gopal Krishna (GK) Industrial Estate	4-4.5	30-35	Weaving, Plastics
36.	Narayana Gowda Industrial Estate	3-5	5-6	Stone cutting
37.	GT Industrial Estate	3-4	5	Textiles
38.	Sajjepalya	3-4	10-15	Plastics, Weaving, Textiles
39.	Chairman Kariyanna Industrial Estate	2-3	12-15	Engineering, Textiles
40.	Mehta Industrial Estate	2-3	6-8	Engineering
41.	Chikka Pillappa Industrial Estate	1-2	3-5	Weaving
42.	JB Kaval Industrial Layout	1-2	10-15	Textiles, Oil refineries
43.	Kengeri Ramaiah Industrial Estate	1-2	6-8	Engineering, Plastics
44.	M Ramaiah Industrial Area	1-2	4	Packaging, Engineering
45.	Muddanna Industrial Estate	1-2	3	Optical cables
46.	Jai Maruthi Industrial Estate	1-1.5	5-6	Engineering
47.	Sri Lakshmidevi Industrial Estate	1-1.5	5	Engineering
48.	HC Puttaswamy Industrial Estate	0.5-1	4-5	Plastics
49.	K Narayanappa Industrial Estate	0.5-1	3-4	Chemicals, Plastics
50.	Kademane Industrial Estate	0.5	1	Weaving, Plastics
51.	Chikkamma Industrial Estate	- - -	- - -	Engineering
52.	Gayathri Industrial Estate	- - -	- - -	Engineering
53.	HMR industtrial Estate	- - -	- - -	Engineering
54.	Jyothi Industrial Estate	- - -	- - -	None (mixed)

[8] *Sri Lakshmi Venkateswara*

Private industrial areas		*Approx size in acres*	*Estimate of residing industries*	*Prominent sectors*
55.	Kasthuri Industrial Estate	- - -	- - -	Textiles
56.	Machavahalli Industrial Estate	- - -	- - -	Engineering
57.	Maruthi Industrial Estate	- - -	- - -	Engineering
58.	Nagadevi Industrial Estate	- - -	- - -	None (mixed)
59.	Nalini Industrial Estate	- - -	- - -	Engineering
60.	Raghavendra Industrial Estate	- - -	- - -	Engineering
61.	Sri Manjunatha Industrial Estate	- - -	- - -	Plastics
62.	Srinivasa Industrial Estate	- - -	- - -	Weaving
Bangalore South taluk		**487**	**1,568**	
63.	New Timber Yard Layout	100-150	150-200	Saw mills, Wood work
64.	Rajajinagar Indutrial Town	50-60	200-220	Engineering, Stone cutting
65.	Sundar Industrial Estate	45-50	60-70	Engineering, Electricals, Food processing
66.	Azeez Saith Industrial Town	45-50	200-250	Plastics, Engineering, Paints
67.	Muthachari Industrial Estate	30-40	220-250	Plastics, Engineering, Food processing
68.	JC Industrial Layout	30-35	80-90	Engineering, Textiles
69.	Shankarappa Garden	15-20	60-70	Engineering, Plastics, Oil refineries
70.	Gopalpuram	12-15	50-60	Engineering, Plastics
71.	Jyothinagar	10-15	40-50	Engineering, Electricals
72.	Banashankari 2nd Stage Industrial Estate	10-15	25-35	Textile, Software, Engineering
73.	Gubbanna Industrial Estate	8-10	60-65	Engineering, Plastics
74.	New Kalappa Block	5-10	30-35	Engineering, Incense sticks
75.	Robertson Block	5-10	20-25	Engineering, Incense sticks
76.	MM Industrial Estate	5-10	20-25	Engineering, Electronics
77.	Saibabanagar	5-6	12-15	Engineering, Incense sticks
78.	Flower Garden	4-5	15-20	Ceramics, Chemicals
79.	MC Ramaiah Industrial Estate[9]	4-5	20-25	Engineering, Textiles, Electricals
80.	Konanakutte Industrial Estate	4-5	15-18	Engineering, Textiles, Printing
81.	Annapoorneshwari Industrial Estate	4-5	20-25	Engineering, Plastics, Textiles
82.	Sree Shyla Industrial Estate	3-5	2	Engineering
83.	Selvam Industrial Estate	3-4	10-15	Stone trading, Plastics, Printing
84.	St Anthony Industrial Estate	3-4	25-30	Engineering, Plastics
85.	Harsha Feeds and Industrial Sheds	3-4	6-8	Engineering
86.	Om Shivashakthi Industrial Estate	2-4	10-12	Plastics, Textiles, Packaging
87.	Kademane Industrial Complex	2-3	6-8	Engineering, Electronics
88.	7th Mile Stone Industrial Estate	2-3	10-12	Engineering
89.	Srinivasa Industrial Estate	2-3	4-5	Electronics
90.	Avalahalli	2-3	10-14	Soaps/detergents
91.	Dr TCM Royan Road	2-3	30-35	Engineering, Weaving, Incense sticks
92.	Beerappa Garden	1.5-2	4-6	Glass, Engineering
93.	Hanumanthappa Industrial Estate	0.5-1	1	Plastics
94.	Byanna Industrial Estate	0.5-1	5-6	Engineering
95.	AVS Industrial Area	- - -	- - -	Software
96.	Koramangala Industrial Layout	- - -	- - -	Engineering, Stone cutting
97.	Jakkasandra Industrial Area	- - -	- - -	Engineering
98.	JP Nagar Industrial Area	- - -	- - -	Engineering
99.	Krishnanagar Industrial Area	- - -	- - -	Textiles
100.	MG Industrial Estate	- - -	- - -	Engineering
101.	Sarakki Industrial Layout	- - -	- - -	Engineering
102.	HSM Industrial Town	- - -	- - -	Plastics
103.	Bharath Industrial Estate	- - -	- - -	Chemicals
104.	Doresanipalya Industrial Estate	- - -	- - -	Textiles, Engineering
105.	Sarvabhouma Industrial Area	- - -	- - -	Engineering
106.	Eshwari Industrial Estate	- - -	- - -	Food processing
107.	AM Industrial Estate	- - -	- - -	Software, Textiles, Engineering
108.	Govardhana Industrial Estate	- - -	- - -	Engineering
109.	ESSAE Industrial Estate	- - -	- - -	Engineering
110.	GTR Industrial Estate	- - -	- - -	Engineering
111.	Virgo Nagar Industrial Area	- - -	- - -	Engineering, Chemicals

[9] *Also known as Vijayanagar Industrial Area*

Private industrial areas		*Approx size in acres*	*Estimate of residing industries*	*Prominent sectors*
112.	Orkay Industrial Estate	- - -	- - -	Engineering
113.	Krishna Reddy Industrial Estate	- - -	- - -	Engineering
Anekal taluk		**-**	**-**	
114.	Lingappa Industrial Estate	- - -	- - -	Engineering
115.	Munni Reddy Industrial Estate	- - -	- - -	Mineral water, Engineering
116.	VV Ramu Industrial Estate	- - -	- - -	Engineering
Bangalore Rural district		**1.5**	**5**	
Nelamangala taluk		**1.5**	**5**	
117.	Maya Industrial Estate	1-2	4-6	Engineering, Ceramics
118.	Muniyappa Industrial Estate	- - -	- - -	None (mixed)
	Grand total (based on median)	**1,547**	**4,306**	

Source: EMPRI 2008; KSPCB 2008

Infrastructure and maintenance

As expected, the state of infrastructure contrasts that of developed industrial areas. Main roads exist in a large share of areas, owing to the fact that locations are generally within the city limits and are thus under the care of BBMP. Interior roads however are absent in about 80% of the areas inspected. An estimated 40-50% of areas are supplied with BWSSB water and the balance from a combination of individual bore wells and tankers. 40-50% are estimated to have a connection to BWSSB's sewerage system. Another 10-20% are connected to BWSSB's open drainage. The remaining 30-50%, situated mostly outside the BBMP area, rely on soak pits or discharge sewerage directly into storm-water drains or on open land. Most private industrial areas are established along open drains. No facilities for management of solid industrial waste exist. In comparison to developed industrial areas particularly the lack of roads stands out while water supply and sewerage do not differ significantly.

Table 11: Key infrastructure elements and facilities of private industrial areas

Infrastructure elements	
Road construction	Main roads largely in place; interior roads only in 20% of areas
Access to rail link	none
Access to port facilities	none
Sheds constructed	none
Water supply through	40-50% through BWSSB; else individual bore wells and tankers
Drainage system	40-50% connected to UGD, 10-20% to open drainage; else soak pit or direct discharge
Common STPs, ETPs	none
Waste management	none

Source: EMPRI 2008

Figure 6: Private industrial area on Mysore Road

1.2.3. Ancillary industry estates

Land and allotment

There are six ancillary industry estates all of which are in the central urban *taluks*, Bangalore North and Bangalore South. Ancillary industry estates were created for dedicated suppliers of selected larger public sector units (PSUs) in their proximity. This concept has the advantage of reducing distance and transport needs while offering greater proximity between customer and client. The allotment process does not involve KSSIDC and is entirely in the hands of respective PSUs. The relevance of ancillary industry estates with a total of merely 99 acres of land occupied by 163 industries is marginal and no growth has been recorded since the mid 1980's. Indicators are pointing at some ancillary industry estates being gradually dismantled, such as the case with NGEF.

Table 12: Ancillary industry estates in BMR

	Ancillary industry estates	*Taluk*	*Developing agency*	*Approx launch*	*Approx area (acres)*	*Estimated number of industries*	*Prominent sectors*
1.	ITI ancillary industrial estate	Bangalore South	KSSIDC	1980	45	100	Engineering
2.	BEL ancillary industrial estate	Bangalore North	KSSIDC	1985	20	10	Engineering
3.	NGEF ancillary Industrial Estate	Bangalore South	KSSIDC	1978	16	15	Engineering
4.	HMT Industrial Estate	Bangalore North	KSSIDC	1980	10	15	Engineering
5.	Wheel & Axle ancillary estate	Bangalore North	KSSIDC	1982	6	15	Engineering
6.	HAL ancillary industrial estate	Bangalore South	KSSIDC	1960	2	8	Engineering
Totals					**99**	**163**	

Source: KSSIDC 2008; KSPCB 2008

Infrastructure and maintenance

KSSIDC's role is limited here to ensure the transfer of land. Infrastructure is developed and maintained by the respective PSU to the extent deemed required for the operation of its suppliers. Unlike the industrial areas, public access to ancillary industry estates is generally restricted, in some cases even prohibited because of the manufacture of defence-related products. No information is available as to the state of roads, water supply, sewerage facilities and solid waste management.

1.2.4. Industrial single unit complexes

Land and allotment

Single unit complexes (SUCs) are lands provided to individual industries on specific requisition. Sites are almost always outside of industrial areas and isolated from other industrial areas. KIADB is responsible for the acquisition and transfer of ownership. Requisitions are predominantly of industrial nature but also include non-industrial projects such as universities or the new airport at Devanahalli. In this section only industrial SUCs are considered, as non-industrial SUC land does not account for industrial development. 97 industrial SUCs exist in BMR, allotted to roughly the same number of industries. The great majority of industrial SUCs are located in the two central most *taluks*, Bangalore South and Bangalore North. Table 13 below provides an overview of industrial SUCs.

Table 13: Key data of industrial SUCs

Parameter	
Number of industrial SUCs	97
Number of allotments	about 97
Total land covered in acres	3,744
Responsible agency	KIADB

Source: KIADB 2008

Infrastructure and maintenance

The role of KIADB is limited to land acquisition and infrastructure is neither provided nor maintained by the agency. Similar to ancillary industry estates, infrastructure development and maintenance is the responsibility of the occupying industry and depends on the individual perception of needs. Infrastructure facilities available thus vary from one SUC to another.

1.2.5. Special Economic Zones

Following the examples of other states, Karnataka also has been promoting the establishment of Special Economic Zones (SEZs) in order to attract greater investments, particularly foreign direct investment (FDI). No geographic area has been established as designated SEZ in BMR so far. However, 20 industries in BMR have been granted the status of SEZs based on individual applications. 18 of these industries belong the IT and IT enabled service (ITES) sector while the remaining two are biotechnology companies. The SEZs of BMR extend to a total of around 960 acres, situated chiefly within developed industrial areas. Their size therefore does not add to that of developed industrial areas.

1.2.6. Summary

Key parameters of industrial land are summarised in the following table. The data suggests that industrial areas (private and state-developed) accommodate only about 22% of industries while the remaining share of nearly 55,000 is scattered across residential areas. Cottage industries, located in residential areas by virtue of their nature, are assumed to account for a prominent share.

It appears that private industrial areas have a higher industry density. With 2.8 industries per acre as compared to 0.9 in developed areas, private areas are roughly thrice as dense. This leads to the conclusion that, on average, industries in private areas are smaller and are more likely to belong to the micro and small-scale segment. Figure 7 presents the location of industrial areas in Bangalore Metropolitan Region.

Table 14: Summary of industrial land in BMR

Type of land	*Number*	*Total area (approx)*		*Estimate of industries*	*Share of industries*
		in acres	*in km^2*		
Developed industrial areas	26	10,267	41.5	8,902*	within 12.7%*
Private industrial areas	118[‡]	2,210[Δ]	8.9[Δ]	6,151[Δ]	at least 8.8%[Δ]
Ancillary industry estates	6	99	0.4	163	0.2%
Industrial SUCs	97	3,744	15.2	97	0.1%
SEZs	20	(960)	(3.9)	(20)	(0.04%)
Total (excluding SEZs as non-additional)		**16,320**	**66.0**	**15,313**	**21.9%**

* *Extrapolation from Peenya data, refer to Table 8*
‡ *Considering verified private industrial areas only*
Δ *Extrapolated from data of 70% of pertaining areas, refer to 1.2.2*

Source: KIADB 2008; KSSIDC 2008; EMPRI 2008; KSPCB 2008; DIC 2008

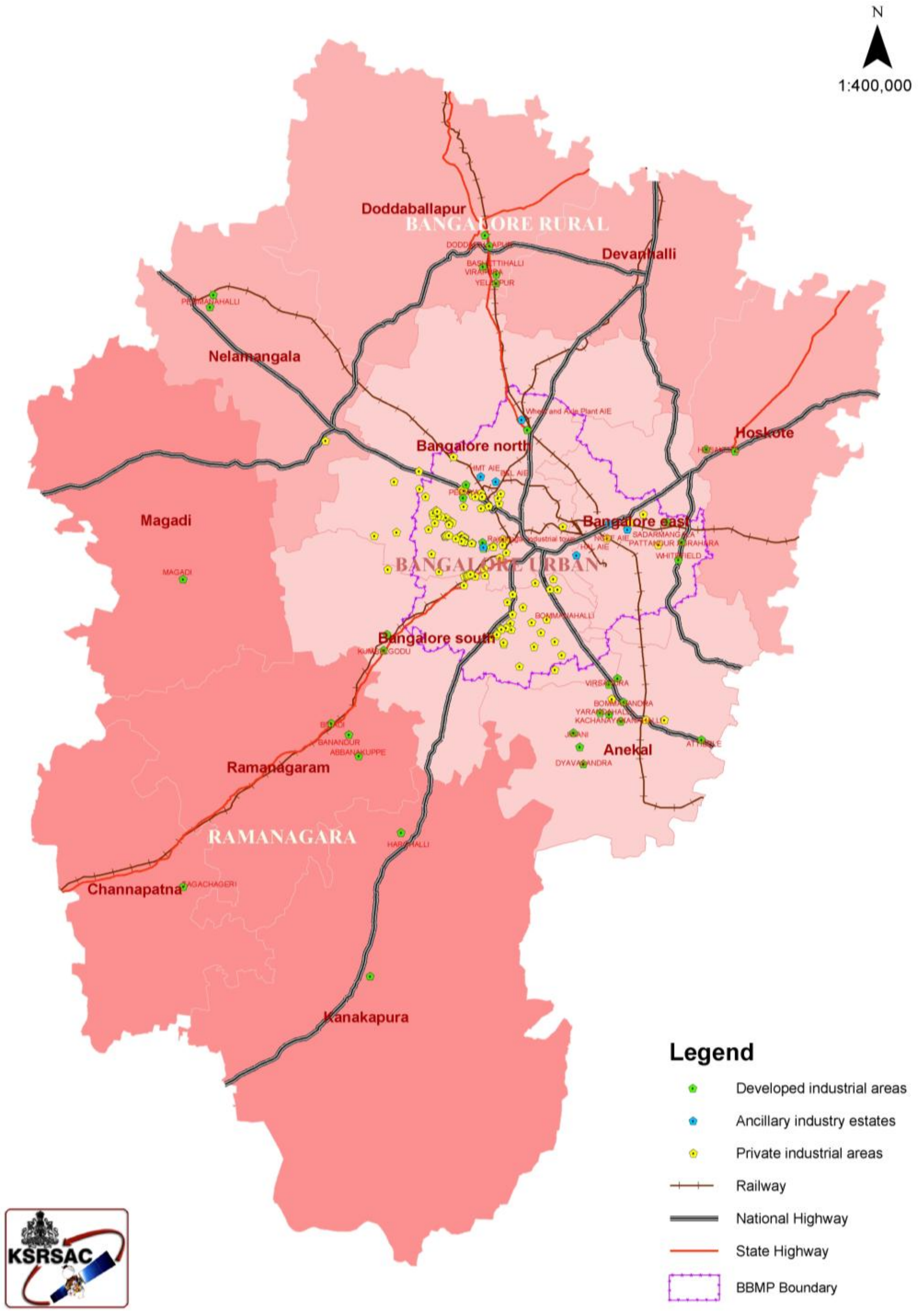


Figure 7: Industrial areas excluding SUCs and SEZs in BMR

1.3. FRAMEWORK OF INDUSTRIAL DEVELOPMENT

1.3.1. Development agencies

In BMR as well as elsewhere in Karnataka, the development of industrial areas is undertaken by Karnataka Industrial Areas Development Board (KIADB) and Karnataka Small-Scale Industries Development Corporation (KSSIDC) respectively. Both agencies were established under the Karnataka Industrial Areas Development Act of 1966 to provide industries with the necessary infrastructure in designated areas in a planned manner. Their establishment sought to address a couple of issues at once. On one hand the early industrial development has led industries to scatter across the region which is undesirable from the perspective of town planning and infrastructure development. On the other hand entrepreneurs had to approach a multitude of authorities for obtaining the necessary permissions, making the establishment of industries a laborious and time-consuming process. The role of development agencies sought also to reduce bureaucratic hurdles by providing the entire range of required services through a single window. KIADB and KSSIDC share an array of commonalities but differ in some essential functions. Land acquisition for all projects, disregarding of which of the two agencies assumes responsibility for development, is the sole role of KIADB. KSSIDC on the other hand caters specifically to the needs of small-scale industries, developing smaller plots, often built up with ready-to-use sheds. Apart from that KSSIDC also holds a special mandate to supply certain raw materials to industries at government-approved rates.

1.3.2. Siting guidelines

Bangalore Metropolitan Area Development Authority (BMRDA) is the central infrastructure and town-planning agency. Conversely, BMRDA is not proactively participating in the process of planning for the development of land for industrial purposes. This task is left exclusively to KIADB and KSSIDC. BMRDA limits its role to an integration of sites proposed by KIADB and KSSIDC into the BMR master plan under observation of boundaries of protected zones ('interstitial zones') that are deliberately excluded from urbanisation and industrialisation to preserve their predominant agricultural or forest nature. Apart from concern for the conservation of these zones, BMRDA is not known to have stipulated guidelines for the location of future industrial areas. KIADB's and KSSIDC's approach to proposing new industrial areas tends to focus on immediate needs. Criteria for proposing new industrial areas encompass the range of infrastructural and legal considerations that common sense would suggest, including:

- Analysis of demand for industrial land in the proposed locality;
- Unobstructed access from national highways and other major roads;
- Feasibility of power and water supply;
- Preferably even topography;
- No obstruction form overhead transmission lines;
- Land being free from encumbrances such as encroachments.

Apart from these practical considerations the focus does not appear to be embedded in a larger perspective of town planning, regional development and environmental criteria; perspectives that are imperatively called for.

In the absence of siting guidelines for industrial areas efforts have been made to establish policies for individual industries. Back in 1985 Environmental Guidelines for Siting of Industries were issued by the Central Government to integrate environmental aspects in the development of industrial projects. These guidelines were apparently not considered as much as intended but lead to the development of Environment (Siting for Industrial Projects) draft Rules in 1999, which aimed to restrict the establishment of certain highly polluting industries in the vicinity of municipal corporations, core biosphere zones, archaeological monuments, highways and rail links. The past nine years however have not seen the legislation of this draft.

At state level, policy guidelines for siting of orange and green category industries were established by Government of Karnataka in 2003. KSPCB developed siting guidelines for a host of environmentally critical industries, generally belonging to the Red category, and introduced a site clearance procedure stipulating environmental impact assessments (EIAs) and appraisal of their results before considering the award of consent. While these initiatives certainly point in the right direction, clarity on the applicability of coverage and their systematic adoption appear currently not guaranteed. In conclusion, it emerges as evident that environmental considerations in the process of placing industrial areas into an urban and semi-urban setting are not integrated in a systematic way. Current considerations appear to be limited to a fraction of individual industrial projects.

1.3.3. Industrial policy

Karnataka takes pride in having achieved substantial growth in emerging key sectors such as electronics, telecommunication, IT, engineering, automobiles, biotechnology and garments and being among the top five industrialised states of the country. Investments in new industries in Karnataka during the period of the industrial policy 2001–2006 exceeded INR 137,000 crore (1,370 billion) that were linked to an employment potential for 23 lakh workers (2.3 million). 2006–2008 saw the approval of investment of another INR 273,000 crore (2,730 billion) with an employment potential of 39 lakh workers (3.9 million). It is apparent that industrial policy is a highly capable instrument for attracting investment and growth targets remain ambitious.

Shortly after formation of the new government in Karnataka in 2008, the release of a new industrial policy was announced to replace the 2006–11 policy in effect. The new policy 2009–2014 was eventually released in February 2009 and aims to attract investment of INR 300,000 crore (3,000 billion) and generate employment of 10 lakh (1 million). It retains many of the instruments of the previous policy while adding further facilities indicative of a broader and more diversified approach to industrial development. The replacement of the earlier 3-tier classification of the state of *taluk* development through a 4-zone system (from Zone 1: Most backward *taluks* to Zone 4: Industrially developed *taluks*) paired with systematically higher incentives for more backward zones appears a capable instrument tool to gradually address regional imbalances that have resulted into exceptionally high growth of urban agglomerations such as BMR and migration from industrially underdeveloped regions.

The policy also aims to simplify the process of land acquisition for industrial development, an issue that has seen many projects being contested in court as well as agitations by concerned citizens, a fact that added very substantial delays to the development and rendered the process virtually unplannable. On a broad array of issues the policy states worthy objectives such as an emphasis on capacity building, infrastructure development and strong private sector participation, yet without a clear indication of scope, benchmarks or means to achieve that.

Table 15: Selected instruments of the Karnataka Industrial Policy 2009-2014

Instruments
▪ Investment subsidy for micro, small and medium enterprises with higher incentives for Zone 1, 2, 3;
▪ Waiving of conversion fees for conversion of agricultural into industrial land for Zone 1, 2, 3;
▪ Exemption from entry tax on plant and machinery for export oriented units (EOU) for all zones;
▪ Interest free loans on VAT for large and mega projects for Zone 1, 2, 3;
▪ One-time subsidy of up to 50% for setting up of effluent treatment plants. Ceiling: INR 100 lakh in Zone 1, 2, 3; and INR 50 lakh in Zone 4;
▪ In part subsidy of employees state insurance and employees provident fund for new establishments in the six districts with the lowest human development index;
▪ 50% subsidy for SMEs for rain water harvesting systems (ceiling INR 1 lakh), waste water recycling (ceiling INR 5 lakh) and zero discharge process (ceiling INR 5 lakh) for all zones
▪ 10% subsidy for SMEs for energy conservation and use of renewable energy (ceiling INR 5 lakh) for all zones.

Source: Department of Industries and Commerce 2009

Another noteworthy aspect of the policy is that, while it promotes a wide range of chosen sectors, it considers certain other sectors ineligible to incentives and concessions. Ineligible sectors include for instance, mining, distilleries, dye manufacturing, brick and lime kilns, fertiliser mixing and manufacture of tobacco products. Though the policy does not assign reasons, it appears that most ineligible sectors listed are large water consumers and effluent dischargers or have a high potential of causing direct harm to human health. Also the promotion of ETPs and energy saving articulates clear concern for the environment amidst envisaging growth. And unlike other concessions, environmental incentives are provided throughout all zones including the BMR.

1.3.4. Key stakeholder agencies

Table 16: Key stakeholders of industrial development

Agency	*Objective*	*Functions performed*
Karnataka State Pollution Control Board (KSPCB)	KSPCB was established to regulate the discharge of sewage, effluents, air emissions, hazardous and biomedical waste under the Water (Prevention and Control of Pollution) Act, Air (Prevention and Control of Pollution) Act, Hazardous Waste (Management and Handling) Rules and Biomedical Waste (Management and Handling) Rules. KSPCB is the primary agency responsible for safeguarding the environment in consonance with the existing legislation.	A central function is the management of consent for establishment and operation of industries, offices and healthcare establishments to ensure compliance with environmental legislation. Further functions include monitoring of environmental performance of industries, offices and other establishments as well as periodical analysis of water bodies, effluents discharged and air emitted.
Bangalore Metropolitan Region Development Authority (BMRDA)	BMRDA plans, coordinates and supervises the orderly development of areas within the jurisdiction of BMR. It was created with the purpose of being the central coordinating agency among all the concerned agencies and corporations including BDA, BWSSB, KIADB, KPTCL and KSRTC, BMTC etc.	The authority plans and develops new urban blocks, townships and roads within BMR. It identifies infrastructure requirements and formulates schemes to raise finance and extends assistance to other agencies.

Agency	Objective	Functions performed
Department of Industries and Commerce	The objective of the department is to recognise and address the needs of industries and catalyse industrial development. Its key objective is strengthening of industrial base to harness its potential as driver for socio-economic development.	Key functions of the department include formulation and implementation of state policies, facilitation of dialogue between entrepreneurs and the government, enhancing competitiveness of the through modernisation, technology upgradation and adoption of best practices through its specialised agencies.
District Industry Centres (DICs)	It was created with the objective to further registration of micro and small-scale industries and to act as decentralised interface between industries and the department. ■ DIC is a specialised agency of the Department of Industries and Commerce.	The centre is issuing provisional registration certificates before the start of production and permanent certificates after commencement of production on voluntary basis. DIC also acts as facilitator of entrepreneurship development programmers of the Department of Industries and Commerce.
Karnataka Council for Technological Upgradation (KCTU)	Primary objective of the council is to enhance the competitiveness of micro and small enterprises (MSEs) through assisting entrepreneurs in the upgradation of technology, facilitation of diversification, cost reduction and quality enhancement. ■ KCTU is a specialised agency of the Department of Industries and Commerce.	The council organises workshops and seminars for industries on emerging topics such as quality management and certifications. It provides testing and calibration facilities, offers assistance in patent registration and guidance in modernisation, plant design, product diversification and technology transfer.
Karnataka Udyog Mitra	Karnataka Udyog Mitra's objectives include the acceleration of industrial growth, attraction of investment, increase of exports and employment and reduction of regional imbalance. ■ Karnataka Udyog Mitra is a specialised agency of the Department of Industries and Commerce.	The agency guides potential investors on government policies and infrastructural considerations and acts as facilitator in the establishment of new industrial projects and clearance procedures.

2. IMPACT AND UNDERLYING CAUSES

2.1. WATER POLLUTION

2.1.1. Pressures

Industries pollute water with a wide range of contaminants. This includes toxic chemicals, lubricants, pathogens, hazardous compounds, oil and grease, dyes, suspended solids, and non-biodegradable matter. Water polluting industries are by and large those that also consume large amounts of water. Prominent sectors contributing to water pollution are listed in Table 17.

93% of the 7,257 operating industries registered with Karnataka State Pollution Control Board (KSPCB) in BMR are coming under the purview of the Water Act. However, KSPCB registered industries account for only about 10% of the total of 70,000 industries in BMR. The number of actual water polluters would therefore be much greater. An estimate presented in Table 18 shows that the total industrial sewage generation in BMR amounts to about 56 million litres per day (MLD). This estimate is derived from the number of industrial workers, estimated to be 1.6 million and the assumption that an average worker produces 35 litres of sewage per day. This fact should, nevertheless, not be overrated because these workers, if employed in trade establishments or even if unemployed, would still generate a similar amount of sewage if they reside in BMR.

Table 17: Key water polluting industries

Industry sectors	
Electroplating	Distilleries
Chemical	Food processing
Dyeing and printing	Stone cutting and polishing
Engineering	Automobile servicing
Tanning	Paper and Pulp
Pharmaceuticals	Fabrication
Pesticides and fertilisers	IT, ITES and BT (sewage generation)
Slaughter houses	Garments (sewage generation)

Source: EMPRI 2008

Table 18: Sewage generation by industries in BMR

Taluk	*Area in acres*	*Industrial areas*			*Number of industries (extrapolated)*	*Number of industrial workers (interpolated)*	*Industrial sewage generation in MLD*
		Developed in acres	*Private (approx) in acres*	*Share of industrial area*			
Bangalore Urban							
Anekal	130,472	2,958	0	2.27%	16,516	57,122	2.0
Bangalore North	222,889	2,889	1,059	1.77%	16,249	1,160,305	40.6
Bangalore South	175,198	1,287	487	1.01%	21,606		
Bangalore Rural							
Devanahalli	112,927	0	0	0%	1,473	38,210	1.3
Doddaballapur	197,190	820	0	0.42%	2,314	58,362	2.0
Hoskote	134,920	424	0	0.31%	1,786	44,701	1.6
Nelamangala	129,483	339	2	0.26%	1,597	34,106	1.2
Ramanagar							
Channapatna	134,672	15	0	0.01%	1,721	52,527	1.8
Kanakapura	392,898	262	0	0.07%	2,275	66,183	2.3
Magadi	197,190	14	0	0.01%	2,444	39,529	1.4
Ramanagar	154,441	1,260	0	0.82%	2,020	48,954	1.7
Totals	**1,982,279**	**10,267**	**1,547**	**0.60%**	**70,000**	**1,600,000**	**56**

Source: CURIP 2008; EMPRI 2008; Department of Statistics 2007

As far as trade effluents are concerned there exists no dependable estimate as to the total volume. One could approximate the quantum through an extrapolating of sector specific averages onto the entire industry base but, regrettably the sector data available (see 1.1.2) is far too coarse to provide a reliable base. In absence of better data, information from a set of sample industries may permit some insights here. As shown in Table 19, for a sample set of 34 randomly selected Red category industries in BMR, sewage, effluent and internal consumption account for 49%, 22% and 30% respectively. Extrapolating these proportions on to the whole of BMR using the known sewage quantum provides indicative totals with the limitation that the effluent quantum would be overestimated because non-Red category industries, the great majority in BMR, produce less or no effluent. The estimate of 25 MLD thus provides an upper ceiling of the total effluent quantum while the actual amount is assumed to be in the order of 5 to 15 MLD. For comparison, the combined capacity of BMR's four common effluent treatment plants (CETPs) is about 1.5 MLD.

A second conclusion is that the upper ceiling for the total requirement for industrial water is around 115 MLD. The actual value is thus estimated to be between 95 and 105 MLD. It is interesting to note that the supply of industrial water of Bangalore Water Supply and Sewerage Board (BWSSB) is only about 21 MLD, about 20% of the total. It is reasonable to assume that the balance amount is met through bore wells and tankers although the possibility exists that also unaccounted-for water, the total of which amounts to 509 MLD, meets a certain part of the demand (refer to Chapter 3 "WATER SUPPLY AND SANITATION", section 2.2).

Table 19: Water intake and effluent discharge of industries in BMR

Data set		*Sewage discharge*	*Effluent discharge*	*Internal consumption*	*Total water requirement*	*Total supply to industries by BWSSB*
34 sample industries classified as Red by KSPCB	in MLD	2.55	1.15	1.55	5.24	n/a
	in %	49%	22%	30%	100%	n/a
Estimated total for all 70,000 industries in BMR in MLD		**56**	**5 to 15** < 25	**34**	**95 to 105** < 115	**21**

Source: KPSCB 2009, EMPRI 2009, ISEC 2008

2.1.2. Causes

Contamination of water

Water bodies are being contaminated by industrial wastewater through a variety of sources.

Leakages of underground drainage (UGD) systems: Regular inspection of UGDs is rare and remedial actions are generally limited to emergency repairs, undertaken *after* the identification of breakdowns.

Leachate from unauthorised dumpsites: Leachate from unauthorised dumpsites of industrial waste percolates into the water table and contaminates the ground water. Lack of solid waste management encourages disposal in unauthorised places and no preventive or remedial actions have been taken to clear these dumpsites.

Infiltration from soak pits: Sewage at various degrees of disintegration seeps out of soak pits as containment is limited by the virtue of nature.

Leakages and overloading of septic tanks and soak pits: Poor construction and placement paired with the widespread absence of maintenance together form and compound leakages. Loading septic tanks in excess of capacity invariably results in direct discharge into the environment.

Direct discharge of sewage or effluent: Direct discharge of waste streams into drainages, lakes or on open land is not uncommon. This problem is brought about by the absence of treatment facilities, UGDs, soak pits and septic tanks, their negligent overflow, avoidance of treatment cost, underlying which is an obvious lack of concern for the environment. In case of effluents the magnitude of the problem comes to light from the discrepancy between projected effluent generation and quantities sent for treatment. Monitoring appears too limited to keep violations in check.

Figure 8: Drain polluted with dyes, Kamakshipalya

The analysis of lake water and bore well samples by KSPCB in 2007 provides evidence of pollution with several parameters exceeding permissible limits: calcium (by up to 13%), chloride (20%), residual sodium chlorine (115%), dissolved solids (132%), BOD (300%), turbidity (372%) and iron (3,293%). It may be added that industrial sources are not solely responsible for the contamination of ground and surface water. Although the quantity of industrial effluent discharged may be small compared to the total volume of wastewater generated, its pollution potential is substantially higher.

Inadequacy of waste water treatment

The performance of treatment plants differs. With 6,734 operating industries under the purview of the Water Act, a large share of these industries is required to treat trade effluent and/or sewage. There are 1,252 industrial ETPs and four CETPs operated by Pai & Pai, Eco Green Solutions, Lidkar Tanners Private Limited, and KSPCB Regional Office Peenya respectively. Industries generating trade effluent without own treatment facilities are required to avail of treatment through CETPs. Following close checks by KSPCB, many industries have therefore established a memorandum of understanding (MoU) with commercial operators, though a large share of these is apparently not translating into regular supplies of the agreed quantity. No data exists on the installed capacity of ETPs; the combined capacity of the four CETPs is about 1.5 MLD vis-à-vis an estimated total effluent generation of 5 to 15 MLD.

Table 20: Industrial ETPs in BMR

Industry category	ETPs		
	Operating	Under construction	Planned
Red	537	11	10
Orange	301	20	3
Green	414	43	0
Total	**1,252**	**74**	**13**

Source: KSPCB 2008

Information on sewage treatment plants (STPs) is not readily available. Apart from the STPs maintained by BWSSB, two out of KSPCB's eleven Regional Offices have 26 industrial STPs on record. Especially labour intensive industries such as garment, IT and ITES have established STPs. The output of many treatment plants is, however, non-compliant with norms. STP and ETP data of KSPCB in 2007 shows the following parameters exceeding permissible limits: pH (by up to 8%), calcium (8%), percent sodium (22%), conductivity (46%), total dissolved solids (109%), chloride (112%), BOD (176%) and total suspended solids (920%). The main reason for non-compliance is the lack of adequate maintenance on account of costs involved.

2.1.3. Impact

On water bodies: Pollutants alter parameters such as acidity, electrical conductivity, turbidity, temperature, and enhance toxicity. Pollutants also increase the level of nutrients causing eutrophication resulting in ground water contamination. Organic matter discharged binds substantial amounts of oxygen for biological degradation causing an increase in the biological oxygen demand (BOD). An in-depth analysis of quality of water in BMR can be found in Chapter 3 "WATER SUPPLY AND SANITATION", section 1.6. An evaluation of the impact on water bodies is discussed in Chapter 3 "WETLANDS", section 1.3.

On soil: Surface water contaminates the soil. The presence of hazardous chemicals alters the soil chemistry and the metabolism of organisms residing in the soil environment. Exposure to pollutants degrades land and leads to loss of fertility.

On vegetation: Soil contamination affects plant metabolism and reduces growth, reducing crop yield in agricultural areas and tree growth in urban areas. High concentration of total dissolved solids (TDS), chloride, sodium and oil are specific contributors. The presence of heavy metals and phenols may lead to abnormal tree growth on one hand and retard crop growth on the other. Mercury inhibits physiological activities of plants even at low concentrations.

On animals: Pollutants affect animal life primarily through the food chain. Direct ingestion may cause muscular weakness and dizziness. Acidic compounds in water may cause mutagenic effects. Organochlorines present in untreated water severely affects metabolism in birds. High levels of chemical compounds threaten the extinction of certain bird species of BMR.

On humans: Water-borne diseases and water-caused health problems are mostly due to contaminated water and inadequate management of its resources. Exposure to polluted water may cause diarrhoea, respiratory problems or skin irritation. Untreated wastewater contains arsenic, chlorides, chlorinated solvents, phenolic compounds and some carcinogenic hydrocarbons. Lead is hazardous to health as it accumulates in the body and affects the central nervous system (CNS). A deeper analysis of the health impact of water pollution in BMR can be found in Chapter 5 "HEALTH", section 3.3.

2.2. AIR POLLUTION

2.2.1. Pressures

Rapid industrialisation, increasing vehicular traffic and progressive decline of green space are the main reasons for the loss of air quality. Key air polluting industries include chemicals, pesticide and fertiliser manufacturing, foundries, paper mills, food processing, stone cutting and stone crushing industries. Sources of industrial air pollution include chiefly single-point sources such as furnaces, boilers, incinerators and diesel generator (DG) sets. Apart from that the uncontrolled burning of waste is a very significant additional source of air pollution.

Figure 9: Burning industrial waste, Peenya

64% of the 7,257 operating industries registered with KSPCB in BMR are coming under the purview of the Air Act. However, KSPCB registered industries account for only a fraction of the total of 70,000 industries in BMR and the number of actual air polluters would therefore be greater. Prominent pollutants emitted include sulphur oxides (SO_X), nitrous oxides (NO_X), carbon monoxide (CO) and particulate matter. Carbon dioxide (CO_2), in contrast, is a greenhouse gas discussed separately in 2.4 and not classified as air pollutant. Based on the known consumption of industrial fuels the quantum of sulphur dioxide (SO_2) is estimated to be in the order of 12,000 metric tons per annum (refer to Table 21). No dependable estimate can be provided for pollution loads of other air pollutants. An analysis of concentrations of SO_2 and other air pollutants can be found in Chapter 4 "AIR", section 1.

Table 21: Industrial SO_2 emissions in BMR

Industrial fuels	*Consumption in 2006-07 in Mt/a*	*Sulphur content*	*SO_2 in Mt/a*
Motor spirit	1,549	*negligible*	-
High speed diesel	255,269	0.035%	179
Furnace oil	183,301	3.00%	10,987
Low sulphur heavy stock	38,556	1.00%	770
Total SO_2 emitted in Mt/a			**11,936**

Source: Enzen Global 2008, EMPRI 2009

2.2.2. Causes

Combustion of fossil fuel: Operation of furnaces, boilers, DG sets relies primarily on fossil fuel. The number of boilers registered with the Department of Factories and Boilers in BMR is 699. CPCB estimates the number of DG sets to be in the order of 100,000. The use of DG sets has seen an increase as they are not only used to back up electricity supply but are becoming its regular substitute with captive generation offering economical advantages.

Burning of waste: The absence of a comprehensive management system for industrial solid waste has made unauthorised dumpsites a common sight. Waste dumps are frequently set on fire, leading to emissions typical for uncontrolled combustion and often accompanied by noxious odours, especially when plastics, other mineral oil-based products or rubber are involved. This source of pollution is considered particularly critical because the pollutants are likely to be more hazardous than those from the combustion of fuel and secondly, the process is entirely uncontrolled and the combustion generally incomplete. Burning dumpsites can be found in almost all industrial and even residential areas.

Generation/stirring of dust and ash: Destructive mechanical processes disintegrate material into fine particles, light enough to be carried and moved away by the ambient air. Cutting of stones, grinding, drilling of bore wells, sawing of wood, and grinding of grains are prominent examples. A multitude of processes do not in fact generate dust but stir it up from places where it has settled down. Movement of parts and components from storage is a common cause here while the most effectual methods involve cleaning with the aid of air pressure.

According to KSPCB, 68% of industries registered with the board under the Air Act have adopted some kind of control measures. Control measures include end-of-the-pipe engineering controls, fuel changes and ensuring a certain minimum chimneystack height. Regularity of compliance checks has helped ensuring more stringency in the implementation of law.

Table 22: Air pollution control measures adopted by industries in BMR

Industry category	Industries under the Air Act	Air pollution control measures		
		Operating	Under construction	Planned
Red	2,151	1,272	14	- - -
Orange	969	575	10	- - -
Green	3,720	2,677	34	2
Total	**6,840**	**4,524**	**58**	**2**

Source: KSPCB 2008

2.2.3. Impact

Pollutants from industries impede plant growth and impair the health of animals and humans. A linkage between pollutants and their specific impact is established in the following.

Carbon monoxide (CO): CO is a poisonous gas produced by incomplete combustion of fuel. At low levels of exposure to CO, humans may experience a variety of neurological symptoms including headache, fatigue, nausea, and vomiting. CO poisoning and fatalities are often caused by faulty vents and chimneys.

Oxides of nitrogen (NO_X): The high temperature combustion of fuels is the principal source of nitrogen oxides. Higher concentrations of NO_X damage the leaves of plants; retards photosynthetic activity and causes chlorosis. Higher levels of NO_X in humans cause gum inflammation, internal bleeding, pneumonia, oxygen deficiency, lung cancer and bronchitis. NO_X is a key contributor to acid rain.

Oxides of sulphur (SO_X): These gases are emitted from burning of coal and oil. It is a highly irritating gas which adversely affects human, animals, plants and materials. It causes eye irritation, lung cancer, asthma, respiratory disorders and bronchitis. SO_2 damages vegetable crops, affects plant growth and its quality. SO_2 is also a key contributor to acid rain.

Particulate matter (PM): These are tiny particles of suspended in a gas comprising of smoke, dust, mist, spray, and fumes, some of which are respirable (RSPM). Particulate matter less than 10 micrometers (μm) in diameter is capable of entering the nasal cavity and 2.5 μm can enter the bronchi and lungs. Increased levels of fine particles in the air are a health hazard associated with heart diseases, respiratory disorders, altered lung functions and lung cancer.

Dioxins: Dioxins are halogenated organic compounds that are highly toxic to living organisms. The largest quantified source of dioxin emissions is uncontrolled burning. They are also produced while manufacturing chlorinated chemical and metal smelting. It causes damage to the immune system, birth defects, thyroid disorders, abnormal teeth and accumulates in humans and animals causing cancer.

Volatile organic compounds (VOC): VOCs are organic chemical compounds. The most common VOC are aliphatic and aromatic hydrocarbon solvents such as toluene, xylene and benzene. Also petrol and diesel have a high VOC content. VOCs are generally toxic or highly toxic, affecting the central nervous systems.

A deeper analysis of the health impact of air pollution can be found in Chapter "HEALTH", section 3.1.

2.3. WASTE GENERATION

2.3.1. Hazardous waste

About 1,042 industries in BMR generate about 23,756 tons of hazardous waste (HW) per annum. An analysis of the sources and composition of HW can be found in Chapter 8 "WASTE", section 1. The following table profiles sectors with a substantial overall contribution to HW generation.

Table 23: HW generating industry sectors

Industry sectors	
Automobile service	Metal surface finishing
Breweries	Paint manufacturing
Cement industry	Pharmaceutical industry
Chemical industry	Re-processors
Dyes manufacturing	Tiles manufacturing
E-waste recyclers	Transport corporations
Food processing	Industries operating effluent treatment plants (ETP)

Source: EMPRI 2008

Prior to 2009 Karnataka had no facilities for treatment and safe disposal of HW. Only a few technically inadequate incinerators were in operation. Storage and disposal of non-incinerable HW was completely unaddressed. Particularly in SMEs storage is often inadequate as storage space is limited and suitable containers are not available. The incineration fee levied to producers of HW cuts into pricing and competitiveness and is a deterrent for adequate treatment. The problems are now being addressed by the Treatment, Storage and Disposal Facility (TSDF) in Dobbaspet commenced operation in January 2009. The cost of treatment might however remain a critical factor that limits participation in safe disposal compliant with legal stipulations. KSPCB is expected to play a significant role in ensuring compliance.

Until recently safe disposal practices were rare. According to a 2004 survey by HAWA, as many as 25 illegal HW dumping sites were identified in BMR, three of which greater than 20 acres where mixtures of paint sludge, ETP sludge, spent solvents, used oil and incineration ash are interacting with the environment. Hazards impact aquatic life, ground water and, indirectly, human health. Affected are particularly children, women and the poor. Especially the urban poor live in close proximity to polluted drainage canals, contaminated sites and enterprises causing pollution. When it comes to safe drinking water the urban poor are disadvantaged because purification of municipal water tends to be out of economic reach. Also the health of workers of industries generating HW is affected, particularly in SMEs where processes are unsafe and HW storage is inadequate.

2.3.2. Electronic waste

About 8,000 tons of electronic waste (e-waste) are generated by industries per annum (refer to Chapter 8 "WASTE", section 5). With the recent amendment of the HW (Management, Handling and Transboundary Movement) Rules, 2008 e-waste has been reclassified as hazardous. Apart from households, major contributors of e-waste include the IT (information technology) industry, IT Enabled Services (ITES), and the cross-section of industries as operations are usually backed by electronic data processing.

Industry sectors such as IT and ITES that intrinsically rely on data processing equipment have seen rapid growth. The underlying technology is developing fast resulting into a high obsolescence rates and shorter replacement spans. These factors drive the explosive growth of e-waste. Since it contains a large array of valuable constituents recycling emerges as logical solution and is economically viable.

Figure 10: Escaping mercury vapours – Informal tube light recycling near a slum on Pottery Road

Existing material recovery is almost entirely in the hands of the informal sector. The concerns surrounding e-waste are primarily related to occupational health and safety aspects of recycling workers. Workers are exposed to intolerable health hazards, some of which are presented in Table 24. The informal sector lacks the capacity to undertake certain processes without affecting workers' health and living conditions of the neighbouring population severely. The main reasons are the inadequacy of equipment and processes, the lack of awareness of intrinsic risks among workers and lack of enforcement of health, safety and environmental standards. It is believed that the problem is best addressed by shifting operations to licensed industries in the formal sector.

Table 24: Health effects of e-waste constituents

Constituent	Heath affects
Barium	Exposure to fumes and dust may cause damage to heart, liver, spleen and cause muscle weakness
Beryllium	May cause lung cancer and chronic beryllium disease (beryllicosis)
Brominated flame retardants	May disrupt the functions of the endocrine system
Cadmium	May cause irreversible toxic effects, malformation of embryos (teratogenicity) and neural damage (neurotoxicity). Accumulates in kidney and liver
Hexavalent chromium	Causes DNA damage and asthmatic bronchitis
Lead	May cause damage to central and peripheral nervous system, blood stream and kidney. May affect the brain development of children
Mercury	Causes chronic brain damage in humans. Causes skin and respiratory disorders in aquatic life due to bioaccumulation
Plastics (including PVC)	None unless plastic is being burnt. Exposure to burning fumes may cause reproductive and developmental disorders, damage the immune system and interfere with regulatory hormones

Source: EMPRI 2005

2.3.3. Industrial solid waste

It is quite apparent that the amounts of non-hazardous industrial solid waste (SW) are considerably high. However, no estimates are available to describe its magnitude. SW generated by industries is a seriously under-addressed issue. Though risk levels are low compared to HW or e-waste, industrial SW is generated in large quantities that are generally excluded from the collection system of civic authorities who manage municipal solid waste (MSW). In absence of an adequate collection system industrial SW is liberally disposed on vacant land or into lakes.

Table 25: Industry SW generating sectors

Industry sectors
Plastics manufacturer
Casting and moulding
Foam industry
Textile industry
Engineering industries
Stone cutting and polishing
Ceramic industries
Industries disposing packaging material
Industries/ contractors disposing construction material

Source: EMPRI 2008

Figure 11: Burning industrial waste on Shivapura tank bed, Peenya

Constituents of SW include an array of materials ranging from rigid materials such as glass, metal scrap and construction material to ductile matter such as rubber, plastic, foam and fabric waste. Recycling options are explored only by rag pickers.[10]

There are two key impacts of unmitigated disposal of solid waste. Firstly, waste dumps are frequently set on fire, leading to emissions typical for uncontrolled combustions and often accompanied by noxious odours, especially when plastics and other mineral oil-based products are involved. Secondly, the leachate of waste dumps percolates into ground water and water bodies, contributing steadily to an increase of water pollution. The lack of waste management also has a noteworthy aesthetical and psychological impact on citizens. The liberal spreading of waste across the environment is gradually lending environment itself the look and smell of a continuous garbage dump, leaving citizens and perhaps especially younger generations convinced that no matter how clean a habit one may adopt at the individual level, at the collective level it would probably not make any difference.

[10] The absence of management of industrial SW is so obvious even in prime industrial areas such as Peenya that here the private sector was prompted to initiate action by establishing a local waste collection and handling system in public-private partnership (PPP) with Government of India (GoI) and Government of Karnataka (GoK). This PPP is a commendable model whose replication potential is limited to a few large and well-organised industrial areas.

2.4. GREENHOUSE GASES

2.4.1. Pressures

The primary greenhouse gas (GHG) is carbon dioxide (CO_2). Other GHGs include methane (CH_4), nitrous oxide (N_2O) and halogenated substances (e.g. ozone depleting substances). By comparison the latter three groups are playing a less significant role and are not elaborated further here.

CO_2 is released through combustion of fossil fuels such as coal, oil, diesel and gas in industrial processes. The level with which an industry contributes depends on its energy requirement and to what extent this requirement is met through fossil fuels. Industry sectors of high energy intensity include foundries, glass and ceramics, brick kilns and chemicals. CO_2 is also released from the generation of electricity from fossil fuels at power plants. The use of electricity thus implies release of CO_2 as well. In Karnataka and BMR however, hydropower accounts for a substantial share in electricity supply thus reducing CO_2 per unit. Another cross-sectional CO_2-emtitter is the captive power generation through DG sets. More than 10,000 DG sets are registered with the Electrical Inspectorate while CPCB estimates their number to be about 100,000 in Bangalore alone. It should be noted that every single industry relies on or uses some form of conventional energy and is thus contributing to GHG emissions.

Industrial CO_2 emissions from fuels and grid-supplied electricity in BMR amount to about 2 million tons per year. 75% – the great majority – can be attributed to commercial fuels as shown in Chapter 9 "ENERGY", section 3.4. The remaining 25% are attributed to generation of electricity consumed by industries (see to Table 26). This estimate assumes an emission factor of 0.60 kg_{CO2} per kilowatt-hour considering the substantial share of hydropower and does not take into account distribution losses and DG set emissions.

Table 26: Industrial CO_2 emissions in BMR

Taluk	Area in acres	Industrial areas: Developed in acres	Industrial areas: Private (approx) in acres	Industrial areas: Share of industrial area	Number of industries (extrapolated)	Industrial electricity consumption exc. DG sets in Mill. kWh	CO_2 emissions from electricity generation excl. DG sets in Mt/a
Bangalore Urban							
Anekal	130,472	2,958	0	2.27%	16,516	57.7	34,638
Bangalore North	222,889	2,889	1,059	1.77%	16,249	445.2	267,090
Bangalore South	175,198	1,287	487	1.01%	21,606	206.0	123,594
Bangalore Rural							
Devanahalli	112,927	0	0	0%	1,473	7.8	4,684
Doddaballapur	197,190	820	0	0.42%	2,314	17.9	10,768
Hoskote	134,920	424	0	0.31%	1,786	16.4	9,864
Nelamangala	129,483	339	2	0.26%	1,597	13.3	7,992
Ramanagar							
Channapatna	134,672	15	0	0.01%	1,721	16.0	9,612
Kanakapura	392,898	262	0	0.07%	2,275	17.1	10,289
Magadi	197,190	14	0	0.01%	2,444	9.7	5,846
Ramanagar	154,441	1,260	0	0.82%	2,020	12.8	7,668
BMR total	**1,982,279**	**10,267**	**1,547**	**0.60%**	**70,000**	**820**	**492,046**
CO_2 emissions from industrial fuels (diesel, furnace oil, low sulphur heavy stock, petrol) in Mt/a							1,501,086
Total industrial CO_2 emissions in Mt/a							**1,993,132**

Source: CURIP 2008; EMPRI 2008; Department of Statistics 2007; Enzen Global 2008

2.4.2. Causes

Industrial GHG emissions are chiefly caused by dependency on fossil fuels. In electricity generation too fossil fuels are the major source of energy albeit hydropower accounts for a tangible share in Karnataka. Factors contributing to the strong dependency on fossil fuels may be divided into four categories that are intrinsically linked to each other:

Economics in favour of fossil fuels: Fossil fuels provide energy at cost less than that of non-fossil alternatives. Only in niches renewable energy can compete with fossil fuel and even here chiefly in presence of targeted promotional incentives. The reason that fossil fuel prices are low is because the actual cost of GHG emissions and climate change is, in India and the world over, borne by society and not by the emitter. Real costs of fossil fuels are thus not internalised, which, if undertaken, would price fossil fuels much less favourable.

Lack of viable alternatives: For generation of high-temperature process heat, no viable alternatives exist currently that are capable of replacing fossil fuel in urban industrial applications. The options available are limited to energy conservation that reduces but does not replace fossil fuels.

Lack of promotion of alternatives: Renewable sources of energy require targeted incentives to enter into and sustain a market that is dominated by low-cost fossil fuels. Given the fact that economically exploitable potential of fossil fuels is expected to exhaust within this century, application oriented research and promotional strategies for large-scale development of alternate fuels is missing. Mere platitudes will not help to usher in alternate non-fossil energy sources.

Energy savings insufficient: Measures taken to save fossil fuel do bear fruits. But in terms of gross consumption the savings achieved are eaten up and exceeded by industrial growth and its demand for energy. There remains no net saving in the total and annual energy consumption is ever increasing. However, research and development on increasing energy efficient equipment and processes needs to continue.

2.4.3. Impact

The 2007 report of the Intergovernmental Panel on Climate Change (IPCC) has corroborated substantial scientific evidence that ascertained beyond doubt that anthropogenic emissions of GHG are responsible for global warming. CO_2 concentrations in the atmosphere have risen from 280 ppm to 379 ppm between the pre-industrial area before 1750 and 2005. The rise of GHG concentrations increases the heat retention of Earth's atmosphere while reducing heat emissions into outer space. The climate is steadily warming up. Eleven of the last twelve years (1995-2006) rank among the twelve warmest years since 1850. Increased temperatures have been observed across the globe but are greater at higher northern latitudes. Rises in temperatures were found to be consistent with the rise of sea levels, imposing far-reaching consequences for inhabited low-lying land. Sea levels have been rising at 1.8 mm per year since 1993 with contributions from the melting of glaciers and ice caps, polar ice sheets as well as thermal expansion. A drastic change in weather patterns is certain to occur but predicting local consequences given the complexities of this dynamic system is hard. The impact and implications of global warming are considered extremely serious, possibly the most critical global challenge to humankind in this millennium and the global response will determine under what conditions future generations may inherit earth.

IPCC Report 2007: Impact projection for Asia

- By 2050s freshwater availability in Central, South, East and South-East Asia, particularly in large river basins is projected to decrease.
- Coastal areas, especially heavily populated megadelta regions in South, East and South-East Asia, will be at greatest risk due to increased flooding from the sea and in some megadeltas, flooding from the rivers.
- Climate change is projected to compound the pressures on natural resources and the environment associated with rapid urbanisation, industrialisation and economic development.
- Endemic morbidity and mortality due to diarrhoeal disease primarily associated with floods and droughts are expected to rise in East, South and South-East Asia due to projected changes in the hydrological cycle.

2.5. OZONE DEPLETING SUBSTANCES

2.5.1. Pressures

Ozone depleting substances (ODS) used in India comprise of six groups: CFCs, halons, carbon tetrachloride (CTC), methyl chloride, methyl bromide and HCFCs. The use, production and trade of ODS is regulated by the Montreal Protocol to which India is Party since 1991. Key application areas of ODS are shown in the following table.

No ODS is manufactured in BMR but there is no reason to assume that ODS use has been completely discontinued, especially considering that BMR holds a fair number of enterprises in concerned industry sectors. Defining the quantities of ODS consumed in BMR is difficult. Nevertheless, India's total consumption is known from the ODS inventory kept for reporting obligations under the Montreal Protocol. According to latest data, India was consuming more than 13,000 tons of ODS in 2006, not counting feedstock uses, exempted uses such as metered dose inhalers (MDI) and military applications. Given the significance of BMR as hub of the Indian industry, it may be assumed that its ODS consumption would be in the order of 5% of the national quota, translating into a consumption of about 650 tons per annum. Consumption in the pre-phase-out era is expected to have been substantially higher as many large scale consumers, primarily public sector units and fire extinguisher manufacturers, were known to use ODS such as CTC back then.

Table 27: Applications of ODS in India

ODS	ODP	Application	Industry sector
CFC-11, CFC-12	1.0	Refrigerant; Ingredient of metered dose inhalers (MDIs)	Refrigeration and air-conditioning (RAC), pharmaceuticals
CFC-113a	0.8	Special cleaning agent air force applications	Air Force
Halon 1211, Halon 1301	3-10	Fire extinguishant	Fire extinguisher manufacturers
Carbon Tetrachloride (CTC)	1.1	General cleaning agent	Engineering, garment, offset, power utility
1,1,1-trichloroethane a.k.a. Methyl Chloroform (MCh)	0.11	Precision cleaning agent in special applications	Machine tools, engineering
Methyl Bromide	0.6	Grain fumigant	Grain depots
HCFC-22	0.055	Refrigerant, especially in air conditioning as replacement for CFC-11, CFC-12	RAC
HCFC-141b	< 0.06	Foam blowing agent	Foam manufacturers
HCFC-123	0.11	Specialty solvent in special applications	(no data available)

CFC-11/12 with an ozone depleting potential (ODP) of of 1.0 forms the baseline for determination for that of other ODS.

Source: UNEP Ozone Secretariat 2000; GTZ Proklima 2008

Table 28: ODS consumption excluding exempted and feedstock uses in India

ODS	Production	Baseline consumption in Mt/a	Baseline period	Consumption in Mt/a		
				2004	2005	2006*
CFC-11	Yes	6,681	1995-97	426	337	515
CFC-12	Yes			1,808	1,609	3,018
CFC-113a	Yes			10	14	-
Halon-1211	-	260	1995-97	-	-	-
Halon-1301	-			-	-	-
Carbon Tetrachloride (CTC)	Yes	10,459	1998-00	6,781	1,495	3,637
1,1,1-trichloroethane a.k.a. Methyl Chloroform (MCh)	-	1,467	1998-00	-	-	-
Methyl Bromide	-	214	1995-98	-	-	-
HCFC-22	Yes	Yet to be defined	2009-10	7,228	8,854	6,137
HCFC-123	-			60	15	-
HCFC-141b	-			1,357	2,156	-

** Amounts indicate that phase-out targets for CFCs and CTC have not been met. In the case of CFCs this has been confirmed in the 2007 Meeting of the Parties (MOP) and a penalty has been levied on India for non-compliance. In the case of CTC, the surprisingly high level of consumption as compared to the previous year appears erroneous as no information on India's non-compliance has been published. The data on HCFCs too appears erroneous because its market share is expected to rise until its phase-out in 2040 is accomplished.*

Source: Ozone Cell, Ministry of Forest and Environment (MoEF) 2008; GTZ Proklima 2008

2.5.2. Causes

Mechanisms that propagate the use of ODS belong largely to the past. Today, under the ODS phase-out regime remaining emissions are basically residual practices for which change-over processes and timeframes have already been defined. Consumption is decreasing rapidly and only the consumption of HCFCs is slated to rise in its use as replacement for CFCs in particularly air-conditioners. Reasons that are contributing to delays in changing over to non-ODS:

Performance barrier: ODS have been absorbed by a rapidly expanding market for specific properties and which distinguish them from other substances. Equipment or processes that rely on ODS are designed around their specific properties. There exist very few instances where an ODS can be readily replaced with a non-ODS without reducing the process performance. Alternatives by comparison usually emerge with a poorer rating.

Know-how barrier: Substitution of ODS usually requires a change of practice and, in some cases, a change of process. Especially in small and medium enterprises, know-how is usually limited to the current practice and little or no effort is invested in research unless the issue is recognised as imminent. Particularly for such industries the access to relevant information is constrained. In certain cases, such as the substitution of CTC-11 and CTC-12 in the air-conditioning (RAC) service sector, extensive capacity building at technician level is required (and in this case also provided) to ensure updation of maintenance practices.

Investment barrier: A change of process goes hand-in-hand with procurement of equipment capable of facilitating new processes. That applies to both manufacturing and servicing. Investment cost is a barrier if not a deterrent here, especially since the primary objective of the investment is not an improvement of quality or economics and can, in many circumstances, not even be successfully combined with that.

Operating costs barrier: Most ODS are used as consumables and their replacement with another product invariably will have financial implications, in many cases with a negative balance. Win-win situations such as the garment industry where CTC is being replaced with detergents that cost less than the ODS substituted are a rare example. The adoption of alternatives typically disadvantages an enterprise economically, making it harder to stay competitive in market with small margins. The fact that the gradual phase of ODS is bringing supplies below the demand leading to rising prices is a favourable trend addressing this problem. However, this trend works for only some ODS and in some applications. This led, as in the case of CTC, to the advantageous situation that the ODS is increasingly being displaced by less expensive alternative, a factor that supports the phase-out prominently.

Lack of declaration: The phase-out regime created an unfavourable reputation of ODS. This reputation leads the market to respond with products that contain ODS but are not declared as such. Consumers purchase such produces unaware of the fact that these contribute to ozone depletion.

2.5.3. Impact

ODS are sooner or later released into the atmosphere. In the case of refrigerants this occurs due to system leakages during service. As for fire extinguishers (halons) and metered dose inhalers (MDI), release occurs through use. In all solvent applications, ODS are released during their use as well because evaporation is part of the cleaning process. Once released, ODS rise up to the stratosphere and destroy the ozone layer.

Given the effort of the international community to phase out ODS, first signs of a slowing down of ozone layer destruction and recovery were detected in 2006. Apart from global warming, ozone depletion is the only other issue of environmental concern where cause and impact are far apart from each other.

Figure 12: Certain gas cylinders were cleaned with carbon tetrachloride (CTC), which is an ODS

2.6. NOISE

2.6.1. Pressures

The last three decades have witnessed an increasing concern for the environment. Also noise has been recognised as a substantial threat and is consequentially treated akin to pollutants at municipality and workplace levels. Noise is unwanted sound. Industrial sectors and cross-sectoral activities constituting the main sources of noise are presented in Table 29. Processes in the general manufacturing industry are almost intrinsically linked to generation of noise. Vehicular movement, as catering to or induced by industrialisation, is another significant source of noise.

Limited self-monitoring data available from some engineering, construction and power loom industries located in Peenya Industrial Area indicates that limits prescribed by CPCB are occasionally exceeded. Equally limited data on Jigani Industrial Area as presented in Chapter 4 "AIR", section 3 provides, however, no indication of excess levels. Apart from the occasional on-time measurement, there exists a considerable dearth of data on industrial noise without which no conclusions can be drawn.

Table 29: Key noise polluting industries

Industry sectors	*Activities across sectors*
Engineering (fabrication)	Drilling
Cold forging	DG sets
Stone crushers	Air compressors
Quarries	Hammering
Power looms	Grinding
Construction work	Machine sawing
Automobile service	Exhaust ventilation

Source: EMPRI 2008

2.6.2. Causes

Noise has become an integral part of urban life. Many larger companies have shown to assume responsibility and are monitoring its levels regularly. It appears realistic to assume that industries that monitor might also act on findings. Regular monitoring, however, is limited to the initiatives of a few larger industries and does not encompass the great majority of micro and small fabricators in BMR. For many essential engineering processes limited options for noise reduction exists. For these the only feasible measure apart from end-of-the-pipe solutions such as earplugs is the restriction of the number of concurrent noise producing processes.

2.6.3. Impact

An in-depth evaluation of the impact of noise can be found at Chapter 5 "HEALTH", section 3.2.

2.7. LAND USE

BMR's geographical area includes built-up areas and industrial land but also agricultural land, forest, wasteland and uncultivated land. Out of the total area of 8,022 km^2, industrial areas account for only 66 km^2 (0.82%). Some industrial activities are carried out on unconverted agricultural land while industrial land is also used for lorry terminals, road lines, weigh bridges, godowns and warehouses. The existence of industrial areas without adequate infrastructure is a key issue for urban development and indicates that the capacity of the government needs to be strengthened.

Expansion of industrial areas has lead to permanent loss of agricultural land. The rate of agricultural production has been gradually decreasing due to increased industrialisation; the per capita holdings of farmland are declining. Industrial land use has led to loss of habitat of the flora and fauna in most of the rural and semi urban areas of BMR. Encroachment of lakes, parks and forest areas by industries has reduced the respective areas. Disposal of industrial and construction waste has lead to temporary loss of portions of many lakes, parks and some forests.

KIADB plays a major role in the conversion of agricultural land. After occupation by industries, converted agricultural land in rural areas tends to gain potential as industrial zone, attracting further industries and driving up the land price of surrounding areas. Though agricultural land means livelihood to farmers, the temptation to benefit from windfall sales is strong. Industrialisation is therefore a major driving force behind the appreciation of land values that promotes conversion of further agricultural land.

3. TRENDS AND PROJECTIONS

3.1. TRENDS

Table 30: Trends observed and their bearing on environment

Trends		*Bearing*
Increasing competition	Before India opened its market the economy was shielded from international competition and consequently, competition was limited to few which did not pose enough of a threat to invest seriously in innovation. This framework entirely changed, making competition for both local and the international markets a key element in the Indian manufacturing industry's pursuit of greater markets. The key element for that is, besides innovation, cutting cost.	**Negative.** Pollution control cost disadvantages position in the market.
Difficulty in land acquisition	While the state is promoting industrial development and the industrial area development agencies pursue the development of further industrial areas, land acquisition has emerged the major bottleneck for the success of development. The development process of many estates is held up awaiting court decisions on transfer or conversion of land.	**Negative.** Speed of industrial area development seriously constrained.
Shrinking of urban industrial areas	Rising land costs are displacing industries in state-developed and privately established industrial areas of Bangalore South and Bangalore North *taluks* in favour of office complexes, commercial establishment and even apartment complexes.	**Negative.** Especially state-developed industrial infrastructure loses its purpose.
Slimming to core business	Similar to outsourcing in the service sector, the manufacturing industry is increasingly outsourcing the processes to specialised companies or job workers for better control of quality and price. This includes processes of greater environmental risks such as electroplating. The concept of the 'composite textile mill' is disappearing rapidly in favour of smaller units of greater specialisation.	**Neutral.** Transformation from fewer larger players to more smaller players that are better equipped but harder to monitor.

Trends		*Bearing*
Growth of sector specific estates	The concept of industry sector specific estates is not new but has, apart from the electronics industry, not been realised in BMR so far. However, plans for a dedicated area for printing industry ('Printech Park') have been finalised and areas for automobile components manufacturing and textile industry are currently under discussion.	**Positive.** The implementation of industry specific pollution control approach is expected to simplify.
Relocation of industries	The Supreme Court had passed a judgement directing Delhi authorities to relocate industries currently residing in residential areas. By the strength of this judgment steps have been initiated to prepare for the relocation of industries in Bangalore. Karnataka Small-Scale Industries Development Corporation (KSSIDC) is pursuing the acquisition of suitable land for development of an industrial area for relocated industries.	**Positive.** Land once used by industries will be reclaimed for urban development. Industrial area infrastructure and monitoring might improve while transportation needs increase.
Sectoral development	Karnataka's industrial policies (general policy, IT, ITES, BT) favour certain industries that do not have severe adverse impact on environment and declares several sectors/activities associated with damage to environmental and health as ineligible to incentives.	**Positive.** Industry sectors that contribute less to pollution are expected to prosper greater.

3.2. REGIONAL DEVELOPMENT

Bangalore Metropolitan region Development Authority Regional (BMRDA) plans, coordinates and supervises the development of BMR. The agency has developed a master plan for the region's development in view of the longer-term needs of the region, particularly considering Bangalore's rapid expansion. While today only two *taluks* of Bangalore Urban district are urbanised, the plan proposes the extension of urbanisation to new townships in other *taluks*, thus integrating the expansion process into the surrounding *taluks* in a planned manner. BMRDA projects that by 2021 BMR's population would reach 155 lakh (15.5 million) as compared to 84 lakh (8.4 million) in 2001, implying an annual growth rate of 3.11%.

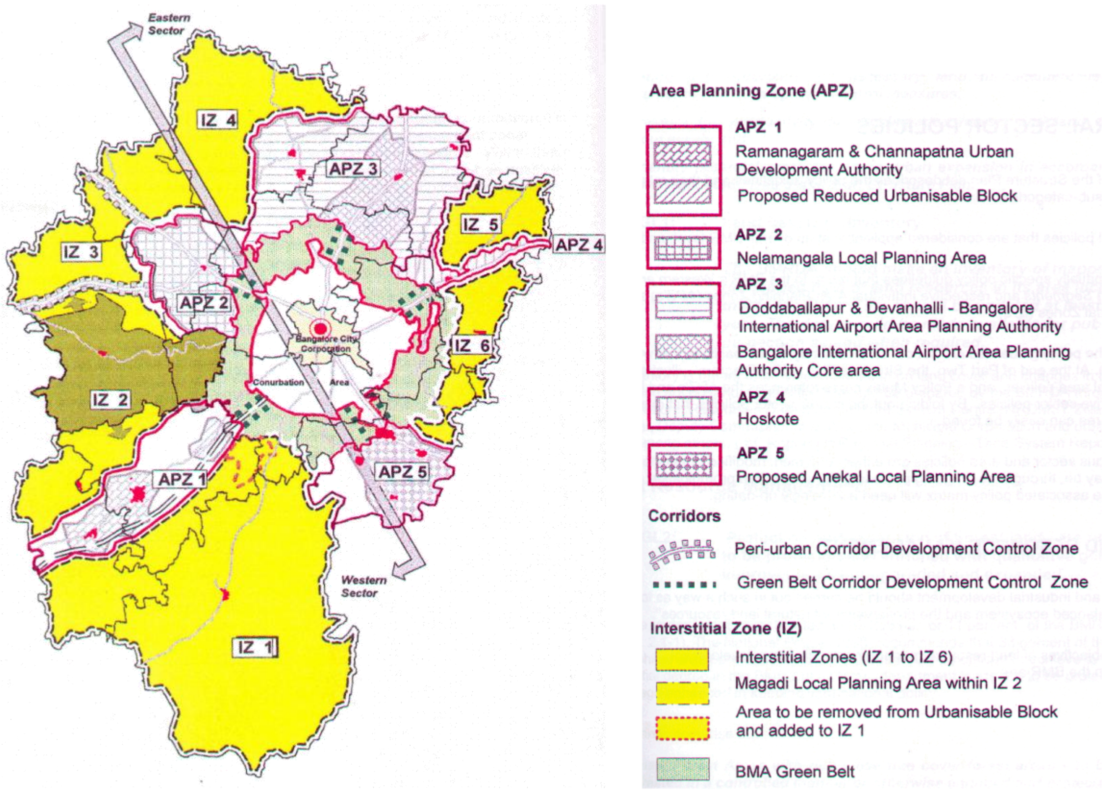


Figure 13: BMRDA's structure plan of BMR with designated zones

The structure plan proposes a clear distinction between urbanisable areas termed 'area planning zones' (APZ) and reserved zones currently excluded from township development termed 'interstitial zones' (IZ). In reserved zones a conservatory approach is taken with regard to predominantly agro-based livelihoods and the natural environment. Future development however is not wholly excluded here but at this time deliberately put on hold. Five townships with specific economic activities are planned in Bidadi, Ramanagar, Sathanur, Solur and Nandagudi. The township concept seeks to integrate working and living in close proximity so that commuting is contained through measures at the planning stage. Economic activities specifically defined for these integrated townships include IT-BT, health, education and finance. New industrial areas would be limited to urbanisable zones (APZ).

3.3. INDUSTRY BASE GROWTH

Forecasting future growth for a 22-year period cannot produce high-certainty predictions. The variables are many and most of these are entwined, making the overall model complex and highly dynamic and sensitive to even small changes in assumptions. Before presenting the growth model it may be worthwhile looking at indicators of past growth. The only suitable data available are industry registrations with DICs presented in Figure 14. The weaknesses of this data is that it comprises only small-scale industries (SSI) that voluntarily registered and that it is inflated in terms of absolute numbers as explained in section 1.1. The annual growth rates, ranging around 10% for the period from 1975 to 2002 followed by a sharp dip to below 5%, surprisingly, do not conform to the observation that industries have grown at an accelerated pace especially during the past decade. DIC's data in fact suggests the contrary and the resulting average growth of only 4.6% for the past ten years does not appear reliable.

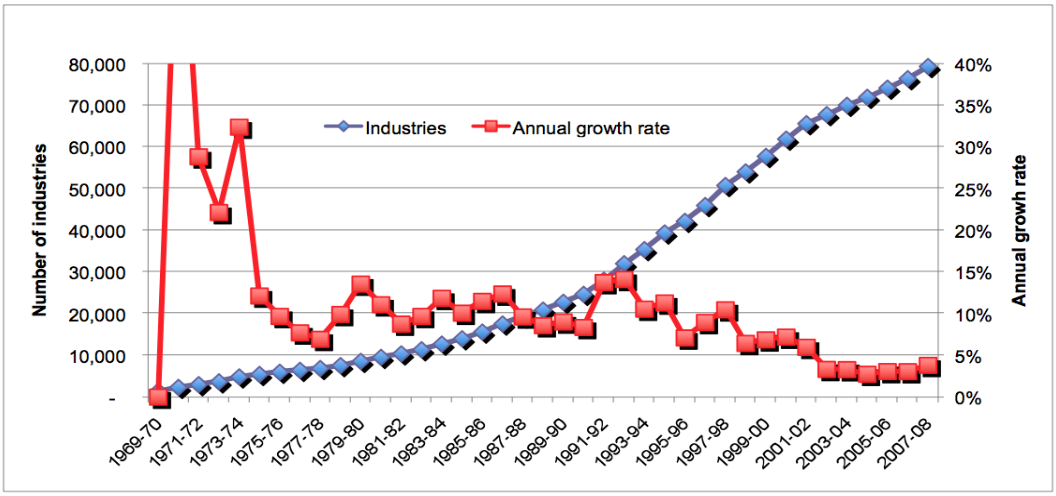


Figure 14: DIC registrations of small-scale industries in BMR

Karnataka Small Scale Industries Association (KASSIA) observed a growth of about 20% per annum over the last 5+ years against a mortality of 10-12%, resulting into net growth of 8-10%. This seems to correspond well with the magnitude of district income growth as shown in Table 31. Past growth until the beginning of the economic downturn in the second half of 2008 should thus be assumed to be in the order of 8% per annum.

Table 31: Annual growth of district income of Bangalore Urban district

Industries	1993 to 2000	2000 to 2005	1993 to 2005
Manufacturing total	6.86%	8.09%	8.07%
▪ Registered	6.12%	7.48%	7.33%
▪ Unregistered	13.17%	11.75%	13.62%

Source: CIRJE, University of Tokyo and Institute for Social and Economic Change (ISEC), 2008

Looking beyond 2008, the downward trend is not assumed to continue beyond a maximum of five years. But it does not appear realistic to expect that growth at the previous rate of 8% could be sustained for a period spanning two decades. If indeed it would, the result would be 380,000 industries by 2030 instead of today's 70,000. It is not easy to conceive how, hypothetically, BMR would cope with these, infrastructurally and environmentally. Thankfully, growth would be slower. One reason is that a sustained demand growth at previous rates is unrealistic. Another reason is that certain factors specific to BMR impede growth. Such factors include water scarcity, power shortages, land unavailability and infrastructural constraints. The growth model presented in Table 32 attempts to rate the impact of key constraints vis-à-vis previous growth and long-term expectations, and thus predicts the presence of 195,000 industries in BMR by 2030.

Table 32: Growth projection of BMR's industry base

Industry sectors *(Classification as)*	*Annual growth rate 2008*	*Recovery and long-term confidence rating*	*Growth constraints*					*Effective long term growth rate*	*Number of industries*			
									Baseline 2008		*Projection 2030*	
			Water scarcity	*Power, fossil fuel shortages*	*Infrastructure limitations*	*Land unavailability*	*Policy and governance*		*Sectors*	*Subsectors*	*Sectors*	*Subsectors*
General engineering (Machinery and equipment other than transport)	9.7%	-2%	-0.5%	-0.5%	-0.5%	-0.5%		**5.70%**	13,387		45,325	
Textile (Textile products including apparel)	4.5%	2%			-0.5%	-0.5%		**5.50%**	12,458		40,457	
Wet processing thereof (Textile products including apparel)	4.5%	1%	-1.0%	-0.5%		-0.5%	-0.5%	**3.00%**		60		115
Other services (Service sector)	8.7%	-1%			-1.0%			**6.70%**	7,328		30,522	
IT thereof (Service sector)	8.7%				-1.0%			**7.70%**		2,100		10,739
BT thereof (Service sector)	8.7%				-1.0%			**7.70%**		200		1,023
ITES thereof (Service sector)	8.7%				-1.0%			**7.70%**		245		1,253
Job work (Other manufacturing industries)	2.9%	2%	-0.5%	-0.5%				**3.90%**	6,530		15,151	
Electricals, electronics (Other manufacturing industries)	2.9%	2%			-0.5%	-0.5%		**3.90%**	5,539		12,852	
Miscellaneous products (Other manufacturing industries)	2.9%	2%	-0.5%	-0.5%		-0.5%	-0.5%	**2.90%**	5,467		10,255	
Quarries thereof (Mining & Quarrying)	2.4%	-1%				-0.5%	-0.5%	**0.40%**		1,800		1,965
Stone crushers thereof (Mining & Quarrying)	2.4%			-0.5%				**1.90%**		350		530
Brick kilns thereof (Mining & Quarrying)	2.4%		-0.5%			-0.5%	-0.5%	**0.90%**		27		33
Mines thereof (Mining & Quarrying)	2.4%	-2%					-1.0%	**-0.60%**		5		4
Printing and stationery (Paper, paper products, printing, publishing & allied Industries)	1.8%	3%	-0.5%	-0.5%		-0.5%		**3.30%**	3,543		7,238	
Wood, wood products (Wood, wood products, furniture, fixtures)	-8.9%	11%					-0.5%	**1.60%**	3,269		4,635	
Rubber and plastics (Rubber, plastic, petroleum, coal products)	-2.3%	7%	-0.5%	-0.5%		-0.5%		**3.20%**	2,866		5,730	
Food and beverages (Average of (a) Food products and (b) Beverages, tobacco and related products)	4.3%	2%	-0.5%	-0.5%		-0.5%	-0.5%	**4.25%**	2,833		7,078	
Chemicals (Basic chemicals, chemical products)	2.4%	4%	-1.0%	-0.5%	-0.5%	-0.5%		**3.90%**	2,546		5,908	
Basic metals (Basic metal and alloy industries)	4.9%	2%	-0.5%	-0.5%	-0.5%	-0.5%		**4.90%**	1,515		4,339	
Glass and ceramics (Other Manufacturing Industries)	2.9%	2%	-0.5%	-0.5%	-0.5%	-0.5%		**2.90%**	1,005		1,885	
Leather, leather products (Leather and leather & fur products)	-6.1%	9%	-0.5%			-0.5%	-0.5%	**1.40%**	991		1,345	
Transport equipment (Transport equipment and parts)	1.4%	5%		-0.5%	-0.5%	-0.5%		**4.90%**	723		2,070	
Total								**4.76%**	**70,000**		**194,792**	

Source: Department of Industries and Commerce 2008; KASSIA 2008; EMPRI 2008; Department of IT, BT, Science and Technology 2008; Textiles Committee 2006; Department of Mines and Geology 2008; Central Statistical Organisation 2009; LiveMint.com 2008

The model presented in Table 32 projects growth trajectories of individual industry sectors based on sector-specific assumptions. In each case, the resulting annual long-term growth rates lead to exponential growth because of the compounding effect. Sector-specific trajectories derived from the same model are shown in Figure 15. Calculations show a weighted average growth rate for all sectors is 4.76% per annum for the 22-year period, buoyed mainly by the high growth expectancy of 'Other services' which includes the IT, BT and ITES industry. 'General engineering' and 'Textile' emerge as secondary growth drivers.

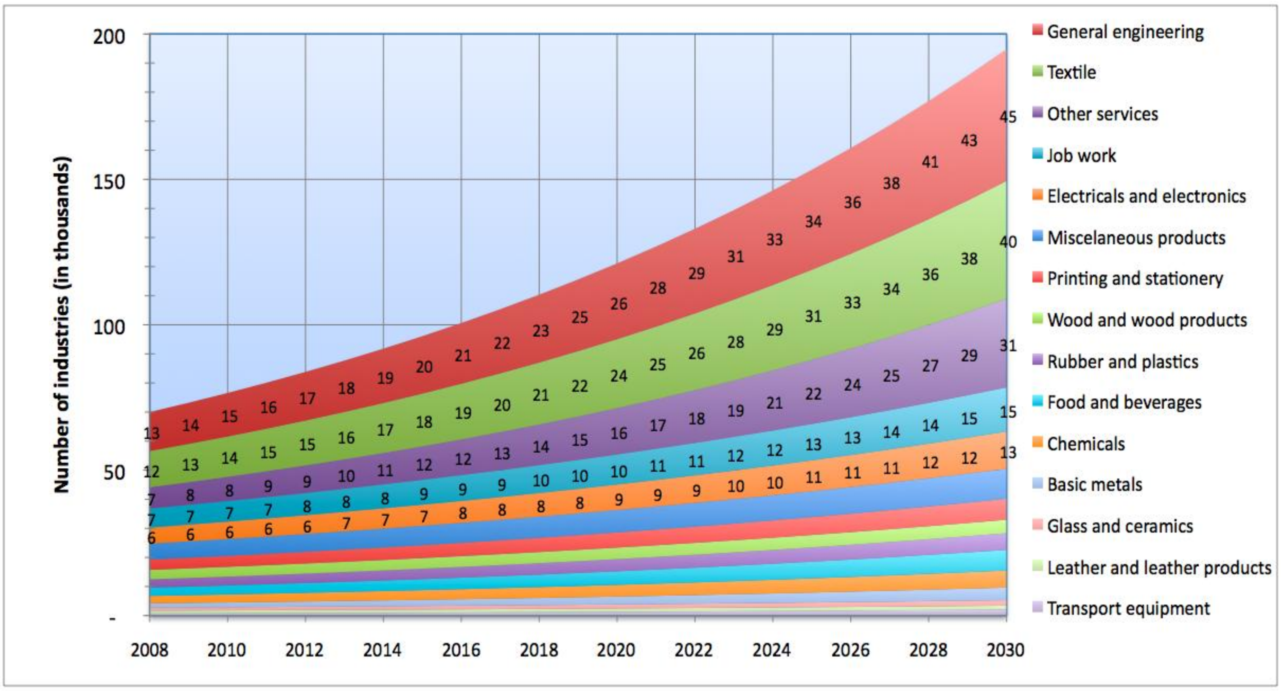


Figure 15: Growth projection of BMR's industry base

The spatial dimension of growth is likely to be uneven. Existing IT and ITES clusters in Whitefield and the south-eastern parts of Bangalore might attract more similar enterprises. Nevertheless, in absence of infrastructural incentives growth might not be limited to these areas. In view of the considerable distance to Bangalore's new airport far north, one should expect that new establishments with significant personnel long-distance travel such as the IT and ITES industry would gravitate tangibly towards north over the coming years.

The presence of the general manufacturing industry is expected to grow around traditional areas, predominantly in the north-west of Bangalore, and newly established industrial areas in the periphery. But given that industrial areas in city limits are occupied near to capacity, growth would be accommodated primarily outside these, an aspect that the following section will shed more light on.

3.4. INDUSTRIAL AREA GROWTH

In the 1950s the state begun to assume an active role in industrial development. The first industrial areas established were Ramanagar in 1957 (5 acres) and Rajajinagar in 1959 (37 acres). The next step was the development of substantially larger industrial areas with Dyavasandra in 1968 (525 acres) and Peenya Phase I–IV in 1971 (1,197 acres). Developed areas expanded rapidly at an average rate of about 282 acres per year but the expansion pace was not steady. The years from 1983 to 1994 were marked a 12-year period of relative stagnation while the industry base grew unabated. Another period of stagnation occurred between 1998 and 2002 in a period of rapid industrial growth. Figure 16 illustrates the historical growth of areas developed by state agencies KIADB and KSSIDC. Undated industrial SUCs totalling to 33 acres have not be included here.

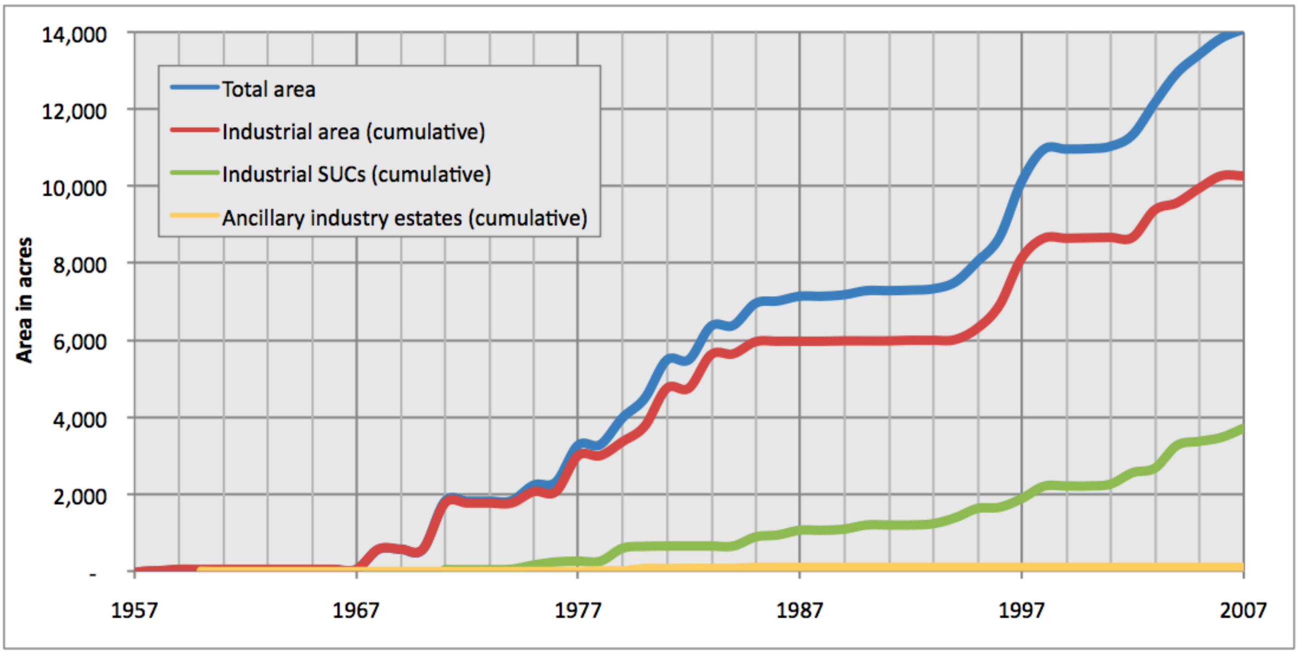


Figure 16: Growth of state-developed industrial areas

The development of further industrial areas is under preparation. Land acquisition for seven projects covering a total area of 2,810 acres has been completed. Around 91% of this area is being developed by KIADB, the remainder by KSSIDC. In addition more than 8,300 acres have been earmarked and proposed for development. The process might take time for completion as the most unpredictable component is land acquisition. Disputes have increased over the past decades and the process involves and relies more often on the judiciary, which adds not only to delays but renders the realisation virtually unplannable. Table 33 provides details of these projects while Figure 17 indicates their locations against those already existing.

Table 33: Upcoming industrial areas in BMR

	Upcoming industrial areas	*Taluk*	*Development agency*	*Approx. area (acres)*
Currently finalised				
1.	Devanahalli - Aerospace components	Devanahalli	KIADB	918
2.	Sompura Industrial Area (Pemmanahalli, Niduvada, etc)	Nelamangala	KIADB	794
3.	Harohalli II (Harohalli, Hullikundanahalli, Makanakuppe, etc)	Kanakapura	KIADB	748
4.	Tavarakere	Magadi	KSSIDC	250
5.	IT Corridor	Bangalore North	KIADB	97
6.	Kanakapura - Madamaranahalli	Kanakapura	KIADB	2
7.	EPIP Sonnenahalli	Bangalore North	KIADB	0.05
	Total currently finalised			**2,810**
Proposal stage				
1.	Kanakapura (Harohalli)	Kanakapura	KIADB	3,346
2.	Kannamangala, Poojanahalli	Devanahalli	KIADB	1,186
3.	Ganapathyhally, Karigiripura, Pongamaranahalli, Ajjanahalli	Magadi	KIADB	950
4.	Mayaganahalli	Ramanagara	KIADB	549
5.	Hardware Park	Bangalore South	KIADB	450
6.	Yelahanka, Yeshwanthpur etc	Bangalore North	KSSIDC	428
7.	Vaderapura, Venkatala	Bangalore North	KIADB	278
8.	Ahobalapalya, Kachanahalli	Magadi	KIADB	254
9.	Tavarekere	Magadi	KSSIDC	147
10.	Electronics City IV	Anekal	KIADB	138
11.	Electronics City III	Anekal	KIADB	114
12.	Printech Park	Kanakapura	KIADB	57
13.	Dobbaspet III	Nelamangala	KIADB	50
14.	Bagalur	Bangalore North	KIADB	50

Upcoming industrial areas		Taluk	Development agency	Approx. area (acres)
15.	Lalagondanahalli	Devanahalli	KSSIDC	40
16.	Sriramanahalli	Bangalore North	KSSIDC	38
17.	Doddaballapur	Doddaballapur	KSSIDC	35
18.	Chikkahosahalli	Anekal	KSSIDC	26
19.	Channapatna	Channapatna	KIADB	18
20.	Channapatna Training School	Channapatna	KSSIDC	16
21.	Bedrakadahalli	Anekal	KSSIDC	14
22.	Ramasagar	Anekal	KSSIDC	14
23.	Arehalli	Anekal	KSSIDC	13
24.	Doddaballapur	Doddaballapur	KSSIDC	13
25.	Krishnapurdoodi	Ramanagara	KSSIDC	12
26.	Sullibele	Hoskote	KSSIDC	10
27.	Sollur	Magadi	KSSIDC	8
28.	Kanakapura Industrial Estate II	Kanakapura	KSSIDC	7
29.	Indigananalla village	Hoskote	KSSIDC	6
30.	Sugganahalli	Ramanagar	KSSIDC	4
31.	Dasanapura	Anekal	KSSIDC	2
32.	Doddaballapur Apparel Park III	Doddaballapur	KIADB	---*
	Total proposal stage			**8,274**
	Grand total in acres			**11,084**

** No data available as yet* *Source: KIADB 2008; KSSIDC 2008*

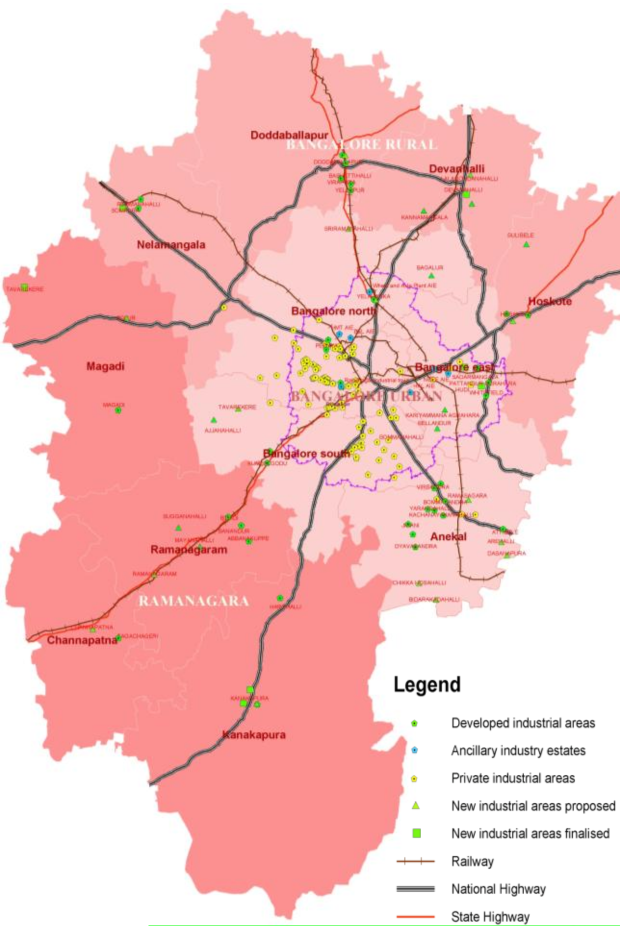


Figure 17: Locations of upcoming industrial areas

SUCs are expected to continue to grow along a trajectory comparable to that in Figure 16 but by and large independent from the development of industrial areas. Their growth is more immediately demand-based and alternative locations can be identified with less difficulty than is the case with industrial areas, should the need arise. Ancillary industry estates are already receding and no further growth is expected for this model.

Fuelled by the success rates in other states of India and a conducive industrial policy, special economic zones (SEZs) in BMR might in future be promoted on a larger scale. Selected proposed projects are presented in Chapter 11 "Socio-Economic Development", section 2.3. However, it appears likely that most of these projects will not in fact be developed by the state at par with industrial areas but constitute mainly of land allocation and conferring the SEZ status to self-contained industries which are required to assume the responsibility for development.

Table 34: Summary of existing and upcoming developed industrial areas in BMR

State-developed industrial areas	State-developed industrial area in acres (approx)		Growth
	Individual	Cumulative	
Existing*	10,267	10,267	100%
Currently finalised	2,810	13,077	127%
Proposed	8,274	21,351	208%

** Excluding ancillary industry estates and industrial SUCs* *Source: KIADB 2008, KSSIDC 2008*

Evaluation of the adequacy of the extent of upcoming industrial areas requires a look at its growth trajectory in comparison to that of the industry base. This has been attempted in Figure 18 based on the following assumptions:

- Current growth scenario (red dashed line): Future industrial areas grow at a long-term average of 282 acres/year;
- Rapid growth scenario (orange dashed line): Future industrial areas grow at an accelerated rate of 625 acres/year;
- Projection of the industry base growth (blue dashed line) in accordance with the model of Table 32 at a long-term growth rate of 4.76% per annum;
- Past industry base growth as derived from the correlation of DIC registrations with the baseline assumption of 70,000 industries in BMR in 2008.

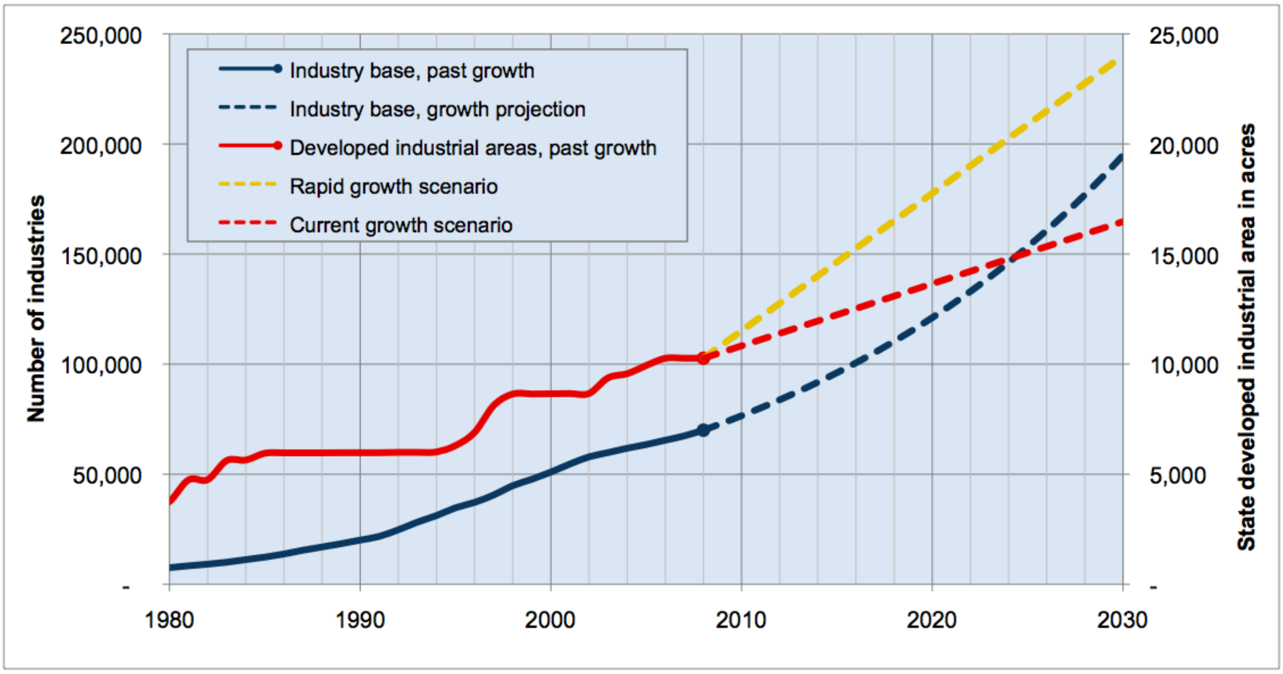


Figure 18: Growth trajectory of state-developed industrial areas and industry base

Two conclusions emerge from this projection. Until 2008, the growth pace of the industry base and industrial areas has been more or less uniform, with industries growing slightly faster. In spite of the relative sameness in pace, 13% or six out of seven industries in BMR reside currently outside developed industrial areas (see 1.2.6). If the development of industrial areas relies on the current speed then the share of industries on developed land would decrease further in future. Likewise, the number of industries in residential areas and the number and extent of private industrial areas might increase for want of alternative accommodation. About 625 acres of developed industrial land would be required to be added every year to keep up with the current and already poor ratio. Much more would be required to enable industries that are currently outside developed industrial areas to shift to designated developed areas.

3.5. IMPACT ON ENVIRONMENT

Future growth is expected to impact the environment. Table 35 presents indicative pointers at the impact trend under consideration of the current and anticipated development.

Table 35: Anticipated trend of impact on environmental key pressure points

	Aspect	Current state	Trend parameter A	Trend parameter B
Water	Water quality	BOD, dissolved solids, chloride, sodium chlorine, iron, turbidity and conductivity of surface/ground water exceed limits	Water contamination	Treatment of effluent
Water	Water availability	Ground water table and surface water significantly reduced while demand grows	Resource decline	Demand growth
Air	Air pollutants	SO_X, NO_X, SPM, CO exceed limits	Concentrations	Frequency
Air	Traffic induced	Vehicular population very high	Density	Emission norms[11]
Air	Respiratory diseases	High prevalence of respiratory disorders	Persistent asthma	Airway inflammation
Air	Industrial noise	Abatement and monitoring limited	Spatial expansion	Intensity
Waste	Hazardous waste	Disposal limited to inadequate incineration	Generation	Disposal[12]
Waste	Electronic waste	Recycling jeopardises workers' health	Generation	Recycling
Waste	Solid waste	Absence of management	Generation	Disposal[13]
GHG	CO_2 emissions	Increasing proportional to growth	Spatial expansion	Intensity
ODS	Non-feedstock uses	Declining use under phase-out regime	Spatial expansion	Intensity
Land	Land use pattern	Progressive conversion of land for industrial purposes	Loss of agricultural land	Misuse of industrial land

Legend	Degree of change:	Drastic deterioration	Deterioration	No change	Improvement

Source: EMPRI 2008

4. IMPACT MITIGATION

4.1. CONSTRAINTS

Absence of industry area siting rules: While siting guidelines exist for individual industries, environmental considerations are not integrated in a systematic way in the process of placing entire industrial areas into an urban or semi-urban setting.

Absence of sector focus of industrial areas: While the concept of sector specific industrial areas is not new, only one such area has so far been developed in BMR. In spite of clear intentions in this respect the current industrial areas development policy does not appear to hold sufficient provisions to realise this objective. The consequential absence of sector focus impedes the economic viability of common effluent treatment plants (CETPs).

Absence of action on drain pollution: Drains are visibly and measurably polluted. Conclusions from limited monitoring activities do not appear to lead to action on the findings, i.e. control of pollution. The problem is particularly severe in private industrial areas.

Absence of industrial waste management: Industrial solid waste is generated in large quantities and generally excluded from the collection system of civic authorities for municipal solid waste (MSW). In absence of an adequate collection system industrial solid waste is liberally disposed on vacant land or into lakes. Its

[11] Given the long life spans of commercial vehicles, more stringent emission norms lower emissions only after decades

[12] The Treatment, Storage and Disposal Facility (TSDF) at Dobbspet has commenced operation

[13] Based on current trends. The implementations of recommendations of this report would improve on this

leachate exacerbates the pollution of the water table, its burning sets off toxic emissions.

Insufficient sewerage facilities in industrial areas: Though industrial area development is guided by the objective of providing for infrastructural requirements, this target is frequently not met. Common sewerage facilities are unavailable not only in many private industrial areas but also in developed industrial areas. Entrepreneurs are left to deal with sewage treatment and disposal individually. A consistent sewage treatment policy committed to state of the art facilities is wanting.

Insufficient action on noise: While limits for noise in the ambience and workplaces are prescribed, monitoring and compliance efforts are limited to a small fraction of larger industries. In the absence of a monitoring and mitigation initiative from the regulatory authorities KSPCB and Department of Factories and Boilers, noise pollution continues unabated.

Absence of industrial area maintenance: With the development of industrial areas the maintenance responsibilities for most of them were transferred to local bodies. Little or no justice has been done to actually maintaining them and in many areas the infrastructure is in a deplorable state. Greenbelts and buffer zones are missing.

Macro-level monitoring of environmental performance is constrained: Factuality and scope of environmental statements prepared by industries vary greatly. The statements are not verified at KSPCB's end and they are believed to be too inaccurate to assist in improving environmental management. Consent information on the other hand, which is verified and which forms the backbone of decisions on pollution control measures to be adopted by industries, is kept solely in hardcopy case files spread over 11 Regional Offices. Industry information thus remains inaccessible to macro level assessments on resource requirements, pollution loads and compliance issues of industries. Similarly, the potential of case information to aid decisions at macro level for environmental management cannot be utilised. This study, for example, could not utilise consent information as the review of several thousand files was not feasible.

Absence of partnership in pollution control: The relationship between industries and KSPCB is not characterised by trust or confidence in each other. The regulatory role of KSPCB, the fact that its revenue is benefited by pollution and the absence of assistance or service provision poses a constraint for leveraging its know-how on furthering pollution control.

Absence of environmental guidance: New industries are generally started by entrepreneurs familiar with the commercial side of the business but not its environmental dimension. In the absence of prior knowledge and experience entrepreneurs are not prepared to conceive or consider environmental impact and options for impact mitigation.

Insufficient action on encroachment: Agricultural land, forest land, parks and even lakes are encroached by industries under the eyes of authorities, i.e. Department of Agriculture, Department of Horticulture Department, Biodiversity Board, Lake Development Authority, Department of Fisheries, Karnataka Forest Department, and Bruhat Bangalore Mahanagara Palike.

Absence of a common industry registry: Industries may register with District Industries Centre (DIC), KSPCB or Department of Factories and Boilers but no single agency is endowed with a mandate to provide single-window registration services for all manufacturing industries. Consequentially data on industries varies from agency to agency and is fragmented and unrepresentative of the overall situation. This impedes functioning of government agencies and the formulation of appropriate policy. For example, only 14% of industries are registered with KSPCB.

4.2. RECOMMENDATIONS

1. Recommendation: Improvement of drain water quality	
Establishment of a long-term drain water quality monitoring and action programme.	
Issues addressed:	Occurrences of industries disposing sewage and trade effluents into drains are not uncommon. This practice is caused by lack of sewerage and common effluent treatment facilities. The current monitoring system is limited to water bodies such as lakes, tanks and rivers and, on the other side, effluents of individual industries. Drains are currently not being recognised as water bodies and are therefore excluded from regular monitoring. Drains however bear the brunt of effluents and are feeding pollutants in high concentration into water bodies.
Proposed ownership:	KSPCB
Implementation arrangement:	Drains need to be recognised as water bodies and should be included in water body monitoring. A dedicated mobile squad should identify hot spots, trace polluters and initiate the required action to effectively curb discharges above permissible limits across all industries.

2. Recommendation: Development of industrial land and CETPs	
Acceleration of the development of new industrial areas while establishing demand-oriented sector foci and common effluent treatment plants (CETPs).	
Issues addressed:	The large number of private industrial areas bear testimony to the fact that space availability in developed industrial areas is a constraint. The growth rate of developed industrial areas is falling below that of the industry base. On the other hand, even in established areas common effluent treatment plants (CETPs) do not exist save one exception. Sector focus is a necessity for making CETPs economically viable. Yet with the exception of Electronics City, sector-specific industrial areas do not currently exist. The absence of CETPs is considered a hurdle for environmental compliance vis-à-vis competitiveness, especially for micro and small-scale enterprises.
Proposed ownership:	KIADB and KSSIDC respectively
Implementation arrangement:	KIADB and KSSIDC are sought to accelerate the development of industrial land by increasing the growth of areas from 282 acres per year (the long-term average) to about 500-600. The agencies are sought to identify sector demand versus geographical locations and define a sector range for each new industrial area. Allotments should consider comparability of waste streams as primary admission criteria. The agencies are further sought to establish CETPs in each new industrial area based on predominant waste streams. Operation could be entrusted to private operators while KIADB or KSSIDC would retain a supervisory role and be responsible for the overall functioning. The progressive development of further industrial areas is expected to attract industries from existing industrial areas without common facilities. This intervention is sought to avoid the mistakes that have been made in the past in this respect.

3. Recommendation: Establishment of industrial eco parks	
Establishment of state developed industrial areas as designated industrial eco parks.	
Issues addressed:	The spatial break-up of industries in BMR is skewed and the allotment and siting are not following environmental considerations. Industrial areas developed by the state lack essential facilities required for good environmental management such as integrated solid waste management facility, hazardous waste management facility, effluent treatment plants, buffer zones, greenbelts.
Proposed ownership:	DIC and DFEE
Implementation arrangement:	A policy to be formulated to develop industrial eco parks with location guidelines for acquiring land for industries. All new industries in future to be established only in industrial eco parks. These parks could be acquired by KIADB, KSSIDC or private developers, but should meet the criteria for industrial eco-parks.

4. Recommendation: Management of industrial SW	
(a) Establishment of an industrial solid waste (SW) management system across developed and private industrial areas; (b) Rehabilitation of unauthorised dumpsites; (c) Vigilance to prevent illegal waste disposal.	
Issues addressed:	Industrial SW is generated in large quantities and generally excluded from the collection system of civic authorities for municipal solid waste (MSW). In the absence of an adequate collection system industrial SW is freely disposed of on vacant land or into lakes. The leachate of industrial SW compounds the pollution of the water table; its burning sets off toxic emissions.
Proposed ownership:	(a) and (b) KIADB and KSSIDC respectively, subsequent transfer of ownership to operator; (c) KSPCB and civic authorities
Implementation arrangement:	(a) and (b) KIADB and KSSIDC to mutually agree on custody for unattributed private industrial areas. The agencies are sought to allot a site for waste handling in each area and establish a functioning fee-based system through designated private operators whose operation is monitored by the agencies. c) A task force is sought to be constituted by KSPCB and civic authorities to keep vigilance to prevent illegal disposal.

5. Recommendation: Establishment of an industry registry	
Establishment and maintenance of a common industry registry.	
Issues addressed:	No single agency today possesses a comprehensive registry or inventory of industries. The resulting lack of data impedes the understanding of the magnitude of environmental issues caused by industries as well as their effective redress. 9,470 industries registered with KSPCB as against 70,000 operating industries makes this shortcoming apparent.
Proposed ownership:	Department of Industries and Commerce
Implementation arrangement:	Establishment of a single window for registration of all manufacturing industries through decentralised registers. The registration should be compulsory, annually renewable and free of charge while being issued unconditionally. The registration certificate would be roughly comparable to a trade licence without which operation of an industry would be illegal. Data would be maintained digitally and be accessible to all government departments including KSPCB, Department of Factories and Boilers, KIADB and KSSIDC. The compulsion for registration is sought to be enacted and the register maintained should comprise information pertaining to all departments.

6. Recommendation: Improvement of environmental monitoring	
Establishment of a state-wide electronic consent management information system at KSPCB.	
Issues addressed:	Consent information which is verified and which forms the backbone of decisions on pollution control measures to be adopted by industries, is kept solely in hardcopy case files spread over 11 Regional Offices. Case information thus remains inaccessible to macro level assessments on resource requirements, pollution loads and compliance issues. Similarly, the potential of case information to aid decisions at macro level for environmental management cannot be utilised.
Proposed ownership:	KSPCB
Implementation arrangement:	Setting up of a cell at KSPCB's Board Office to plan and supervise the establishment, commissioning and operation of a state-wide electronic consent management information system. This database application is to be developed as web-hosted central repository with multi-point interface offering read/write access for each of Karnataka's Regional Offices. The application is to be developed around the stipulations arising from the legal requirements while making sufficient provisions for analysis. The functions of the cell include: ▪ Definition of specifications of the database considering conformity with the consent process, inspection reports, legal stipulations and anticipated legal and procedural changes; ▪ Assignment of application development and after-sales service to a professional service provider; ▪ Developing a strategy for implementation of the consent management information system in all 33 Regional Offices throughout the state in a phased manner starting with a pilot phase in a selected Regional Office; ▪ Addressing data safety issues at planning, commencement and operation stages to protect the data from unauthorised or accidental access, modification and deletion; ▪ Post implementation, systematic analysis of data including simulations to reach conclusions with regard to individual industries as well as for macro level decisions.

7. Recommendation: Partnership towards pollution control	
KSPCB to assume provision of environmental services.	
Issues addressed:	The relationship between industries and KSPCB is not characterised by trust or confidence in joint efforts in the mitigation of pollution. The regulatory role of KSPCB, the fact that its revenue is benefited by pollution and the absence of assistance or service provision poses a constraint for leveraging its know-how on furthering pollution control. This is compounded by the perception that in spite of the magnitude of KSPCB's fees collection, the agency does not utilise these resources for proactive pollution mitigation. Apart from that, the earlier Cleaner Production Centre (CPC) does not exist any longer and therefore cannot serve as supplemental source of guidance and inspiration.
Proposed ownership:	KSPCB
Implementation arrangement:	KSPCB is sought to expand its portfolio through proactive promotion of pollution control measures encompassing: ▪ Facilitation of regular environmental awareness creation programmes for new entrepreneurs in decentralised locations; ▪ In its role as member of the State Level Single Window Clearance Committee and State High Level Clearance Committee of Karnataka Udyog Mitra, provision of specific guidance on pollution control on individual projects sanctioned; ▪ Development and dissemination of industry sector specific environmental advisories that address common problems; ▪ Engaging in R&D on advancing pollution control measures and on bringing technology within economic reach of micro and small scale enterprises; ▪ Providing consultancy services (chargeable) on cost-efficient mitigation of pollution to individual industries on request; ▪ The portfolio could also include the re-establishment of the Cleaner Production Centre (CPC), possibly as joint venture with Department of Industries and Commerce and a private sector organisation such as industry association. Technical assistance aims at establishing and maintaining a durable relationship with industries gradually transforming the image of KSPCB to a recognised and valued partner. This transformation could follow the excellent example set by Textiles Committee which today is a well-established partner of the textile industry (refer to http://textilescommittee.nic.in). Such initiative is believed to offer environmental longer-term gains unachievable in the current climate.

8. Recommendation: Monitoring of noise	
Establishment of regular monitoring of industrial noise with focus on both ambience and workers.	
Issues addressed:	Noise nearing or exceeding prescribed limits is rampant and largely unchecked. Monitoring and mitigation measures are limited to a few larger industries and almost completely absent in micro and small enterprises and the great majority of engineering industries. Risk awareness is low.
Proposed ownership:	KSPCB and Department of Factories and Boilers
Implementation arrangement:	A noise monitoring protocol and squad should be established that assumes monitoring of ambient noise vis-à-vis Noise Pollution (Regulation and Control) Rules and workers' noise exposure vis-à-vis occupational health and safety. Findings should be communicated to industries concerned in ways designed to effectively stimulate industries to develop, implement and maintain effective mitigation measures such as workers' protection and limiting noise at source.

9. Recommendation: Provision of UGD with decentralised sewage treatment	
Establishment of underground drainage systems (UGD) connected to decentralised sewage treatment plants throughout current and future developed and private industrial areas.	
Issues addressed:	In almost all developed and private industrial areas outside the boundaries of the Bruhat Bangalore Mahanagara Palike (BBMP) industries are left to deal with sewage disposal individually. Consequently soak pits that infiltrate ground water are operated by a large number of entrepreneurs while some discharge sewage directly into drains.
Proposed ownership:	KIADB and KSSIDC respectively
Implementation arrangement:	KIADB, KSSIDC to agree on assumption of custody for all private areas. The agencies are sought to implement the UGD systems connected to decentralised treatment schemes wherever connection to BWSSB's treatment plants is not viable. Funds could possibly be drawn from the infrastructure upgradation fund established under the industrial policy.

10. Recommendation: Study of industrial carrying capacity	
Carrying out a study on the industrial carrying capacity of BMR.	
Issues addressed:	The spatial break-up of industries in BMR is skewed and the allotment and siting do not follow environmental considerations. An understanding of the industrial carrying capacity is required in order to complement the effort of the zoning atlas developed by CPCB and to identify permissible industrial sectors, the number of industries and the required spacing for current and potential industrial locations. The study should also focus on urbanisation issues related to establishment of such industrial sectors.
Proposed ownership:	CPCB
Implementation arrangement:	CPCB Southern Zonal Office in Bangalore is best placed to finance and commission such a study, ideally in collaboration with KSPCB in order to harness the expertise available. The guidelines emerging from this study should, together with the zoning atlas, be developed into an tool to help ▪ KSPCB in assessing the suitably of a location before according consent for establishment; ▪ KIADB and KSSIDC in the identification of suitable locations for future industrial areas.

Chapter 8

Waste

CONTENTS

TABLES

FIGURES

1. HAZARDOUS WASTE

1.1. CURRENT STATUS

Many industrial activities produce waste that is classified as hazardous. Such waste includes, effluent treatment plant sludge, solvents, used oils and incineration ash apart from process resedues. Hazardous waste is characterised by hazardous properties such as toxicity, inflammability, corrosivity, ignitability and leachability. Recently electronic waste (e-waste) has been reclassified as hazardous waste (HW). These wastes are governed by the rules framed under Environment (Protection) Act, 1986 and Rules framed under this. The rules dictate that every generator of hazardous waste has to obtain authorisation from the Karnataka State Pollution Control Board (KSPCB) and follow a well-defined method for storage, transport, treatment and disposal of waste.

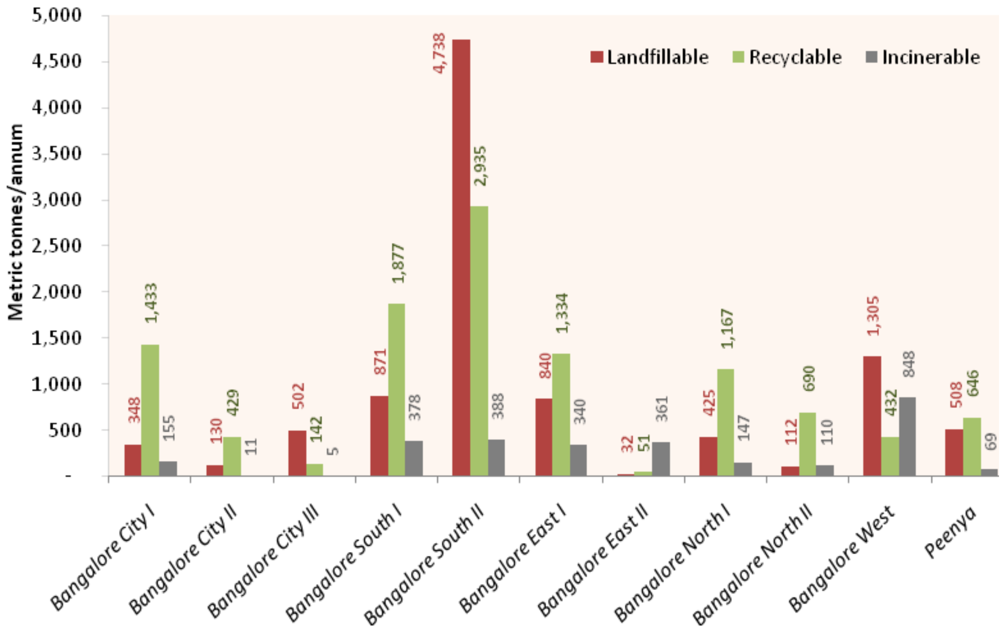


Figure 1: Hazardous waste generation in metric tonne per annum

In Karnataka, the industrialisation has taken place mostly in and around the city of Bangalore making it evident that generation of hazardous waste is maximum in Bangalore followed by Mysore and Mangalore. The BMR has been divided into six zones and eleven sub zones by KSPCB and hazardous waste generated in these zones have been summarised in Table 1 and its graphical presentation in Figure 1.

The total hazardous waste generated in BMR from total of 1,042 hazardous waste generating industries identified is 23,756 metric tonnes per annum (MT/a). It is further seen that incinerable, recyclable and landfillable wastes constitute 2,811 Mt/a (11.8%), 11,135 Mt/a (46.9%) and 9,810 Mt/a (41.3%) respectively. The total number of industries estimated in Bangalore is 70,000. A sectoral breakup is presented in Chapter 7 "INDUSTRY", section 1.1.2. Out of these approximately 30,000 industries may generate HW. However, only 1,042 industries are registered with KSPCB. This is a grey area and needs immediate attention.

Bangalore South II is the largest hazardous waste contributor (8,060 Mt/a) followed by Bangalore South I (3,125 Mt/a) and Bangalore West (2,584 Mt/a). Bangalore South alone accounts for 47.5% of the total hazardous waste generated followed by Bangalore City (13.2%), Bangalore East (12.4%), Bangalore North (11.1%), Bangalore West (10.8%) and Peenya Industrial Area (5.1%).

Approximately 147 industrial units have been identified as hazardous waste generating units in Peenya Industrial Area. The hazardous waste generation from these units is in small quantities indicating that majority of industries are small and medium and may not be generating sizable quantity of hazardous waste. Nevertheless, KSPCB has kept vigilance at all the industrial units as there are reports of industries dumping hazardous waste into the lakes, water bodies and nearby vacant lands.

Bangalore South producing the maximum quantum of hazardous wastes includes the industrial areas of Electronic city, Bommasandra, Jigani and Anekal where large chemical and pharmaceutical industries such as Hikal, Kumar Organics, Biocon, Micro labs, Apotex, etc. are located. Bangalore west covers industrial areas of Bidadi that houses industries such as Toyota Kirloskar Motors, Kirloskar Toyota Tech Park, Coca Cola, etc.

The industries generating HW were asked to store the HW in their own premises in a safe manner until the common TSDF facility becomes operational. Although KSPCB lacks comprehensive data regarding the quantity of hazardous waste stored, yet a total of 18,000 tons is landfilled. Recyclable wastes are usually sold by the industries, to the respective recyclers when economic quantities are reached. However, the grey area is the incinerable stored HW.

A study conducted by HAWA in the year 2003-04 identified about 30 illegal dumpsites in BMR. An illegal dumpsite in Bommasandra was chosen for remedial demonstration. A remedial plan was prepared by HAWA and submitted to KSPCB.

Figure 2: Weighbridge facility under construction-TSDF, Dobbaspet

Figure 3: Sheds for storage and treatment-TSDF, Dobbaspet

Figure 4: Landfill under construction-TSDF, Dobbaspet

Common treatment, storage and disposal facility (TSDF)

The Government of Karnataka through the Department of Forests, Ecology and Environment, Karnataka State Pollution Control Board and Karnataka Industrial Area Development Board has conceptualised a TSDF based on polluter pays principle model. In a bilateral agreement with German Government, GTZ has provided technical support for site identification, EIA (Environmental Impact Assessment) preparation, public consultation, planning & design of landfill, tendering and training the various stakeholders through HAWA team setup in Bangalore.

Salient features of the facility

a) Located at Dobbaspet, off Tumkur Road, 45 km from Bangalore on Bangalore – Pune National Highway (NH4)

b) Total area of 92.3 acre adjacent to KIADB industrial area along Doddaballapura highway with land sloping from southwest to northeast.

c) Soil is sandy loam with underlying clay layers extending from 6m to 30 m below the ground level. The ground water is as deep as 200m.

d) The facility designed to accommodate the landfillable waste to the tune of 8000 T/A with the life of landfill estimated as 20 years with another 30 years of monitoring when the same is handed over to Government of Karnataka.

e) The landfill has a leachate and storm water collection system under gravity flow. The landfill is lined with 1m thick clay liner and 2.5 mm single HDPE liner system with 2000 kg/m^2 geo-textile.

f) The sheds used for various operations are also lined with geo-membrane and geotextile for protection of ground water and soil.

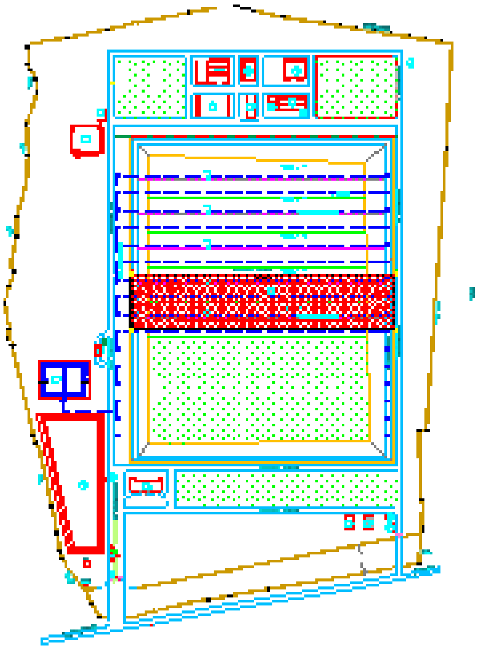


Figure 5: Layout map of TSDF at Dobbspet

Figure 6: Hazardous waste generation in BMR

1.2. MANAGEMENT STRATEGIES

1.2.1. Recyclable hazardous waste

Karnataka State Pollution Control Board has authorised 44 recyclers to recycle the recyclable hazardous waste including lead acid batteries, zinc ash, metal scrap, solvents and used/waste oils as given in Table 1. Except solvent recyclers the other recyclers are also registered with CPCB which regulates the participation of recyclers in auctions by waste generators and import or procurement of these wastes. On recovery of useful materials the hazardous waste generated by these recyclers shall be disposed off at TSDF or incinerated.

Table 1: Zone wise details of recycling units

Zones	Number of recyclers	Category
Bangalore city (I, II & III)	4	Spent solvent-1, Barrel cleaning-1, copper -2,
Bangalore north (I & II)	2	Etching agent -1, E-waste-1
Bangalore east (I & II)	10	E-waste-2, spent catalyst-1, spent solvent-3, used oil-2, Lead-1, Aluminium-1
Bangalore south(I & II)	12	Spent solvent-5, Barrel cleaning-2, Lead-2, Aluminium-1, used oil-2
Bangalore west	3	Barrel-1, Copper -1, cotton waste-1
Peenya	13	Copper-1, Etching agent-2, Lead-5, Spent catalyst-1, Spent solvent-1, Used /waste oil-3
Total	**44**	

1.2.2. Incinerable waste

The hazardous waste that exhibit higher calorific value and loss on ignition and which are neither landfillable nor recyclable fall in the category of incinerable hazardous waste. However, permission has been granted to three small incinerators by KSPCB, in the light of standards notified by CPCB vis-à-vis the crude technology used for incineration without adequate treatment systems, it is difficult for these incinerators to comply with the norms and the stipulations of CPCB. The incinerator facility is in use by Kumar Organics for captive use has already discontinued its operation following the performance evaluation conducted by CPCB. The smaller capacity incinerators without adequate control systems are Century Refinery at Hoskote, Gomati Incinerators at Kumbalgod and Haat Incinerator at Jigani however, continue to be in operation. It is a well-known fact that the neighbouring states do not allow the movement of hazardous waste into their state for treatment and disposal purposes.

Although, KSPCB has initiated the issue of permits for co-incineration of incinerable wastes into the kilns in the cement plants, yet constraints do exist due to locational disadvantages and other economic reasons. There are two co-processing hazardous waste units in entire Karnataka namely ACC Ltd and Rajashri cement. They are Located in north of Karnataka and much beyond the BMR Limits. The cement industries located in Mysore and other nearby areas of Bangalore are yet to explore the possibility of co-processing waste.

1.2.3. Landfillable waste

The hazardous waste that is stabilised and which exhibits minimal or no leaching falls under the category of directly landfillable waste (DLF). If the waste contains moisture more than 20%, the same has to be subjected to treatment either by solar drying or by mixing drying agents such as fly ash, etc.

The hazardous waste that carry highly toxic substances such as cyanides, chromium, arsenic, etc., has to be subjected to treatment for stabilisation and only after ensuring neutralisation, fixation, leachability it should be subjected to landfilling. The TSDF at Dobbaspet has the facility for pre-treatment. However, the individual industries could undertake pre-treatment at source and then send their landfillable waste to the TSDF.

1.3. PROBLEMS

The problems identified in connection with the current hazardous waste management practices are.

- At present there is no provision for a state of the art incinerator in the TSDF. Although three small incinerators have been allowed to operate in BMR, they may not comply with the norms and standards set by the CPCB. Under these circumstances the industries have to either store the incinerable waste within their premises or co-incinerate in the cement kilns.
- Most of the cement industries in Karnataka, which accept HW are located far away from the BMR like Wadi, Sedam, Malkhed and Shahabad of Gulbarga district and the transportation cost outweighs the disposal cost. Also, only selective type of incinerable waste shall qualify for co-incineration and the rest essentially has to be incinerated separately.
- Rapid industrial growth may lead to increase in the generation of hazardous waste thereby decreasing the life of the existing TSDF facility.
- Existing hazardous waste inventory of industries was prepared based on the information supplied by the industries which does not seem to match with the actual generation and storage quantum. Inventorisation on a regular basis by both the regulator and operator of facility needs to be carried out.

- The contamination of ground water and soil due to illegal dumps is yet another major problem. Identification of illegal dumps and identifying the industries that dump illegally is not undertaken in a concerted manner.
- Small and medium scale hazardous waste generating units which are not registered with KSPCB are likely to dispose of the waste generated illegally. Mechanism for verifying the quantity of HW generated and disposed is not yet established.

Figure 7: Tube lights collected for recycling near slum on Pottery Road

1.4. RECOMMENDATIONS

The following recommendations are proposed for effective management of hazardous waste:

- The present TSDF is expected to have a life span of 20 years. However, in the light of rapid industrial growth in BMR and longer road distances from Bidar, Mangalore, Belgaum, etc., an additional TSDF may be planned depending upon the quantity of waste generated. This would also help in enhancing the life of the existing landfill towards managing hazardous waste from BMR.
- The existing common incinerators in BMR need to be upgraded, improved and a state of the art incinerator needs to be planned and installed in BMR to safely dispose off the incinerable HW generated.
- The hazardous waste generation inventory in BMR should be updated on actual basis by using the weighbridge installed at the TSDF. The registration issued to industries then, should be reviewed and corrected.
- Inventorisation of illegal dumpsites to be undertaken in the BMR. Illegal dumpsites should be cleared of all the hazardous waste dumps and the area should be properly fenced so as to stop any further illegal dumping of hazardous waste. The ground water quality should be examined and proper sanitation of the site should be undertaken.
- Collection centers should be planned in industrial areas where small and medium industries are in operation and generating relatively smaller quantum of hazardous waste. Initially, collection centres may be initiated in Peenya Industrial Area and Bommasandra Industrial Area where small quantities of recyclable and landfillable wastes are generated. New industrial areas in the pipeline must provide such collection centres within their boundaries to ensure that the industries do not attempt illegal disposal of hazardous waste outside the TSDF.
- Co-processing of wastes in cement kilns in Mysore and other nearby areas of BMR should be explored. A feasibility study to be undertaken at the earliest.
- The data available with the Department of Industries and Commerce on the registered industries, based on the sectors generating HW, should be verified by KSPCB and registration issued.
- Common facilities for treatment, recycling and or disposal facilities for waste and used oil and solvents to be undertaken immediately.
- KSPCB could insist on industries to provide data on raw material, water and electricity consumption along with finished goods produced substantiated by sales tax payment. This data will help in estimating the quantity of waste generated. Verification of all these data using IT will help identifying the gaps for not only pollution control board, but other departments like electricity boards, industries department, tax department, etc.

2. BIO-MEDICAL WASTE

2.1. CURRENT STATUS

In the light of its infectious nature, the solid waste arising out of hospitals, clinics, pathological laboratories, veterinary clinics, etc., the handling of biomedical wastes has been covered in a separate legislation under the Bio-Medical Waste Handling Rules, 1998 as amended in the year 2000. These rules clearly specify the colour coding of bags for segregation of different category of waste and specifies the technological options for the treatment and disposal of waste. Generally, wastes are either to be incinerated or deep buried, disinfected before disposal.

The regulatory agencies have also discouraged the incineration facilities at individual hospitals. On the contrary, the treatment of waste in the common facility has been promoted in view of easy monitoring and efficiency, efficacy of treatment and final disposal. The regulation also permits the disposal of incinerated ash into common solid/ hazardous waste landfills.

The classification of hospitals has been made on the basis of number of beds available and these classes range between very small (beds below 10) to huge (beds above 500). In BMR, there are as many as 11 hospitals in huge category, 15 extra large, 38 large, 63 medium, 102 small and 624 very small categories. On an average, the BMW generation in BMR is 193.5g/day/bed which is much smaller than the figures estimated in other parts of country which on average is around 250 g/day/bed as published by CPCB.

Table 2: Hospitals with ETPs

Hospital
1. Manipal Hospital
2. Mallaya Hospital
3. Narayana Hrudayalaya
4. Sathyasai Hospital
5. Vydehi Hospital
6. M.S. Ramaiah Hospital
7. St.Marthas Hospital (under construction)

North zone common BMW facility collects waste from as many as 600 hospitals comprising 2.24 TPD and south zone collects from 253 hospitals comprising 1.5 TPD from the total no of beds of 8648 in North zone and 11,789 in South zone. The liquid BMW generated in Bangalore from 850 hospitals is about 15,000 KLD as given in Table 3. The occupancy rate in the hospitals is an important data required to determine the quantity of solid BMW and liquid BMW generated. Only six hospitals out of the 850 health care establishments in BMR treat their liquid waste on site in especially designed liquid waste treatment plants. Table 3 gives the quantity of solid and liquid BMW generated in the government hospitals. Information on other hospitals in BMR is not available.

Table 3: BMW generation in BMR

Category	Number of beds	Number of hospitals	Solid waste in Mt/a	Liquid waste in Mt/a
Huge	500 & above	11	432.8	8,800
Extra large	200 & < 500	15	173.4	2,360
Large	50 & < 200	38	167.3	1,900
Medium	20 & < 50	63	98.6	570
Small	10 & < 20	102	95.4	660
Very small	1 & < 10	624	399.2	1,250
	Total	**853**	**1366.7**	**15,540**

Source: Paradigm Environmental Strategies Private Limited

Figure 8: Dual chamber incineration facility

Figure 9: Autoclave for disinfection

In general, the body parts and other anatomical wastes are incinerated where as infectious components such as plastics and catheters are autoclaved and then subjected to shredding. The shredded plastics are generally recycled by plastic manufacturers. Approximately 7.5-8% of ash is generated from 72% of incinerable waste charged into the incinerator. The bottom ash generated is disposed off into the authorised landfill.

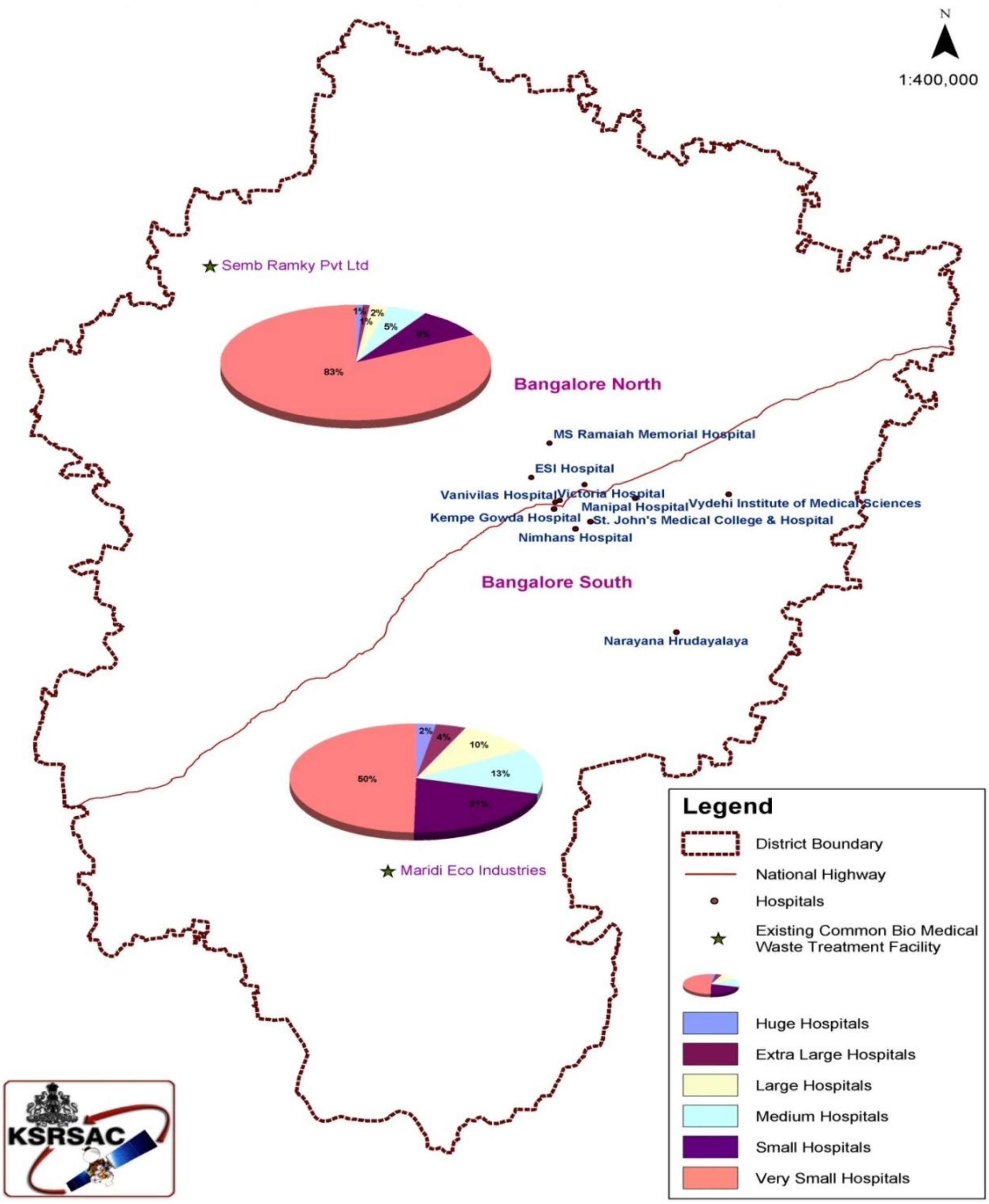


Figure 10: Bio medical waste generation and common incinerator facilities in BMR

Table 4: Zone wise BMW generation in BMR

Zone	Number of hospitals	Number of beds	Waste generated T/A	Total incinerated waste T/A	Rejects for disinfection T/A	Ash generated T/A
North	600	8648	819.5	587.05	232.5	44.4
South	253	11,789	547.2	391.8	155.4	31.7

Table 5: Occupancy rate of major government hospitals

Hospital	Bed strength	Beds occupied	Occupancy rate in %
1. Vanivilas Hospital	550	410	74.5
2. Victoria Hospital	760	460	60.5
3. Bowring and Lady Curzon Hospital	550	350	63.6
4. Minto Eye Hospital	320	100	31.3
5. K.C. General Hospital	450	350	77.77
6. ESIC-Rajajinagar	450	90	20
7. Leprosy Hospital	120	90	75
8. Gosha Hospital	100	50	50
9. General Hospital, K.R.Puram	100	30	30
10. Institute of Nephrology	100	66	66
11. GH-Jayanagara	300	160	53.3
12. PB& CD Government Hospital	120	90	75
13. ED-Hospital	100	16	16
14. ESIC	300	100	33.3

2.2. PROBLEMS

- Mixing of BMW with MSW is one of the significant environmental problems.
- The installed capacities may not be sufficient to handle the BMW in future even though the existing facility is enough to treat the waste generated at present.
- Small clinics generally do not abide by the BMW rules and do not send the BMW to authorised common treatment facility.
- Inadequate funding towards BMW management in government hospitals which not only poses difficulty in making payments to the operators of common facilities but also jeopardises seriously the capacity building of hospitals towards BMW.
- There is lack of awareness among hospital staff about various provisions of BMW notification and amendments from time to time resulting in improper segregation vis-a-vis handling of BMW.
- A large number of hospitals have no effluent treatment plants and untreated effluent is discharged into public sewer system irrespective of the fact whether the sewer leads to municipal sewage treatment plant or not. Only a handful of hospitals are presently treating the liquid BMW while others are discharging the effluents either into open sewers or underground sewer systems.

2.3. RECOMMENDATIONS

- In the light of estimated growth of 20% in the health care sector it is expected that the existing common facilities would be able to handle the excess generation of waste, provided there is capacity enhancement. A feasibility study to establish another common facility in the east could be explored.
- To address the mixing of BMW with MSW, the regulators should step up the monitoring and vigilance system to force the hospitals to comply. The BBMP also should exercise strict vigilance on illegal dumping of BMW into waste bins.
- A series of training programmes should be taken up by agencies such as EMPRI, KSPCB, GTZ and Health Department for creating awareness and for capacity building.
- Government should earmark sufficient funds for health sector to improve the existing scenario of BMW handling in government hospitals.
- Hospitals should install effluent treatment plants to treat the effluents and only treated effluents should be allowed to be discharged into public sewer system.

3. MUNICIPAL SOLID WASTE

3.1. CURRENT STATUS

Due to increasing population in BMR, the municipal solid waste (MSW) generation has also been increasing proportionately.

3.1.1. MSW composition

MSW in BMR usually comprises of the components such as putrescible (72%), paper (11.6%), dust and ash (6.7%), plastics (6.2%), glass (1.4%), clothes and rags (1%), metals (0.2%) and at times hazardous wastes (0.9%) such as, batteries, cells, bulbs and fluorescent tubes, electric and electronic items, etc. The highest contribution of putrescible waste is from residential areas, markets, hotels, restaurants and street sweepings; whereas, the dust and ash are from slums, paper, and plastics are from commercial areas. It is generally seen that street sweeping also contains inorganic carbon mainly contributed by continuous rubbing of tyres on the roads (specifically unpaved and pot holes). The detailed composition of MSW by weight has been given in Table 6.

3.1.2. MSW generation

MSW generation is directly proportional to the population specifically in residential areas, hotels, restaurants and markets. Presently a total of 2,559 TPD garbage is generated and the district/*taluk* wise generation and collection of waste in BMR have been furnished in Figure 12.

Table 6: Physical composition of MSW in Bangalore

Waste type	Composition % by weight						
	Residential	Commercial	Hotels and restaurants	Markets	Slums	Street Sweeping	All sources
Putrescible	71.5	15.6	76	90	29.9	90	72
Paper	8.4	54.6	17	3	2.5	2	11.6
Plastic	6.9	16.6	2	7	1.7	3	6.2
Glass	2.3	0.7	0.2	-	8.4	-	1.4
Metals	0.3	0.4	0.3	-	0.2	-	0.2
Dust and ash	8.1	8.2	4	-	56.7	5	6.7
Clothes, rags	1.3	4	0.4	-	0.5	-	1
Hazardous	1.2	-	-	-	-	-	0.9

Bangalore Urban district which covers mainly the Bruhat Bangalore Mahanagara Palike (BBMP) areas and Anekal *taluk*, generates almost 93.15% of the total MSW generated in the BMR. Bangalore Rural district comprising of Doddaballapura, Devanahalli, Hoskote and Nelamangala and newly carved Ramanagar district comprising of Channapatna, Kanakapura, Magadi and Ramanagar generate a small 3.14 % and 3.67 % respectively. Almost 95.2% of the garbage is collected and transported away from human habitation either for composting or for landfilling in vacant and low-lying areas situated in the outskirts. It is generally seen that the rural areas generate significantly less municipal solid waste as compared to urban areas. Whereas the deficit to the tune of 4-5% may not be collected by the authorities and could be illegally dumped.

Figure 11: Construction, industrial and domestic waste, collection yard in BTM Layout

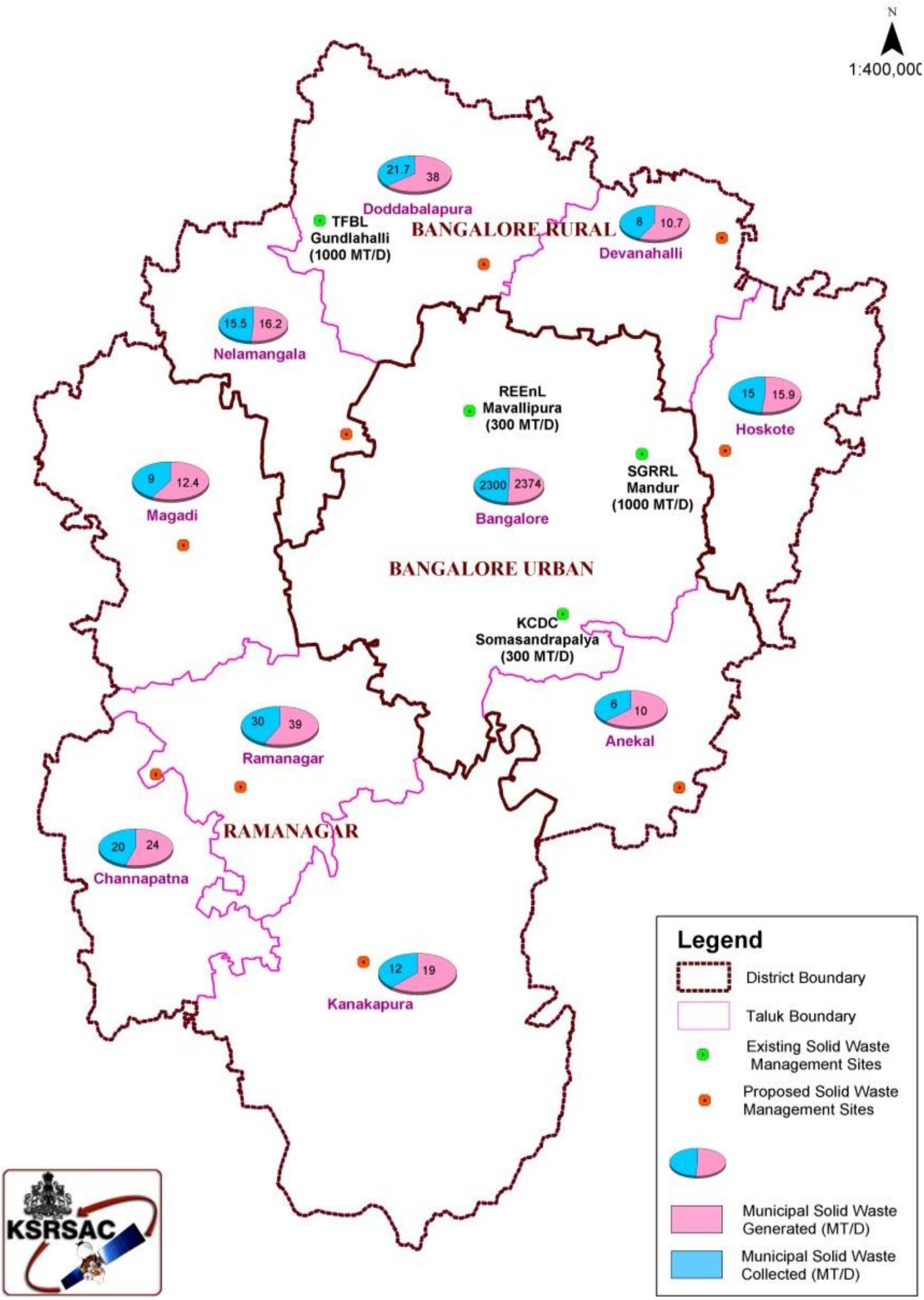


Figure 12: Municipal solid waste management in BMR

3.1.3. MSW Management System of BBMP

In the old zones namely south, west and east, the BBMP has altogether 100 wards which have been subdivided into 355 health wards. There is one health officer in each zone and 30 Medical Officers of Health (MOH) in three zones who report to Joint Commissioners in their respective zones. For 253 health wards, there are 30 package contractors in place and the remaining 102 wards are managed by BBMP through a total of 4,240 *pourakarmikas*. The *pourakarmikas* employed by contractors are as many as 10,000 and supervised by 282 supervisors.

Recently, new zones have been created by taking over from CMCs and these new zones are Mahadevapura, Byatarayanapura, Bommanahalli, Dasarahalli and Rajarajeshwari Nagar. In the new zones the solid waste management is handled by environmental engineers. Directorate of Municipal Administration (DMA) plays a major role to create a blue print of Municipal Solid Waste Management Plan for the entire BMR.

3.1.4. MSW collection and transport

The MSW (Handling and Management) Rules 2000 have clearly laid the procedure for collection, segregation, storage, transportation, processing and safe disposal in an environmentally sound manner to minimise the deleterious impacts on health and environment.

Though, door-to-door collection is prevailing in many wards in Bangalore, although not satisfactorily, the bulk of MSW is still collected in community bins and the waste reaching disposal sites is usually mixed rendering the treatment process more tedious. Wherever door-to-door collection is practised, the plastics, metals and other useful materials are segregated and recycled, though not always. Only the organic fraction and unassorted waste shall reach the bins where the transporting vehicles transport the waste to disposal sites. It is often seen that the garbage reaching disposal sites is more or less of a mixed type. Many times the garbage heaps are seen burning which is against the norms laid out in MSW Rules as well as in the Air Prevention and Control of Pollution Act, 1981. The collection and transport activities are administered by Health Department of BBMP and the details of these vehicles are shown in Table 7.

The statistics reveals that the BBMP has deployed 68 lorries (3 dumpers) owned by it apart from contractual lorries 222 (28 compactor), contractual autos 603 and 9,280 contractual push carts for collection and transport in the old zones.

Figure 13: Time-honoured waste dump near City Market

3.1.5. Road sweeping

In order to sweep the roads and paved areas in residential and commercial areas, *pourakarmikas* are deployed with conventional broomsticks resulting in generation of dust.

Table 7: Vehicles deployed for waste management in BBMP, Health Department

Zone	Trip basis lorries	BBMP owned lorries	Contractual lorries (Compactor)	Contractual Auto/ Tippers	Contractual pushcarts
West	32	36	72+12	177	2,935
South	26	11+3 (Dumper)	75+9	229	3,175
East	15	21	75+7	195+2 (Mini vehicle)	3,170
Total	*73*	*68+3 (Dumper)*	*222+28*	*601+2 (Mini vehicle)*	*9,280*

3.2. MSW PROCESSING AND DISPOSAL

In the light of organic content present in the garbage, aerobic composting is one of the preferred pathways to reduce the volume of waste for disposal into the secured landfill. Another route for disposal is waste to energy either through refuse derived fuel (RDF) or direct mass combustion.

Currently, the garbage generated in BMR is handled by the following agencies viz;

1. Ramky Energy and Environment Ltd at Mavallipura.
2. Karnataka Compost Development Center (KCDC) off Hosur Road.
3. Terra Firma Biotechnologies Ltd (TFBL) near Doddaballapura.
4. Srinivasa Gayatri Resource Recovery Ltd (SGRRL) Integrated waste to energy project at Mandur.

5. A few private sites near K. R. Puram, Budigere and Garvepalya on Sarjapur Road working on a small-scale.

Table 8: Characteristics of compost

Parameters	Values
pH (1:2.5)	7.7
EC dS/m (1:100)	0.58
OC (%)	18.1
Moisture (%)	20.6
C:N ratio	8.6:1
BD(g/cm^3)	0.48
N (%)	2.1
P_2O_5 (%)	0.93
K_2O (%)	1.4
Zn (ppm)	210
Cu (ppm)	96

3.2.1. Integrated MSW facility at Mavallipura

Towards the north-eastern side of Bangalore, i.e., 20 km from BEL circle, the composting facility of Ramky Energy and Environment Limited is operating under the Public-Private-Partnership (PPP) program in a total land area of 54 acres. The facility receives on an average 300 Mt/d of mixed garbage that is aerobically composted on a reinforced cement concrete (RCC) floor, the fermented material is fed into a rotary sieve through a belt conveyor system to separate the inert, which is finally taken to a secured landfill for final disposal. Leachate collection tanks help to store the leachate and rain water and re-use the same during dry months to maintain the optimum moisture content in the compost. An area of 5 acre has been earmarked for developing secured landfill using 2mm thick geo-membrane and geo-textile along with leachate collection pipe network. The facility is operational since December 2006 and the second phase of waste to energy is under planning and design stage.

In the second phase of waste to energy project utilising 800 Mt/d garbage to produce 10 MW of electrical energy is being set up within the premises. This will help reduce the volume of inert material which needs to be diverted to landfill thereby enhancing the life of landfill. This waste to energy project would become operational by the end of 2009.

3.2.2. Karnataka Compost Development Corporation

KCDC is an aerobic composting and vermi-composting facility operating under the control of Government of Karnataka for the past three decades and is one of the oldest facilities operating since 1974. The facility is located off Hosur Road and handles 100 Mt/d and it is being upgraded to take up 300 Mt/d of garbage. The fermented and composted material is sieved through mechanical screening system and the inert materials are land filled. With a large number of housing projects coming up near this facility as seen in Figure 15, the residents are complaining about the foul smell. It is therefore crucial that the Government stops any further developmental activity in the vicinity for continual smooth operation of the successfully run long-term facility.

Figure 14: KCDC vermi compost yard

Figure 15: Apartments coming up close to the compost processing unit

3.2.3. Terra Firma Biotechnologies Ltd

This private facility is designed to handle 1000 Mt/d of garbage with the recovery of biogas to produce electrical energy. A fraction of the garbage is to be converted into vermi compost as value addition. The facility has recently commenced its operation and it has been indicated that the use of information technology tools like web camera, Global Positioning System (GPS) and online data transfer in the trash trucks shall be employed while transferring garbage to this facility.

3.2.4. M/S Srinivasa Gayatri Resource Recovery Ltd

This facility is under construction to take up 1000 Mt/d of garbage and convert the same into electricity. There is provision for land filling of ash generated following the combustion process along with other inert waste.

Further, the MSW processed and disposed off in the existing facilities is 300 Mt/d by Ramky and 300 Mt/d by KCDC. Once again the balance must be dumped at the outskirts until the other large facilities such as KCDC, SGRRL and TFBL are fully functional .This also includes the commissioning of waste to energy programme (1000 TPD) of REEnl which is in the pipe line.

3.3. PROBLEMS

- Inadequate land allocation for the treatment and disposal of existing and projected volume of MSW generated in BMR.
- The storm water drains in Bangalore are being clogged mainly due to the MSW, especially plastic scrap.
- Lack of properly designed and equipped garbage transporting vehicles for collection and transportation of MSW from source to disposal sites in the entire BMR.
- Marketing of compost produced for a viable price.
- Mixing of plastic with organic MSW due to lack of awareness and improper segregation at source.
- Failure or inadequacy of collection in a scientific manner resulting in overflowing of bins with littering of garbage on roads, vacant lands and low-lying areas within and outside the city limits. Mixing of waste/non-segregation of waste viz., solid waste, biomedical waste and industrial waste causing health and environmental problems.
- Conventional method of road sweeping and burning of waste causing significant air pollution with increased suspended particulate matter, smoke and other toxic components.

3.4. RECOMMENDATIONS

- BBMP to take action against the operators who have obtained clearance to implement common municipal solid waste management facilities but not yet established.
- BBMP to immediately make provisions for notifying buffer zones of appropriate width of about 200m around the common facility to avoid incidents like the ones faced by KCDC. Strict actions to be taken to implement the buffer zone rule.
- Severe penalty to be introduced by BBMP against littering as per the MSW Rules.
- BBMP to implement an "Integrated Solid Waste Management Scheme" with accountability for material flow. For example: If collection and processing of MSW are being implemented separately by different private operators, then a procedure to be introduced by BBMP to maintain records of quantity of waste processed, collected and handed over to the common facility. BBMP to pay the collection contractor only after verifying the quantity of waste handed over to processing facility. The operator of the processing facility should maintain records to prove the processing of equal quantity by way of compost sale. This will prevent indiscriminate dumping of MSW by the private operators.
- BBMP to explore introduction of 'royalty' concept as in Chennai.
- Service level benchmarks as per the Ministry of Urban Development guidelines to be monitored for MSWM collection, processing and landfilling, which is ensuring landfilling less than 15% of total waste generated.
- The garbage collection and transport system requires a thorough relook with a closer watch on the transporting vehicles and use of Personal Protective Equipment (PPE) by the staff handling the garbage. The use of GPS is strongly recommended in tracking the movement of fleet.
- Modern method of road sweeping may replace, where feasible, the conventional manual sweeping by using broomsticks. This will make the process more efficient and environment friendly. The workers engaged can be diverted for other works such as segregation and management of assorted garbage, collection of household hazardous waste such as bulbs, tubes, electric items, battery cells, discarded medicines, waste paper, plastic, etc.
- Establishment of collection centers within the BMR for waste paper, packing material, plastic, metal scrap, battery cells, glass and such other recyclable materials. Such centers in future can be extended for collection of electrical and electronic waste such as computers, refrigerators, washing machines, TVs, music systems, cell phones, etc.
- Networking of rag pickers has to be done on top priority for imparting training to work efficiently and safely at collection centers and at garbage processing plants. This activity shall be taken up through experienced and dedicated NGOs.

- The municipal corporations shall encourage the effective and efficient participation of professional private companies under PPP scheme and work out the viable models for smooth development and operation of processing and disposal facilities.
- Other type of wastes like slaughter house waste, industrial solid waste, garbage from hospitals (non-biomedical waste), construction debris, waste from commercial establishments like shops, hotels, community halls to be studied separately.
- Door-to-door collection of waste, with segregation of bio-degradable and non-biodegradable waste should be strictly enforced and monitored for effective implementation
- waste-to-energy plants to be encouraged so that landfill requirements would be under control.
- Landfills should be properly designed and maintained with no burning allowed.
- Littering by public should be banned and fines imposed immediately and garbage bins should be placed at convenient locations and cleared regularly.
- Garbage trucks should be covered properly in order to reduce littering while transporting to the processing sites.

3.5. TRENDS AND PROJECTION

In the light of projected population as high as 1.6 crore by the year 2025, the MSW generation in BMR is likely to touch a figure of 4,800 Mt/d indicating a two-fold generation of waste from the present. This is indicative of the fact that adequate foolproof systems need to be developed well in advance on a time bound manner or else this may result in the contamination of water and soil thereby increasing health related problems. Following BBMP request for additional land requirement of 918 acre, District Commissioner, Bangalore Urban has identified approximately 747 acre land awaiting Government approval. Additionally in each taluk, additional sites need to be identified on radial roads in all directions to minimise the travel time for transport vehicles in the ever congested traffic.

4. PLASTIC WASTE

4.1. CURRENT STATUS

Plastic is known to have invaded every single household, commercial and industrial establishment. However, excessive use of plastic has further given rise to many other environmental concerns such as choking of drains, floating on lake waters and flying carry bags near illegal dumps. When burnt openly, release of toxic fumes, especially PVC which give rise to formation of dioxins and furans takes place. Plastics pose serious problems by decreasing water permeability and air circulation in the compost yards and make the composting process sluggish. Where the municipal solid wastes are easily accessible to animals and cattle, cows have been noticed eating plastic bags which at times could have fatal consequences. Due to its polymeric nature it is non-biodegradable and remains in the environment for years. If exposed to ultraviolet radiation over a considerable period of time it tends to become brittle and loses its strength and properties. Though, few efforts were made to develop the biodegradable plastics, it could not be popularised in the market due to additional costs.

Regulatory aspects

Though, plastic is recyclable and fetches money to rag pickers there is no motivation for picking up of thin plastics as this occupies more space for the same weight and also as the recycling potential is not encouraging. Therefore, the Recycled Plastics (Manufacture and Usage) Rules, 1999 were legislated, which stipulates plastic carry bags or containers to have a minimum thickness of 20 microns. The 2003 amendment made the rules for storing, carrying, dispensing or packaging of foodstuffs more stringent.

Figure 16: Plastic waste piled up at a traffic island near Jama Masjid

4.2. EXISTING SCENARIO

4.2.1. Plastic recycling

Table 9: Plastic containers and carry bags manufacturers in BMR

Zones as per KSPCB classification	Carry bag making		Container making		Closed
	Virgin	Recycled	Virgin	Recycled	
Bangalore City III	11 (3)	3	30 (10)	10	0
Bangalore North II	20	1	7 (1)	0	4
Bangalore South II	1	0	11 (1)	1	2
Peenya	9	0	2	0	2
Bangalore West	10	0	0	0	1
Bangalore South I	1	0	3	0	0
Bangalore East I	1	0	0	0	1
Total	**53**	**4**	**53**	**11**	**10**

Note: The figures in brackets are companies which use both virgin and recycled plastic for manufacture

There are a total of 118 manufacturing units established in BMR that manufacture plastic carry bags and containers with virgin as well as recycled plastics. It is observed that the majority of plastic units are located in Bangalore city III followed by North II, South II, Peenya and Bangalore West. Approximately, 58 units are engaged in the process of manufacturing plastic containers and out of 55 units only 12 units are manufacturing plastic containers using both virgin as well as recycled plastics. Further, as many as 60 units are engaged in the manufacture of plastic carry bags using virgin plastics. Out of 58 units only 3 units are using virgin and recycled plastics and only a single unit makes use of recycled plastic to manufacture the carry bags. This is indicative of the fact that techno-economic feasibility of recycling plastic carry bag is not encouraging. In the recycling process, since extensive sorting, cleaning and removal of additives is necessary.

4.2.2. Plastics–bitumen mix for roads

Bangalore city has made pioneering efforts in the use of plastics in paving the roads. The experiment conducted reveals that 8% of plastics when blended with bitumen, results into a mix that exhibits 3 times more binding properties and compression strength. This mix also reduces the porosity of the mix by two times, thus making the road more impervious. It is a well-known fact that maximum damage to the road occurs when there is stagnation of water and percolation of the same. A few stretches of roads namely, K. H. Road, Airport Road, T. V. Road in Bangalore was laid some time ago and there is need to study the performance of these pilot projects. Depending on the results, it would be appropriate to make it mandatory for road laying companies to essentially mix 8% of plastics along with bitumen. However, the plastic to be used for the purpose shall have to be cleaned and dirty plastic cannot be used in the interest of maintaining better quality parameters.

4.3. PROBLEMS

Main issues concerning plastic wastes are

- Extensive use of plastic carry bags below 20 micron thickness due to entry of plastic carry bags may also be entering into the city from neighbouring states in addition to those manufactured within BMR.
- Lack of clear-cut specified disposal pathway for plastics resulting in scattering of plastic bags in water bodies and vacant places is a major concern.
- Sporadic burning of plastic waste in the boilers by small industries resulting in release of toxic fumes into environment leads to serious health hazards.

4.4. RECOMMENDATIONS

In the light of environmental impact of plastic waste, techno economic options available and severity of menace, the following action plan is drawn for speedy and effective implementation.

- The Government has been making utmost efforts to discourage the use of plastic at tourist places, forest areas and hill stations. Such concrete efforts are also needed to ban the use of plastics especially drives may be needed to ban the use of thin plastics, in packing food stuff and other eatables.
- Concrete steps need to be taken to find out the permanent pathway for collection and ultimate disposal of plastics which are not suitable for recycling. The use of 8% plastic in bitumen could be made compulsory for road laying companies.
- Government to explore non-recyclable plastics and reject plastics from the common MSWM facility to be co-processed in cement kilns.
- The networking of rag pickers, door to door garbage collection, collection and storage centers for plastics managed by Government or private agencies may be further strengthened through well-known NGOs and other interested organisations.
- Strict vigilance is needed by KSPCB for those involved in illegal manufacture of carry bags less than 20 micron thickness.
- Early introduction of cost-effective biodegradable plastic should be investigated. Departmental stores and shops should offer only cloth, jute or paper bags for their consumers.

5. ELECTRONIC AND ELECTRICAL WASTE

5.1. CURRENT STATUS

Internationally, India is viewed as one of the largest consumer markets and rapidly growing IT sector particularly in Bangalore, where there is availability of professionals in software, hardware and working in MNCs, insurance and financing companies. There is increasing use of computers, printers and other electronic gadgets in schools, colleges, offices, households and even rural areas. Generally, e-waste constitutes a deadly cocktail of toxic substances such as lead and cadmium in printed circuit boards and monitor cathode ray tube, mercury in fluorescent tubes, brominated flame retardants on printed circuit boards, plastic casings and cables.

It has been reported that in Bangalore there were 928 IT companies which rose to 1,850 in April 2005. The actual figure as on date is estimated to be slightly higher and the quantity of e-waste generated in BMR has been estimated as high as 8,000 TPA. This figure still requires updating based on the actual generation and future growth.

Karnataka State Pollution Control Board has so far issued authorisation to store e-waste to a total of 65 software companies in Bangalore. In the absence of adequate legally notified provisions exclusively for regulating the e-waste, these authorisations have been issued under the Hazardous Waste Rules under categories 5.1, 5.2 and 31.1 and the industries have been instructed to store the e-waste within their premises and hand over the same for recycling and disposal to the authorised recyclers only. Out of the total 65 units, 27 units are located in Bangalore City I, 18 units in City II, 9 units in South I, 7 units in East I. A door-to-door survey is significant so that all the e- waste generators could be advised to obtain consent and authorisation from KSPCB and the inventory could be updated for accurate assessment.

E-waste Agency (EWA)

The HAWA-GTZ way back in 2003 took a pioneering step in terms of creating a common platform for exchange of ideas among stakeholders such as IT companies, hardware manufacturers, central and state regulators, e-waste recyclers, NGOs and all others associated with this sector. The E-waste Agency (EWA) was formed under the association act with the scope and objective of collection and compilation of the best practices and prevailing legislation available abroad. Its objective includes carving out a series of programmes to organise workshops, seminars for mass awareness, impart training to back yard recyclers and above all to assist the regulatory agencies in making suitable policies for e- waste management.

EWA has been successfully organising a number of workshops and seminars through pooling of resource persons from Europe and the expertise available within the country. EWA also proposed the first draft on e-waste legislation which acted as a catalyst for the Ministry of Environment and Forest, Government of India in realising the need of legislation. EWA has been actively participating in finalising the draft notified by MoEF / CPCB in this regard. It is aimed that EWA shall play an advisory role for MoEF and KSPCB in this field.

5.1.1. E-waste recycling

In the light of significant e-waste being generated in BMR, the KSPCB has authorised two e-waste recyclers namely E-Parisara and Ash Recyclers. However, a sizable number of backyard recyclers are also actively procuring the e-waste for recovery and recycle using crude methods. The backyard processing is hazardous with deleterious health impact on workers. The recycler's in organised sector with the state-of-the-art recycling system is the need of the hour. Presently, about six e-waste recyclers are authorised by KSPCB in Bangalore, out of which about four recyclers have applied for authorisation from KSPCB to set up plants in Bangalore.

E- Parisara is located in a 1.5 acre plot at KIADB industrial area, Dobbaspet off Tumkur Road approximately 45 km from Bangalore. The facility has been authorised to process 1 TPD of waste which is intended to scale up to 10 TPD. The recycling is mainly carried out manually through dismantling and operating a set of crushing and grinding machines and recovery of precious metals, glass and plastics as products for recycling. The unit has also installed the air pollution control systems to prevent the emission of particulate matter into environment.

Ash Recyclers is authorised to process 10 TPD of waste and is located in the KIADB industrial area at Hoskote, approximately 40 km from Bangalore. The unit mainly employs manual methods for dismantling, segregation and storage of recyclables.

Figure 17: Orderly segregation – CD drives awaiting recycling at E-Parisaraa Pvt. Ltd.

5.2. PROBLEMS

- The ongoing recycling of hazardous waste by unorganised sector is posing a major problem in hazardous exposure of workers engaged in dismantling and dumping of unwanted material illegally in municipal waste, bins, lakes and other vacant lands.
- E-waste, being a new subject in the country, know how for safe and sound practices of recycling of e-waste is one of the burning problems. As such, capacity building of the stakeholders is essential.
- There are no identified specialised recyclers to reuse the recovered components such as plastics, glass, metal alloys, etc. This leads to piling up of recovered components within recycler's premises or sending them to general recyclers.
- Lack of environmentally sound technologies for recovery of gold from recycling of e-waste components resulting in the use of crude acid methods.

5.3. RECOMMENDATIONS

Bangalore city is benefited due to the presence of EWA, HAWA-GTZ for pooling technical expertise for sound management systems, KSPCB for its proactive approach in promoting recycling activities and for exercising regulatory control over e-waste generators and funding brought by private sector under PPP model. Following are the significant recommendations that need to be addressed in managing and reducing e-waste.

- Bringing the unorganised sector into the stream of recycling by employing environmentally sound technologies in the organised sector or else merging with other recyclers authorised by KSPCB. The NGOs may have to play an important role in this transformation.
- To provide legal status to EWA to rope in its use as an advisory body to KSPCB, CPCB and MoEF. Financial support to EWA could be facilitated through State Government is yet another concern for its long term sustainable existence to provide the quality expertise for continual improvement.
- Benchmarking the environmentally sound technologies and setting standards for pollution control systems installed in recycling facilities and operational efficiencies of recycling systems.
- Establishment of few collection centers in industrial, commercial and residential areas for efficient collection of e-waste from smaller generators and transferring the same to authorised recyclers only.
- Mobilisation of specialised vendors for recycling of recovered glass, plastics, metals and other components of e-waste.
- Door-to-door collection of e-waste by rag pickers and authorised persons would help in preventing the dumping of e- waste along with household waste
- It should be made mandatory for electronic goods sellers to take back old and discarded computers, printers, cassettes, CDS, DVDs, etc. Discount on return of e-waste should be encouraged so that the waste is scientifically recycled.

Chapter 9

Energy

CONTENTS

TABLES

FIGURES

1. ENERGY PROFILE

Energy consumption is driven by the population served, the extent of development, lifestyles, transport needs, commerce and to a large extent by the industry. Future energy demand is determined primarily by the growth that each of these sectors portend and energy pricing. Since the last decade Bangalore has witnessed a remarkable economic growth, particularly after the 1995 software industry boom. The transformation of the garden city into "hi-tech city" resulted in significant increase in the energy demand, though the IT sector by itself is not energy intensive. With business as usual expanding in the coming decades the demand for energy will be unprecedented and existing resources will need to be supplemented.

1.1. ENERGY CONSUMPTION PATTERN

Commercial end-use fuels in Bangalore are petroleum fuels, LPG, biomass and electricity. Alternative sources are used in a small way through solar water heaters, solar photovoltaic (PV), biogas and hybrid systems. Power generation in Bangalore Metropolitan Region (BMR) is minimal. There is a small hydropower plant of 10 MW in operation and a diesel power plant of 128 MW operated by Visvesvaraya Vidyuth Nigama Limited (VVNL).

Electricity is needed across all sectors with the possible exception of transport. Bangalore Electricity Supply Company (BESCOM) serves about 6.2 million customers in BMR. BESCOM procures electricity from coal, hydroelectric, oil and even wind power plants, located mostly outside BMR. A break-up of power purchases is shown below.

Table 1: Power purchases of BESCOM in 2006-07

Generating stations	Quantum purchased in million kWh
Karnataka Power Corporation Limited Hydel	4,017.5
Karnataka Power Corporation Limited Thermal	4,064.5
Visvesvaraya Vidyuth Nigam Limited Hydel	270.6
Visvesvaraya Vidyuth Nigam Limited Diesel Generation	128.3
Central Projects CGS	3,517.0
Major IPPs	272.2
Minor IPPs/ NCE	1,813.3
Others	0.0
Bilateral trading	18.6
UI	225.0
Total	**14,327**

BESCOM's distribution network supplies electricity through two of its zones namely, Bangalore Metropolitan Area Zone (BMAZ), which comprises of Bangalore Urban district excluding Anekal *taluk* and Bangalore Rural Circle (BRC) covering Bangalore Rural district and Anekal *taluk*. Domestic connections are dominant in Bangalore Urban with 85% and Bangalore Rural and Ramanagar with 75%.

Figure 1: BESCOM switchyard in Cooke Town

However, in urban areas the electricity consumption of industrial consumers is 36% and thus ahead of the consumption of domestic sector. In Bangalore Rural and Ramanagar 52% of consumption is attributed to pump sets while domestic consumption accounts only for 11%. As per the 2001 census, 86% of 383,592 households are electrified. The total electricity consumption in BMR was about 9,000 million kWh in 2006-07. Power consumption has grown at 14% annually over the last two years, a trend that will only be accentuated over the coming years.

Table 2: Electricity consumers and consumption in BMR in 2006-07

Sector	Consumers in thousands		Consumption in million kWh	
	Urban	Rural	Urban	Rural
Domestic	2,491.1	493.9	2,476.8	162.2
	84.4%	*74.8%*	*32.8%*	*10.7%*
Commercial	367.3	39.0	2,043.4	67.3
	12.4%	*5.9%*	*27.1%*	*4.5%*
Industrial	62.7	20.4	2,733.4	452.5
	2.1%	*3.1%*	*36.2%*	*30%*
Pump sets	11.3	103.7	190.1	784.3
	0.4%	*15.7%*	*2.5%*	*51.9%*
Street lights, water supply	20.6	3.7	106.3	44.1
	0.7%	*0.6%*	*1.4%*	*2.9%*
Total	**2,953**	**661**	**7,550**	**1,510**

Not surprisingly, fossil fuels account for the major source of all energy consumed across all sectors. Biomass such as firewood is, however, an important exception. Its use is generally restricted to cooking in rural or economically weaker households, apart from limited consumption in some small-scale industries. Data on biomass consumption is not available.

Table 3: Fuel matrix

Sectors	Petrol	Diesel	Kero-sene	LPG	Fuel oil	Furnace oil	Bio-mass
Power		Yes					
Industry		Yes		Yes	Yes	Yes	Yes
Transport	Yes	Yes		Yes			
Domestic			Yes	Yes			Yes

1.2. POWER GENERATION

There are no coal fired power plants in BMR. The only two power stations are a 128 MW diesel power plant at Yelahanka and a mini hydroelectric power plant of 10 MW in Kanakapura *taluk* (see Box). In addition there exist diesel generator (DG) sets usually referred to as captive power plants. Captive power generation caters to industry, trade and agriculture. DG sets are used either as a backup for power shutdowns, as an alternative source of power or, as in the case of agriculture, as stand-alone power supply for pump sets. Due to supply deficiencies power shutdowns are ubiquitous in the city. There are around 10,304 registered DG sets in Bangalore with a capacity greater than 50 kVA but CPCB estimates the total including small sets may be in the order of about 1 lakh. Most of the larger DG sets are clustered in industrial areas. Smaller ones are found in commercial areas, Shivajinagar's Commercial Street being a prominent example. DG set capacity usually does not exceed 500 kVA. If only those 10,304 registered DG sets run for an hour per day, they would consume an estimated 95,000 kilolitre of diesel annually.

The Yelakanka power plant

The Yelahanka 128 MW diesel power generating station is the biggest power plant in South East Asia running on Low sulphur heavy stock (LSHS) and high speed diesel (HSD). The 127.92 MW plant is located in between Bangalore and Doddaballapur Road in an area of 120 acre. It was set up by the former Karnataka Electricity Board (KEB) in 1984. It was commissioned to mitigate the hardship faced by industries at Bangalore due to shortage of power. The 222 crore project has six French diesel engines of 21.32 MW. The six units were commissioned in phases from 1992 to 1994. It has a plant load factor of 44.4% and a typical day's production is 1.363 million kWh.

The hydroelectric plant

The mini hydroelectric power plant consists of three units totalling to 10.25 MW. It was fully commissioned in 2005 and it has been supplying power to the state grid since then. The average annual energy supplied is about 28 to 30 million kWh, sold by Sai Spurthi Power Private limited to Karnataka Power Transmission Corporation Limited (KPTCL) at rates applicable to independent power providers. The plant is set up across Arkavathi River near Chunchidoddi village in Kanakapura *taluk* of Ramanagar district. Arkavathi is a rain fed river and the power produced during monsoon rains is maximum. The project is monitored by UNFCCC to validate its CDM potential.

1.3. TRANSPORT SECTOR

The transport sector is the major consumer of petrol and diesel in BMR. Bangalore has witnessed a remarkable growth in economic activities particularly, after the 1995 software industry boom which has resulted in enormous increase in the number of vehicles on its roads. During the last two decades the vehicular population in Bangalore has increased by over 300%.

Between April 2007 and January 2008 the total consumption of petrol in the BMR was around 400,000 kilolitres and that of diesel 650,000 kilolitres. Figure 2 shows the consumption of petrol and diesel by the transport sector. It has been assumed that about 99% of petrol and 80% of diesel is consumed by the transport sector in Bangalore Urban and the remaining 20% of diesel by industries and commercial activities. In Bangalore Rural and Ramanagar district 40% of diesel is assumed to be consumed by irrigation pump sets. The shift from diesel to LPG has reduced petrol consumption for auto rickshaws thus raising auto LPG consumption from around 8,000 Mt in 2004 to around 47,000 Mt in 2008.

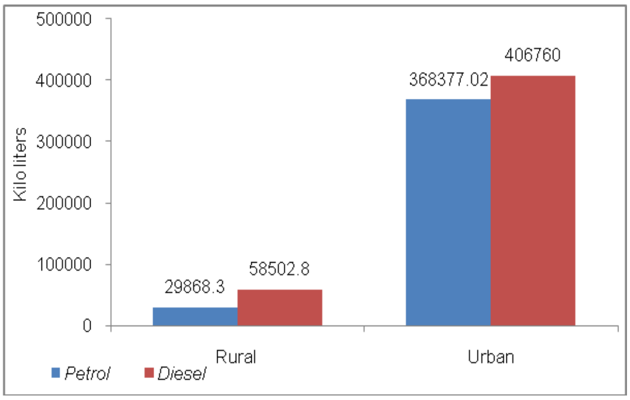


Figure 2: Petrol and diesel consumption in BMR[1]

[1] *The reference to Bangalore Rural district includes Ramanagar district troughout this chapter*

1.4. INDUSTRY SECTOR

It has been estimated that BMR accommodates around 70,000 industries. General engineering industries occupy the top position with 13,000 units followed by textile units whose number is estimated to be above 12,000. Energy consumption is high in many sectors such as engineering, processing and wood industries. Industries use a variety of fuels for processes. Diesel is mainly used for captive power generation and boilers. Table 4 shows the fuel consumed by industries in BMR region. Bulk LPG for industrial and commercial operations has increased from about 20,000 Mt/a to 62,000 Mt/a from 2004-05 to 2007-08. The consumption of biomass briquettes could not be determined.

Table 4: Industrial fuel consumption in Bangalore Urban and Bangalore Rural in 2006-07

Industrial fuels	Consumption in Mt/a	
	Bangalore Urban	Bangalore Rural and Ramanagar
Motor spirit	1,163	386
High speed diesel	211,020	44,249
Furnace oil	22,842	160,459
Low sulphur heavy stock	33,961	4,595
Bulk LPG	*(no data)*	62,019

** 2007-08* Source: Central Power Research Institute

1.5. DOMESTIC SECTOR

The domestic sector is among the major energy consumers. Energy is used for heating, lighting, refrigeration and increasingly for air-conditioning. Table 5 shows that about 94% of households in Bangalore Urban were electrified by the year 2006-07. Only about 4% still depend on kerosene for lighting. In Bangalore Rural and Ramanagar, 86% of households are electrified while 13% depend on kerosene. These comprise mainly of weaker economic sections and nomadic populations. This means there is a need to provide cleaner lighting in rural areas. Shifting this population from kerosene to solar could result in reduction of approximately 20,500 tonnes of CO_2 emissions annually. The use of solar energy for lighting is mainly confined to public properties like parks, playgrounds, streets and traffic signals apart from a few households.

Table 5: Distribution of households by source of lighting

Districts	Number of households	Electricity	Kerosene	Solar energy	Any other	No lighting
Bangalore Urban	1,418,289	1,340,673	67,179	4,146	1,469	4,822
	100%	*94.53%*	*4.74%*	*0.29%*	*0.01%*	*0.34%*
Bangalore Rural and Ramanagar	383,592	329,715	51,339	845	434	1,259
	100%	*85.95%*	*13.38%*	*0.22%*	*0.1%*	*0.33%*

Source: Census 2001

Table 6: Distribution of households by cooking fuel

Districts	Number of households	Firewood	Kerosene	LPG	Electricity	Biogas	Any Other	No Cooking
Bangalore Urban	1,418,289	160,274	536,277	674,433	11,418	8,886	19,349	7,652
		11.3%	*37.8%*	*47.5%*	*0.81%*	*0.63%*	*1.36%*	*0.54%*
Bangalore Rural and Ramanagar	383,592	303,626	32,802	31,300	1,647	3,493	9,888	836
		79.2%	*8.55%*	*8.2%*	*0.43%*	*0.9%*	*2.6%*	*0.2%*

Source: Census 2001

Similarly, there is diversity in fuel for cooking. Statistics show that around 48% of households in Bangalore Urban use LPG while 11% depend on firewood. Firewood is dominant in slums and among low-income groups. In Bangalore Rural and Ramanagar only 8% have LPG connections, the rest use kerosene, firewood or biogas. Kerosene is still the primary cooking fuel in rural households. Kerosene is solely supplied through ration shops and the Public Distribution System (PDS). In Financial Year (FY) 2006-07, Bangalore Urban consumed around 83,000 kilolitres while Bangalore Rural and Ramanagar together consumed 22,000 kilolitres of kerosene. A rough estimate of the LPG consumption on the domestic front shows that around 442,000 tonnes were sold in Bangalore City in 2006-07. An additional 41,000 tonnes have been consumed by the commercial sector, consisting primarily of allied services such as eateries, guest houses and hotels, which saw a booming 200% increase of LPG since 2004. About one third of rural population still relies on biomass, mainly firewood, for cooking and heating. In addition a few small-scale enterprises such as brick making, soap manufacturing, dyeing, food processing and the hospitality industry use biomass. However, data on the biomass consumption in the study area is not available. It is estimated that annual consumption of biomass by domestic and small-scale industries is about 1 million tonnes per annum assuming 1 kg as the per capita consumption of biomass per day in the domestic sector.

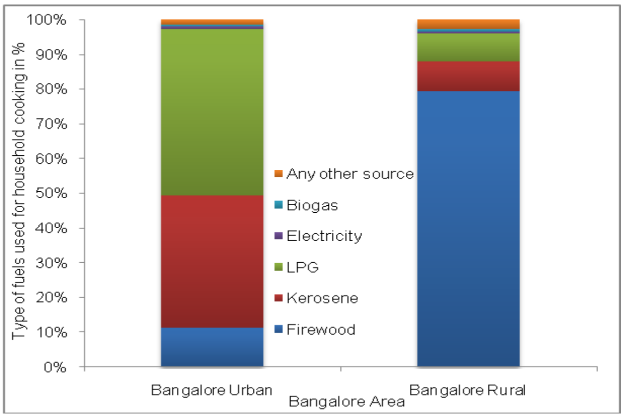


Figure 3: Comparison of cooking fuels

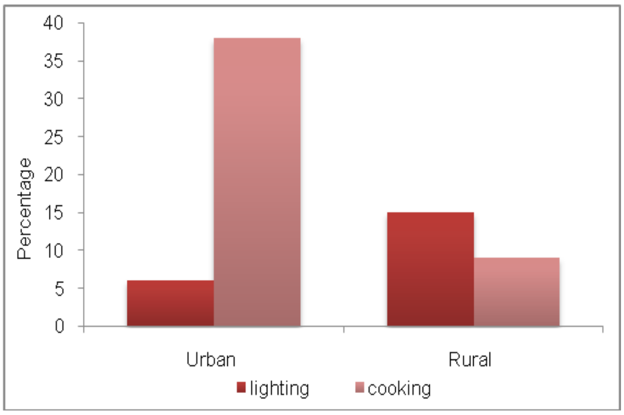


Figure 4: Households using kerosene

2. CONSUMPTION TRENDS

2.1. POWER CONNECTIONS

In Bangalore Urban the industrial sector saw a marginal increase of 5% of low-tension consumers since 2002; consumers in the domestic and commercial sectors have increased by 42% and 29% respectively. A dramatic increase of 74% is witnessed in the high-tension segment, which supplies to large industrial consumers. The stupendous growth in the streetlight and water supply sector of 115% since 2002 can possibly be attributed to population influx with increasing demand for water and also the emphasis on infrastructure development in Bangalore.

A similar comparison of sector wise growth from 2002 to 2006 in Bangalore Rural and Ramanagar districts shows a 32% increase in the domestic consumer base while commercial consumers have gone up by 28% and industry consumers by 15%. Irrigation pump sets have seen a marginal increase of 5%. But as irrigation pump sets are not metered, the registered number of users may not reflect the actual consumption; the increase could be more. Streetlights and water supply connections are up by 15% while there is an unexplained 350% increase in temporary connections.

2.2. PETROLEUM PRODUCTS

The sale of petrol in BMR by government oil companies has increased from 2002-03 to 2006-07 by 11.2%. The same period saw an increase in demand by 24.3% for total diesel sales. Annual sales of government oil companies showed a slight dip from 2004 to 2006 due to entry of private players such as Reliance and Shell who reached a market share of 10% nationally but retreated from the market, unable to supply at comparable prices after the revision and protection of fuel prices of government oil companies. Nevertheless, the overall oil consumption is increasing. Since the mandatory conversion of auto rickshaws to LPG in 2003, auto LPG in Bangalore shot up by 381% to nearly 39,000 metric tonnes from 2004-05 to 2006-07.

Figure 5: Cleaner fuel reduces pollution but not CO_2 – Gas filling station at Banashankari

The bulk LPG fuel market whose primary consumer is the industry has consumed 16,807 metric tons in 2006-07, an increase of 170% from 2004-05. This tremendous increase is attributed in part to the successful intervention of Karnataka State Pollution Control Board (KSPCB) who stipulated fuel switches for a range of industrial processes through the consent process.

There is also a slight decrease in kerosene supplies by 1.3% from 2005-06, which is attributed chiefly to the subsidy on LPG by 100% that makes it more economical for cooking, sometimes even cheaper than kerosene.

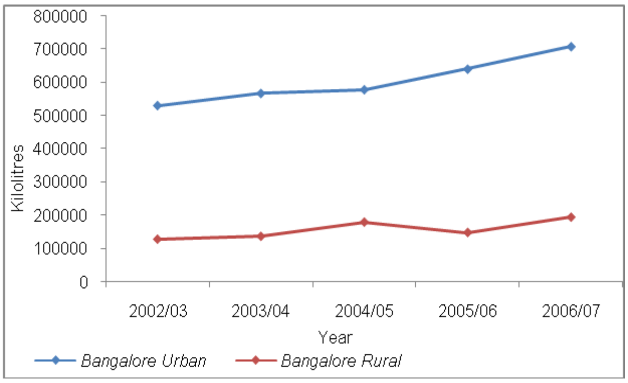


Figure 7: Diesel consumption trend in BMR

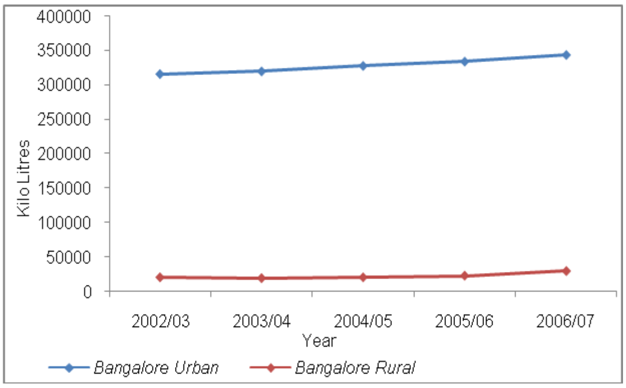


Figure 6: Petrol consumption trend in BMR

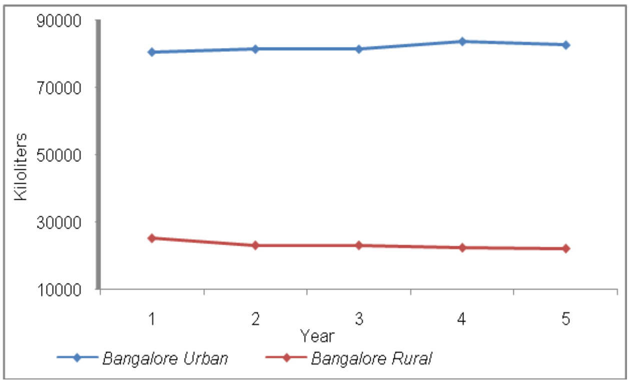


Figure 8: Kerosene supplies through the PDS show a decreasing trend

3. ISSUES AND CAUSES

3.1. INCREASED FUEL CONSUMPTION

The increase in petrol usage reflects the increase of private vehicles and the growing affluence and affordability of personal transport. An in-depth analysis of the vehicle increase can be found at Chapter 6 "TRANSPORT", section 1.2. Diesel consumption in BMR includes industry, railways, public transport and defence sectors. There is inefficiency in the diesel use in DG sets and industrial processes as equipment is often outdated.

The per capita electricity consumption of Bangalore Urban is 884 KWh per annum, which is much higher than India's average of 631 KWh. This reflects the growing affluence of households and a growing number of appliances, washing machines being a noteworthy new entrant here. Also air-conditioners have begun to enter Bangalore's domestic sector in recent years. Modern office buildings often rely on artificial lighting and air-conditioning by design, thus increasing energy consumption as well as per capita energy intensity. A steady increase in consumption is a reflection on the growing affluence and increasing use of electrical devices that did not exist hitherto.

3.2. TRANSMISSION AND DISTRIBUTION LOSSES

Losses across the transmission and distribution network are intrinsic to electricity supply. Distribution losses discount the availability of electricity and constitute an economic loss. The resistance of transmission lines and transformer losses account for the main technical losses. There are also thefts, pilferages and tampered or defective meters. Besides, BESCOM also needs to deal with commercial losses such as outstanding payments. Energy audits in the power distribution sector can help addressing what is referred to as the Aggregate Technical and Commercial losses (AT&C). In the city area losses have been systematically reduced by 6.5 % over the last five years as Figure 9 shows. Transmission and distribution losses in Channapatna are with 20.4% high as compared to Bangalore City (11.6%) and Hoskote (15.7%). Also the values for Ramanagar (18.9)% and Doddaballapur (17.6%) appear high. The collection of dues for billed meters has improved over the last five years by 14%.

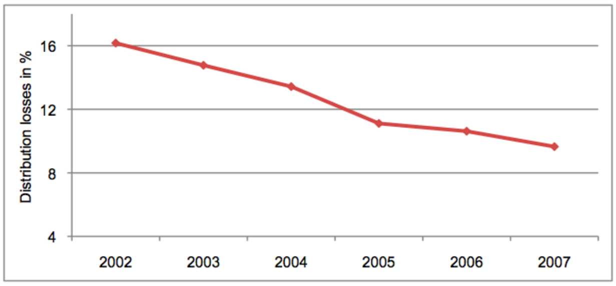


Figure 9: Distribution losses in Bangalore City

Figure 10: Victim of power distribution – Champa tree in J. P. Nagar

3.3. ENERGY LOSSES IN INDUSTRIES

Industries in BMR consume 35.2 % of the total electricity supply. With an energy saving potential of as much as 30% energy intensity of industries could be significantly reduced. Energy saving would also reduce the actual load and hence help close the demand–supply gap. The Energy Conservation Act of 2001 has made energy audits mandatory for industries with a connected load greater than 5 MW.

3.4. GREENHOUSE GAS EMISSIONS

Transport sector

An inventory of greenhouse gas (GHG) emissions from petrol, diesel and LPG in the transport sector of BMR is presented in Table 7. In absence of emission factors specific to Bangalore or India the calculations were based on default values of the Intergovernmental Panel on Climate Change (IPCC).

Figure 11: Future CO_2 emissions on their way

Table 7: GHG emissions from transport sector

Fuels	Consumption Apr 07 to Jan 08 in Mt	Emissions in Mt/a			Emissions in CO_2eq in Mt/a
		CO_2	CH_4	N_2O	
Petrol	303,446	880,249	419	41	901,921
Diesel	730,790	2,266,793	119	119	2,304,851
LPG	536,904	1,679,091	1650	5	1,718,612
Total					**4,925,384**

Note: Emssion factors based on IPCC default values

Industry sector

GHG emissions from commercial industrial fuels in BMR for 2007-08 are presented in Table 8. Bulk LPG, coal and biomass have not been included in this calculation.

Table 8: CO_2 emissions from industrial fuels

Fuel	Fuel consumption in Mt/a	Energy consumption in TJ	CO_2 Emissions in Mt/a
Petrol	1,549	70	4,853
Diesel	255,269	10,686	791,800
Furnace oil	183,301	7,520	582,011
LSHS	38,556	1,582	122,422
Total			**1,501,086**

Note: Emssion factors based on IPCC default values

Captive power generation

Figure 12: DG sets are becoming the norm – A hotel in central Bangalore

Captive power generation is a major contributor of greenhouse gases and air pollutants. Diesel generators also emit suspended particulate matter, which is another important contributor to smog. Of the total particulate matter released by a typical diesel engine, 94% is under 2.5 microns in diameter and thus easily respirable. DG sets harm workers directly. The Occupational Safety and Health Administration (OSHA) finds that workers exposed to diesel exhaust are exposed to increased health risks.

As no data on DG sets was available their CO_2 emissions were estimated to be around 800,000 tonnes per year (see Table 9). The calculation is based on the assumption that the registered DG sets (10,304) would on average run for one hour per day throughout the year. Further a load factor of 80% was assumed. However, looking at the supply-demand gap, power shutdowns could be longer during summer when the water reservoirs are at a low level and hydropower is declining and CO_2 emissions would thus be higher.

Table 9: CO_2 emission model for DG sets

DG set capacity in kVA	Number of DG sets	Estimated CO_2 emissions in Mt/a
Below 15	975	10,128
15 – 35	2,574	54,854
35 – 135	4,963	280,169
135 – 200	442	43,751
200 – 800	1,170	230,420
Above 800	180	149,921
Total	**10,304**	**769,243**

4. PROJECTIONS

The projection of BMR's future energy requirements are largely based on a linear extrapolation of current trends. The parameters used are available at Table 10. This business-as-usual scenario may, however, turn out to be overestimated because it appears unrealistic to expect that growth of this magnitude can be sustained for over two decades.

Power consumption will increase all the more not only due to population increase but also due to lifestyle changes that can be expected to take place on a larger scale in future Bangalore. In order to sustain a GDP growth of 8%, commercial activities and industrial growth will require uninterrupted power supply which quite certainly will remain elusive.

Power

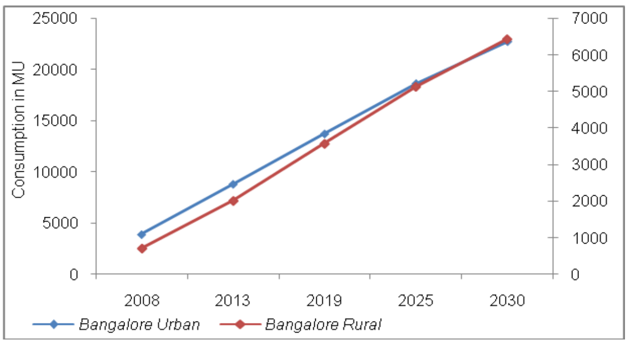


Figure 13: Projection of power consumption[2]

Kerosene

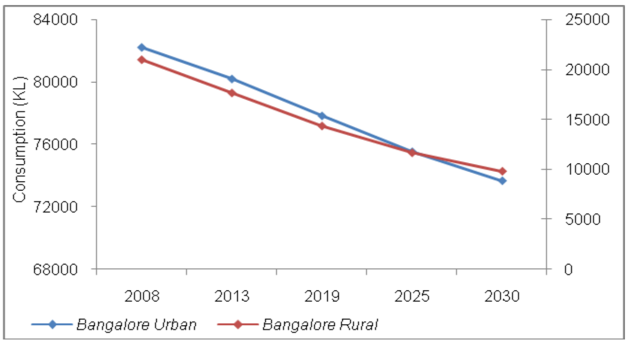


Figure 14: Projection of kerosene consumption

The consumption of kerosene as a fuel for cooking and lighting is expected to reduce. More people are expected to move to LPG, which is the preferred fuel for cooking. With the continued promotion of rural electri-

[2] *The reference to Bangalore Rural district includes Ramanagar district troughout this chapter*

fication through programmes such as Rajiv Gandhi Grameena Vidyutikaran Yojana (RGGVY), kerosene consumption is also gradually giving way to electricity. The key parameters of this projection are available at Table 10.

Doemstic and transport LPG

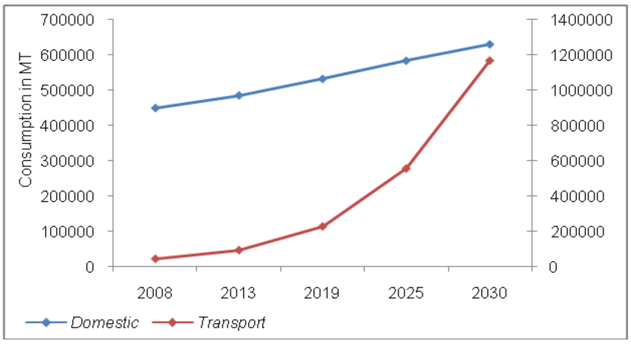


Figure 15: Projection of LPG for domestic use and transport use

The domestic consumption of LPG fuel is on the increase. The additions come from existing households opting for LPG fuel for cooking, population growth and from kerosene or biomass users to switch over to LPG when affordable. Past trends also indicate that some are moving from wood to LPG directly. The mandatory use of LPG in auto rickshaws has resulted in a steep growth demand. The quantities required if the present vehicular growth continues are shown in Table 10.

Petroleum fuels (retail)

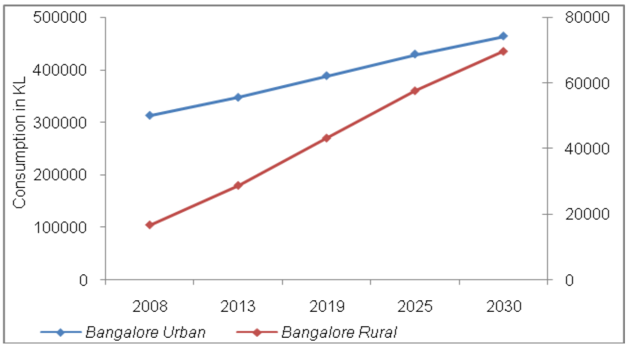


Figure 16: Projection of petrol consumption

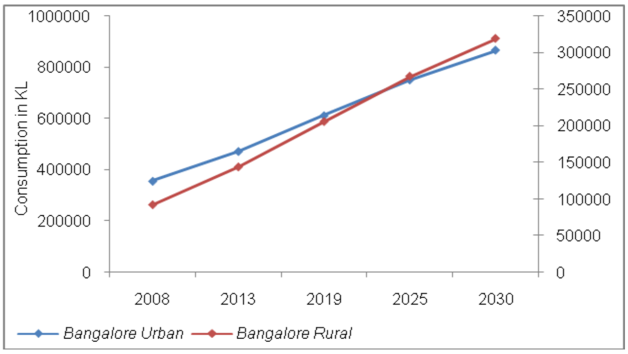


Figure 17: Projection of diesel consumption

Going by existing trends the fuel consumption of the transport sector will increase despite rising oil prices.

Table 10: Projected energy demand up to 2030

Energy type	Region	Current consumption 2006-07	Assumed annual growth rate	Projected consumption for 2030	Projection method and selection rationale
Power	Bangalore Urban	8,215 MU	Average 14%	22,719 MU	Linear projection - based on the power consumption from 2002-2007
	Bangalore Rural and Ramanagar	1,945 MU	Average 30%	6,435 MU	Linear projection - Based on the power consumption from 2002-2007, an avg growth rate of 30 % considered
Kerosene	Bangalore Urban	82,658 Kl	Marginal decrease of 0.5%	73,657 kl	Considering average 3 years growth rate
	Bangalore Rural and Ramanagar	21,732 Kl	Average 3.4 % decrease	9,808 kl	Considering average 3 years growth rate
LPG domestic	BMR	441,577 Mt	Considering 1.56% increase	630,418 Mt	Considering average 3 years growth rate
LPG transport	BMR	38,471 Mt	Average growth of 16% of autos is considered	11,68,607 Mt	Based on the linear analysis of auto LPG fuel growth, projected for the next 24 years, considering 2006-07 consumption data
Petrol	Bangalore Urban	342,153 Kl		463,575 kl	Based on the linear trend analysis of 2002-2007 data
	Bangalore Rural and Ramanagar	28,958 Kl		69,733 kl	Based on the linear trend analysis of 2002-2007 data
Diesel	Bangalore Urban	451,127 Kl			Based on the linear trend analysis of 2002-2007 data
	Bangalore Rural and Ramanagar	140,944 Kl			Based on the linear trend analysis of 2002-2007 data

5. ADDRESSING PRIORITIES – CURRENT MEASURES

Energy conserved is energy generated. Environmentally speaking, energy conserved is actually more than that. Because of transmission and distribution losses, every unit of power saved equals to two units of power generated. Conservation measures bring down the overall demand and the surplus can be used to meet the demands of other sectors. Energy conservation has been encouraged through measures that offer financial incentives to consumers. Grants and subsidies for energy efficient technologies exist; the resulting reduction of electricity or cost is a bonus for consumers and operators. Incentives are offered through various state and national schemes, the most popular ones are shown in the following.

BESCOM Efficient Lighting Programme (BELP)

The programme focuses on residential lighting and covers 16 lakh domestic consumers. It encourages the replacement of conventional incandescent lamps (commonly known as bulbs) with energy efficient compact fluorescent lamps (CFLs). BESCOM consumers can purchase a total of 5 CFLs under this scheme while payment can be made in instalments. It will save the user an estimated INR 17 per month for every bulb replaced with a CFL. The potential in energy savings from using CFLs of 2.6 million BESCOM customers is estimated to be 210 million kWh annually.

BESCOM Efficient Irrigation Pumpset Programme (BEIPP)

The programme seeks to encourage the use of efficient irrigation pump sets by farmers. It offers attractive prices for purchase of pumps through official suppliers under the scheme whose pumps meet certain energy efficiency criteria. Official suppliers include M/s Kirloskar Brothers Limited, M/s KSB Pumps Limited and M/s Crompton Greaves Limited.

Rural Load Management System (RLMS)

The system is put in place to ensure uninterrupted power supply to rural consumers and that power is supplied at the scheduled period for irrigation pump sets. Remote controlled equipment is used to switch on and off supply. It seeks to prevent illegal use and theft, thereby containing power demand. The reduction in feeder load is about 50% and voltage fluctuations are also reduced by a similar percentage.

Accelerated Power Development & Reforms Programme (APDRP)

One of the primary objectives of this programme ushered in by Ministry of Power is to address the aggravated transmission and commercial (AT & C) losses that affect the power sector. The programme aims to reduce the losses to under 10%. The potential this pursuit taps into becomes apparent if one considers that BESCOM's average AT & C losses currently stand no better than 33.5%.

Promotion of solar energy

A wide range of incentives for solar energy is being offered. Table 11 presents the schemes in effect. The "Aditya Solar Shop" established at the office of Karnataka Renewable Energy Development Limited (KREDL) offers solar technology at discounts of 10 to 15%.

Figure 18: A rare sight – Commercial building equipped with 12 solar PV panels, generating approx. 600 W_P, City Market

Figure 19: Solar PV powered traffic signals have become a common sight – Signal at J. P. Nagar

Table 11: Incentives for solar energy

Application	Incentives available	Agency
Home lighting system	Subsidy for solar photovoltaic panels under the SPV Programme: ■ INR 2,500 for 18 Watt peak (W_p) ■ INR 4,800 for 37 W_p ■ INR 4,800 for 74 W_p	KREDL
Street lighting system	System subsidy of INR 9,600 if installed in a cluster of 5 solar streetlights	KREDL
Solar power plants	■ Urban stand-alone SPV power pack: INR 1 lakh up to 1 kW_p Rural stand-alone SPV plant in electrified villages: ■ INR1.25 lakh without distribution line and ■ INR 1.5 lakh with distribution line >10kW	KREDL
Solar water heaters	Soft loans through financing agencies with interest rates of ■ 2% for domestic installations ■ 3% for institutions and ■ 5% for commercial establishments	Rural banks
	Capital subsidy for those who do not avail soft loans above: ■ INR 1,100 per m^2 of collector area for registered institutions ■ INR 825 per m^2 of collector area for registered commercial bodies	MNRE/ KREDL
	Rebate of 0.50 INR/kWh up to a maximum of INR 50 per installation	BESCOM
Solar cookers	Subsidy of 50% of total project cost	MNRE/ KREDL
Solar water pumping systems	Subsidy of INR 30 W_p up to a maximum of INR 50,000 per pump	MNRE/ KREDL
	Soft loan for 90% of the unsubsidised portion at 5% interest rate	IREDA

6. CURRENT LEGISLATION

Bureau of Energy Efficiency

The Energy Conservation Act, 2001 established the Bureau of Energy Efficiency (BEE), lays down guidelines for conservation and efficient use of energy. The Act empowers BEE to:

- Propose a policy framework and direct national energy conservation initiatives;
- Coordinate programmes with stakeholders on efficient use of energy;
- Establish standards, systems and procedures to verify, measure and monitor energy efficiency;
- Leverage multilateral, bilateral and private sector support to implement the Energy Conservation Act;
- Utilise public-private partnership to demonstrate the energy-efficient delivery systems.

The designated agency to coordinate, regulate and enforce the provisions stated in the Energy Conservation Act for Karnataka State (and Bangalore) is KREDL.

Energy Conservation Building Code

The Energy Conservation Building Code (ECBC) 2007 sets forth a set of guidelines for commercial buildings with a connected load greater than 500 kW. A voluntary exercise at present, it will soon be made mandatory under the Energy Conservation Act, 2001 for all parties under its ambit. Implementation of the code is expected to reduce the energy consumption by 25% to 40% resulting in nationwide energy savings of 1.7 billion kWh. ECBC specifies the minimum efficiency for external walls, roofs, glass structures, lighting, heating, ventilation and air-conditioning of commercial buildings in all five climatic zones of the country. Each of the state governments has been given the flexibility to amend these codes to suit their local and regional needs. The codes are integrated into each city by-laws and executed through the municipalities.

The Government of Karnataka, in its effort to realise energy conservation has exercised the powers conferred under the Act and notified the following directives in November 2007:

➲ **Mandatory use of solar water heating systems**: The government has made it mandatory for several categories of buildings which include industries, hospitals, nursing homes, jail barracks, commercial establishments such as hotels, motels, banquet halls, wedding halls, community halls to use solar water heating systems. In the residential category houses built with a floor area of 600 square feet or site area of 1,200 square feet must install the solar water heaters. Government buildings, all forms of educational and training institutions are included.

➲ **Mandatory use of CFLs:** The use of incandescent lamps has been banned in all the new buildings and institutions of the government and those aided by it. This directive will also guide the corporations and autonomous bodies. Defective lamps must be replaced with CFLs but is not clear whether this applies to existing buildings as well and how it is sought to be implemented.

➲ Mandatory use of ISI marked devices in the agricultural sector: All new tube well connections must have ISI approved motor pump sets and accessories such as power capacitor, foot/reflex valves in order to achieve higher energy efficiency.

➲ Promotion of energy efficient buildings: All new buildings constructed by the government or institutions aided by are required to incorporate energy efficient building design concepts and renewable energy technologies.

KREDL has been appointed as the state enforcement and monitoring agency to which the respective government bodies will submit their quarterly report on the progress of energy conservation measures taken.

BMP building by-laws of 2003

The BMP building byelaws of 2003 have made the use of solar water heaters and solar panels mandatory in buildings of various listed categories.

7. INITIATIVES OF KARNATAKA GOVERNMENT

Sustainable transportation

Namma Metro: The Bangalore Metro Rail, estimated to be completed in 2011, reduces energy consumption through traffic decongestion and fuel savings. The Metro is expected to attract citizens by offering shorter travel times, motivating many to shift from personal to public transport. According to BMRCL the Metro is expected to translate into savings of INR 253 crore per year on fuel. However, the possibility that achievements in terms of decongestion might eventually make driving more attractive again should also be kept in mind.

Introduction of bio-fuel by BMTC and KSRTC: BMTC has taken the initiative of using biofuel from *pongamia pinnata* seeds in 25 buses of its fleet. In addition to this, the Doddaballapur Depot of KSRTC operates 81 buses on a 90:10 ratio mix of diesel and *pongamia* oil. The ratio was arrived at in load tests on an engine test bed, emerging as the most economic mix that offers a quantifiable reduction in emissions.

Cleaner fuels

Bidadi Combined Gas Cycle Power Plant: This plant proposed at Bidadi would be the first gas power project in Karnataka. The 1,400 MW combined gas cycle plant will have 4 units of 350 MW each. Sourcing of an estimated 1.26 million tonnes of gas per year is under finalisation. The project is estimated to cost INR 3,750 crore. The infrastructure in terms of land and water supply is in place. Since this plant would contribute to the base load it will add significantly to grid stability. Commencement of supply is projected for 2010-11. This project would be a trendsetter for further gas projects in the state.

Alernative energy

Promoting alternative sources of energy: KREDL acts as state nodal agency of Ministry of New and Renewable Energy (MNRE) to facilitate the development of renewable energy sources and the promotion of energy efficiency. KREDL helps to develop and implement renewable energy projects and conducts programmes of MNRE for promotion of renewable energy. It also monitors energy conservation programmes for BEE.

Hydropower: MNRE supports small hydro projects (SHP) through grants of up to INR 3 lakh detailed surveys, investigation and detailed project reports (DPR). The incentive is applicable to owners of the project site or parties to which it was allocated. Grants can be accessed once pre-feasibility studies have been completed. KREDL has set up an investigation cell to identify potential hydro projects. It undertakes pre-feasibility studies and then offers projects to interested developers. It also encourages private parties to work on self-identified sites.

Hydropower is a relatively cheap option as compared to other renewables such as wind and solar. The investments are one time. Maintenance costs are low and the plant can be operated with a fair level of automation. Plants with a capacity under 25 MW have little adverse impact on the environment unlike their large-scale siblings that supply to BESCOM. There are a number of hydropower project initiatives in BMR in different stages of feasibility and approval and independent power producers are being encouraged.

8. RECOMMENDATIONS

Energy generation is one of the major sources of emissions and pollution. The combustion of fossil fuels produces carbon dioxide (CO_2) as well as air pollutants such as carbon monoxide (CO), oxides of nitrogen, sulphur dioxide (SO_2) and particulate mater, some fractions of which are respirable. Many of these pollutants are of local concern due to their health impacts. Apart from these local impacts, GHG and climate change have become an exceptionally serious concern of global scale. The use of renewable energy sources, cleaner technology and energy efficiency will accrue clear environmental benefits. The recommendations of this chapter provide some pointers in that direction.

8.1. ENERGY CONSERVATION

Domestic sector

Lighting, the most essential need of every individual, requires electricity. Programmes such as BESCOM's Efficient Lighting Programme (BELP) must be popularised to encourage the use of CFLs further. Making their use mandatory, however, is not feasible from the perspective of implementation and monitoring. Also compulsion does not help create higher acceptance. Extensive awareness building programmes are required to educate consumers to effect a shift to informed purchase decisions such as the selection of BEE-rated appliances.

In Bangalore Rural and Ramanagar agricultural pump sets consume considerable amounts of electricity. Pump set efficiency is generally low, largely because of free or subsidized electricity for farmers and the utter absence of incentives for energy saving. Apart from awareness campaigns, monetary incentives are required to promote energy efficiency in this sector.

The building sector offers tremendous potential for efficient use and conservation of energy. Simulation studies have indicated a potential reduction of 30-40% if the Energy Conservation Building Code (ECBC) is implemented in new buildings. For old buildings the government initiated a programme to promote energy conservation through an Energy Service Company (ESCO). Energy audits in several office buildings, hotels and hospitals indicated that the energy saving potential of 23-46% in lighting, cooling, ventilation and refrigeration. That this potential remains unexploited owes to the fact that the economic potential requires largely a longer-term perspective which owners or users do not presently have. This potential could be tapped better through contractors who are paid based on performance measured as actual savings.

The Ministry of Power has launched the Energy Efficiency Standards and Labelling (S&L) programme through BEE. At present, the scheme has been put in place for frost-free refrigerators (FFR) and tubular fluorescent lamps (TFL) on a voluntary basis. As of now 60% of the FFRs and 90% of TFLs are covered. The scheme will be made mandatory later and be extended to other appliances. This will ensure that only those products that conform to Minimum Energy Performance Standards (MEPS) will be promoted. A massive awareness campaign is on to create the required market transformation.

Power sector

Data shows that current distribution losses are high. Distribution losses can be reduced through effective inspections, stricter monitoring, better metering, preventing of power thefts and detection of illegal connections.

Transport sector

- Introduction of alternative fuels such as straight vegetable oils (SVOs), bio-diesel and bio-ethanol in public and private transport
- Use of LPG or CNG for public buses

Industry sector

The increased use of DG sets for captive power generation, especially in industries and commercial areas, is adding to air pollution. A strict monitoring regime by KSPCB is required for controlling pollution. The data already collected by KSPCB from industries should be used to assess the carrying capacity of a particular industrial area. This aspect needs to be considered also by the Department of Commerce and Industries in the process of according permission for establishment of energy intensive industries in BMR and is to be integrated into the zoning atlas recommended in Chapter 7 "INDUSTRY", section 4.2.

8.2. ALTERNATIVE SOURCES OF ENERGY

Karnataka has a huge potential of renewables of which Bangalore district also stands to benefit. Options comprise of solar thermal, solar photovoltaic, small hydropower, converting solid municipal waste to energy and the use of wind energy and hybrid aero-solar technologies in rural areas.

Solar energy

The average solar radiation in Bangalore is 5.18 $kWh/m^2/day$. This translates into an average potential of 20 MW/km^2. Solar energy can be used economically in the domestic sector through solar water heaters where it would also help in shaving peak load demand for electricity. Solar water heaters are made popular through capital subsidies and soft loans (refer to Table 11). It has been estimated that 1,000 solar domestic water heaters (2,000 m^2 of collector area) in use contribute to a peak load saving of 1 MW. Solar thermal clearly deserves more promotion.

Figure 20: Residential solar heating systems enjoy a fair degree of popularity – Roof in J. P. Nagar

The use of photovoltaic solar panels to complement electricity needs in commercial buildings is being experimented with (see Figure 18) but has shown limited success because of the cost involved. Solar panels are also used as hybrid systems in tandem with grid-connected traffic lights and streetlights (see Figure 19).

Wind energy

India ranks fourth in wind energy generation with an installed capacity of 800 MW in 2007. Technologies are in place to tap this inexhaustible natural resource of energy at feasible locations. Wind power densities in the region are monitored by wind monitoring stations. MNRE's feasibility guidelines require an average annual wind power density of over 200 W/m^2 at 50 m above ground and over 150 W/m^2 when the wind turbine is at a height of 30 meters. Sites in Bangalore Rural and Ramanagar districts have been identified as suitable for wind power generation. A capacity of 180 MW is to be realised through five projects, which are yet to be commissioned (for locations see Figure 21). Tapping deeper into existing wind energy potential is deemed desirable for Bangalore as well as Karnataka.

Energy from waste

Municipal solid waste (MSW) generated is estimated to be in the order of 3,000 tonnes per day in BMR. M/s Ramky Consultants plan to produce energy from MSW in their energy recovery plant in Mavallipura, generating 10 MW from approximately 780 tonnes of waste. The technology is mass combustion that fully consumes waste.

M/s Srinivasa Gayatri Resource Recovery Limited has entered into an agreement to produce 8 MW of power through incineration of refuse-derived fuel at Mandur in Bangalore. BBMP will supply 1000 TPD of MSW of which 300 tons will be utilised after segregation. The possibility of converting waste into energy need to be explored further to gain experience.

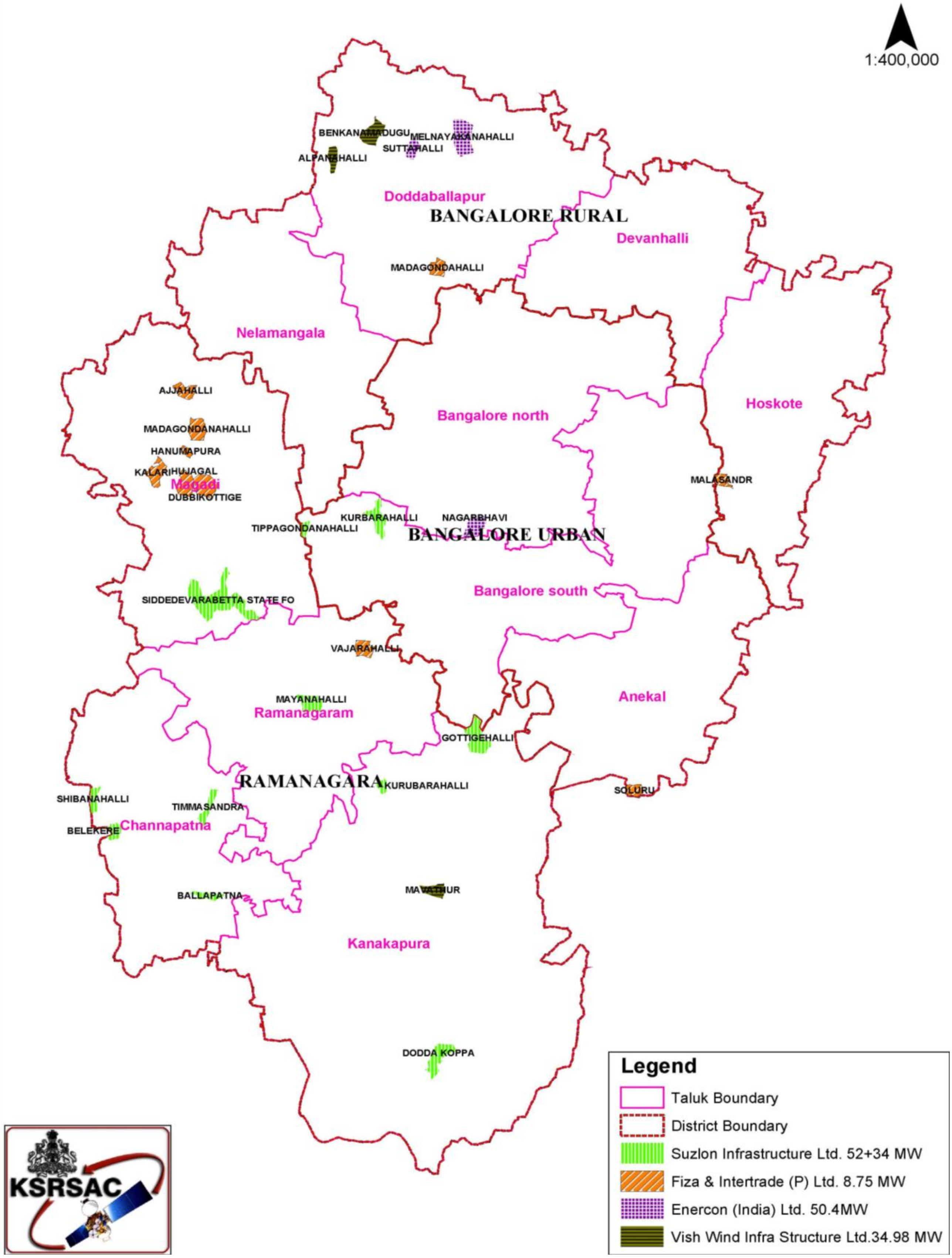


Figure 21: Wind power projects sanctioned in BMR

Chapter 10

Urban Planning

CONTENTS

TABLES

FIGURES

1. STRUCTURE PLAN AND MASTER PLAN

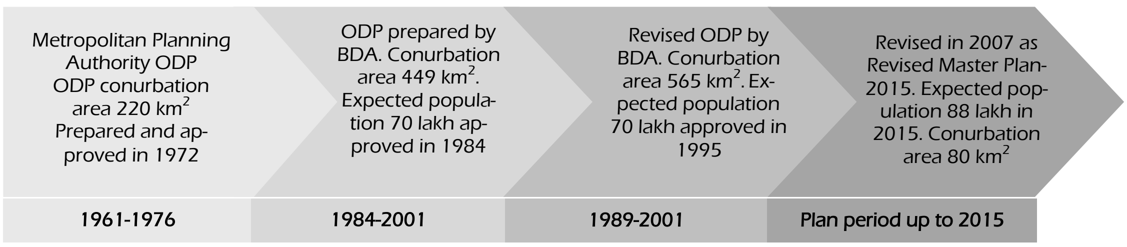
1.1. EVOLUTION OF BMR

Pre-independence period and till 1949 Bangalore was having the city area and cantonment area as independent units. Cantonment area was having the military headquarters and Bangalore City was having the civil area. Bangalore City and Bangalore Cantonment had two separate municipal boards of administration. The Bangalore municipality itself was established way back in 1862 and it was overseeing the housing needs of military and civil areas.

Bangalore City planning and development is having its own historical background. The early part of 20th century saw the emergence of several city extensions such as Visweshwarapuram, Frazer Town, Shankarapuram, Malleshwaram and so on. These extensions did not develop as integrated units hence they resulted in the formation of outgrowths and slums. Therefore, in 1945 to stem the irregular development the "City Improvement Trust Board (CITB)" was constituted. The twin areas of Cantonment and Bangalore City were merged in 1949. During this period, a lot of industrial development was encouraged and a number of industries were set up. This period saw a boom in the growth of population.

In 1952, there was an attempt to meet the needs of unprecedented development and population growth by preparing a development plan. The plan emphasised on land use management but did not succeed due to "no legal backing" for enforcement.

The Government constituted a Metropolitan Planning Authority to prepare the Outline Development Plan (ODP). The Bangalore Metropolitan Authority constituted for the purpose, under the Karnataka Town and Country Planning Act (KT & CP Act) prepared the ODP, which was finally approved by the Government of Karnataka in 1972. The plan period of 15 years 1.e., 1961–1976 was an important document to control the land use.



The ODP prepared by the Bangalore Metropolitan Authority for the designated Local Planning Area (LPA) covered an area of 500 km^2. The conurbation proposed was 220 km^2. The balance area was intended as the rural tract. Though the plan period was only up to 1976, no serious attempt was made to prepare the Comprehensive Development Plan (CDP), containing details of layouts, infrastructure, etc. This delay saw the development of unauthorised layouts and mushrooming of habitats without proper infrastructure. By this time the city administration itself was under confusion as there were many administrative bodies to control the development of Bangalore. There was the City Improvement Trust Board (CITB), the Bangalore City Corporation (BCC), the Karnataka Housing Board (KHB), Bangalore Metropolitan Authority, etc. Each authority worked independently by interpretation of the controlling Act in its own way.

The above circumstances led to the constitution of Bangalore Development Authority (BDA) in 1976. The BDA thus became the planning and development authority and the CITB was superseded and it also became the controller of development activities as far as LPA was concerned. The intervening period that is till the formation of BDA saw the extension of the LPA mostly to control and regularise the unauthorised developments and also to regulate the Ribbon Development along the highway corridors.

The BDA prepared the CDP for the period 1986–2001 for an LPA of 1279 km^2. The plan was approved on 12-10-1984. The conurbation area was extended to 449 km^2 from the earlier ODP conurbation of 220 km^2. The CDP was prepared for an expected population of 70 lakh by 2001. Subsequently, the CDP was revised in 1995. The conurbation was 565 km^2 for an expected population of 70 lakh after which the CDP was again revised in 2007. The plan period of the CDP, henceforth termed as Master Plan (MP) is up to 2015. The revised CDP envisaged a population of 88 lakh.

However, encouragement to industrial activity beyond the conurbation area and change of land use beyond the conurbation resulted in the CDP becoming almost obsolete except for certain development controls under the Zoning Regulations (ZR). There was an acute dearth of infrastructure and the BDA had become more of a housing and infrastructure provider than meeting the needs of housing.

It is in this context, i.e. to bring about the coordination of various bodies like the BDA, BCC, Bangalore Water Supply and Sewerage Board (BWSSB), Karnataka Industrial Areas Development Board (KIADB), etc, the Bangalore Metropolitan Region Development Authority (BMRDA) was created in 1986.

The jurisdiction of BMRDA was extended initially to the districts of Bangalore Urban, Bangalore Rural and Malur *taluk* of Kolar district. However, subsequently the area comprising of Malur *taluk* has been excluded from the jurisdiction of BMRDA. This jurisdiction of BMRDA is the Bangalore Metropolitan Region (BMR). The area comprising Bruhat Bangalore Mahanagara Palike (BBMP) limits and the balance area of the LPA of BDA is the Bangalore Metropolitan Area. The BMRDA Act prescribes the functions of BMRDA and the notable ones are as follows:

- Coordination of various authorities in the BMR
- To prepare the Structure Plan for BMR
- Development control in the BMR

The Structure Plan (SP) was prepared by BMRDA in 1999 and was finally approved by the Government in 2005 and currently the Structure Plan is set for revision. Figure 1 indicates the administrative and territorial jurisdiction of BMR.

Table 1: Population of each *taluk* of BMR

	Taluk	*Area in km²*	*Population in 1991 (million)*	*Population density in people/km²*
1	Bangalore North	902	0.93*	1,031
2	Bangalore South	709	1.01*	1,425
3	Anekal	528	0.19	360
4	Kanakapura	1,590	0.32	201
5	Hoskote	546	0.18	330
6	Devanahalli	457	0.16	350
7	Doddaballapura	798	0.22	276
8	Nelamangala	524	0.14	267
9	Magadi	798	0.19	238
10	Ramanagar	625	0.21	336
11	Channapatna	545	0.24	440

** Excluding Bangalore Urban area*

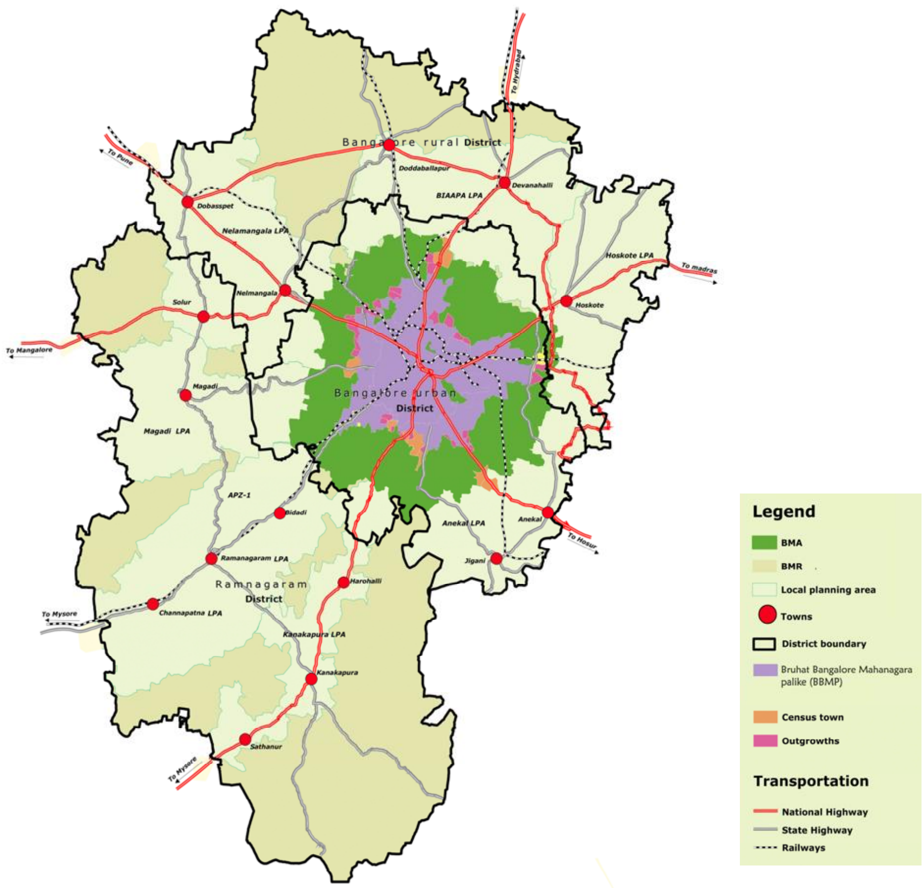


Figure 1: Administrative and territorial jurisdiction of BMR

Table 2: Spatial and functional jurisdiction

Territory	*Area in km²*	*Agency responsible*	*Plan typology*	*Implications of 73rd/74th constitutional amendments*
Bangalore Metropolitan Region (BMR)	1,279	BDA	CDP	Metropolitan Planning Committee, BDA, local bodies review and update CDP
Bangalore Urban districts	911	BMRDA	Structure Plan	District Planning Committee, BMRDA, local bodies prepare District Development Plan
Bangalore Rural and Ramanagar districts	5,815			

1.2. PLANNING ASPECTS

As per the *diktats* of BMRDA Act, the BMRDA has to prepare the Structure Plan. The Structure Plan simply stated is a policy document enunciating the policies that shall guide the development of BMR broadly covering various parameters influencing the growth of the region. This includes policies on control of land use, water resources, industrial growth and curtailment, housing, environment protection, resource mobilisation, slums, legislations land policy, etc. The policies thus enunciated shall govern the preparation of Master Plans for various settlements habitats/ urban settlements. In this direction, the BMRDA prepared the Structure Plan for BMR that was approved by the Government during 2005.

The salient features adopted in the Structure Plan are:

- Three critical variables:
    1. Water resources
    2. Development corridors and
    3. Satellite towns and growth centres
- Target induced population distribution was the preferred strategy

The three critical variables adopted in the Structure Plan are explained briefly below:

1.2.1. Water resources

The source of water for Bangalore is mainly from Cauvery river, which is located about 100 km away. The southern and western zones are close to the water source whereas northern and eastern zones are away from water source. As far as the ground water is concerned, the resources are better in southwest of the BMR. Over 75% of BMR in northeast region is categorised as "dark area" and the balance area is classified as "Grey Area". However, the situation in the southwest segment of BMR is in contrast as over 75% of the area is categorised as "white area".

Ironically, much of the development in BMR is in the northeast of BMA and a higher scale of development is anticipated in the eastern and northern part of the city. Hence, pumping of water is further away from the source than in proximity. The Structure Plan has recommended that conceptually the city should be viewed in two halves, the northeast and east as relatively water starved sector and the southwest and west as the relatively water well endowed sector.

1.2.2. Development corridors

The Structure Plan is very clear about the trends and containment of development in BMR. Critical water situation in the eastern segment of BMR suggests "containment" of development. Hence, it is advantageous to attract the development into western segment due to utilisation of water resources.

The development corridors identified in the BMR are:

- Bangalore–Bidadi–Corridor1 (C1)
- Bangalore–Nelamangala–Corridor 2 (C2)
- Bangalore–Devanahalli–Corridor 3 (C3)
- Bangalore–Whitefield–Hoskote-Corridor 4 (C4)
- Bangalore–Anekal–Sarjapur–Corridor 5 (C5)

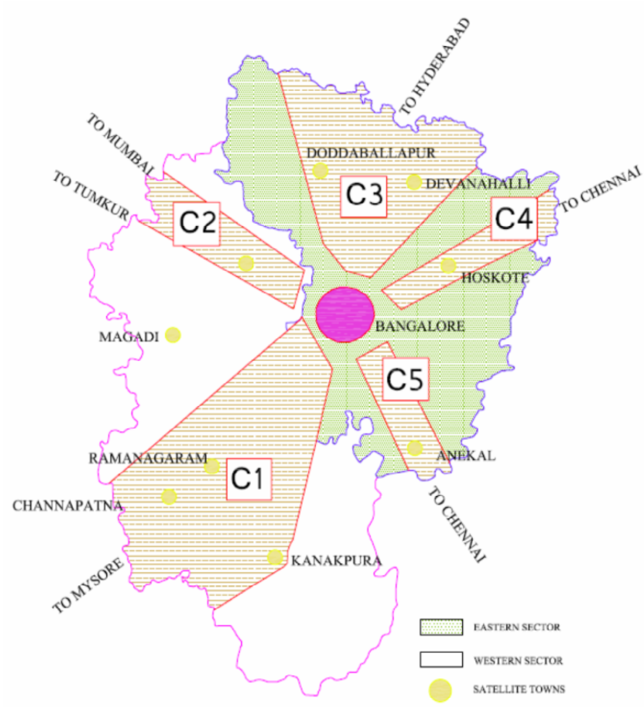


Figure 2: Development corridors identified

1.2.3. Growth centres

Bidadi, located on the edge of green belt of Bangalore LPA towards C-1 has professed infrastructure improvements, especially in Ramanagar and Channapatna Urban Development Authority (UDA) limits. The proposed Express Way (EW) from Bangalore–Mysore Infrastructure Corridor (BMIC) also encourages large-scale development. The expected EW transit envisages development of township to disperse the population and relieve congestion in the core area of Bangalore. The Structure Plan envisages two urbanisable blocks viz. Bidadi in C1 and in proximity to Nelamangala in C2. The urbanisable blocks and the proposed satellite towns at Kanakapura, Ramanagaram, Magadi, Devenahalli, Hosakote and Anekal would be the absorbents of population from the BMA.

Development in C1 and C2 can retrieve the pressure on eastern sector and directed for the development.

1.3. TARGET POPULATION

The Structure Plan states that given Bangalore's attractive cosmopolitan life style in an age of increasing globalisation of trade, it is unlikely that even after applying the policies of growth constraint and decentralisation, its compounded growth rate will fall substantially below which it has averaged over the last 40 years. In the background of this context, the increase in population could be expected in Devanahalli airport area, the 5 townships along the EW and the major industrial development expected along Outer Ring Road (under completion) by the year 2011. Table 3 indicates the distribution targets for BMR and urban population distribution targets.

Table 3: Total population distribution targets for BMR

Area	Population targets in lakh					
	1996	2011			1996 - 2011	
	Estimated	Normal	Induced	Target	Population growth	AAG in %
BMA	51	71	5	76	25	2.7
Western segment						
APZ 1 Bidadi, Kanakpura	8.26	11.38	2.3	13.9	5.42	3.38
APZ 2 Nelamangala	1.57	2.13	1	3.13	1.56	4.71
Magadi Interstitial Zone	2.11	3.05	0.2	3.25	1.14	2.92
Eastern segment						
APZ 3 Devanahalli and Doddaballapura	4.22	5.88	0.8	6.68	2.46	3.11
APZ 4 Hoskote	2.06	2.8	0.2	3	0.94	2.54
APZ 5 Anekal	2.4	3.32	0.4	3.72	1.32	2.96
Total BMR + BMA	**71.6**	**99.56**	**9.9**	**109.36**	**37.74**	**2.86**

Source: Structure Plan

Table 4: Urban population distribution targets for BMR

Area/ sector	Population target in lakh					
	1996	2011			1996-2011	
	Estimated	Normal	Induced	Target	Population growth	AAG in %
BMA	48.67	71	5	76	27.33	3.2
Western segment						
APZ 1 Bidadi, Kanakpura	1.54	1.91	2.30	4.21	2.67	6.78
APZ 2 Nelamangala	0.27	0.34	1	1.34	1.13	13.15
Magadi Interstitial Zone	0.21	0.24	0.2	0.44	0.23	5.05
Eastern segment						
APZ 3 Devanahalli and Doddaballapura	1.08	1.47	0.8	0.27	1.19	5.08
APZ 4 Hoskote	0.31	0.54	0.2	0.74	0.43	5.97
APZ 5 Anekal	0.36	0.55	0.4	0.95	0.59	6.68
Total BMR + BMA	**52.38**	**76.05**	**9.9**	**85.85**	**33.47**	**3.35**

Source: Structure Plan

1.4. ZONES

Because of various ongoing developmental activities in BMR electronic corridor development along the ORR, the induced industrial activities of KIADB did result in innumerable land conversions to non-agricultural activity and mushrooming of several layouts. Under the Structure Plan, the Master Plan had to be prepared in accordance with the KT & CP Act especially for satellite towns. The Interim Master Plan (IMP) have been prepared for the LPA's of Kanakapura, Ramanagar – Channapatna, Magadi, Nelamangala, Hoskote and Anekal. Interim Master Plans are awaiting government assent after which they define the land use development. The Structure Plan defines several zones in BMR, known as Area Planning Zones (APZ) and Interstitial Zones (IZ) as detailed in Table 5.

Table 5: Area Planning Zones (APZ) and Interstitial Zones (IZ) of BMR

Zone	*Span*	*Suggestion in Structure Plan/ remarks*
APZ 1	Existing BDA/ green belt outer limit to the fringe of BMR administrative area	Constitution of a special area planning and development authority
APZ 2	Nelamangala LPA (urbanisable block)	KIADB should promote it as a high priority site for location of major new inward investment for industrial development
APZ 3	Bangalore International Airport Planning Authority (BIAPA) area	"Action Area Corridor" between the proposed Northern Peripheral Ring Road and the city conurbation.
APZ 4	Hoskote town and the LPA	Common "tank" water management agency to be constituted to manage the corridor circumscribing the chain of seasonal water bodies.
APZ 5	Anekal LPA plus extension up to western boundary of Anekal *taluk.*	
IZ 1 to 6	Land areas lying between APZ's and /or corridors	Long-term spatial policy to be adopted. Agriculture should be improved. Area not exceeding 100 ha should be set apart for industrial use.
IZ 1 to 3	In the western segment	
IZ 4 to 6	In the eastern segment	Promotion of agriculture

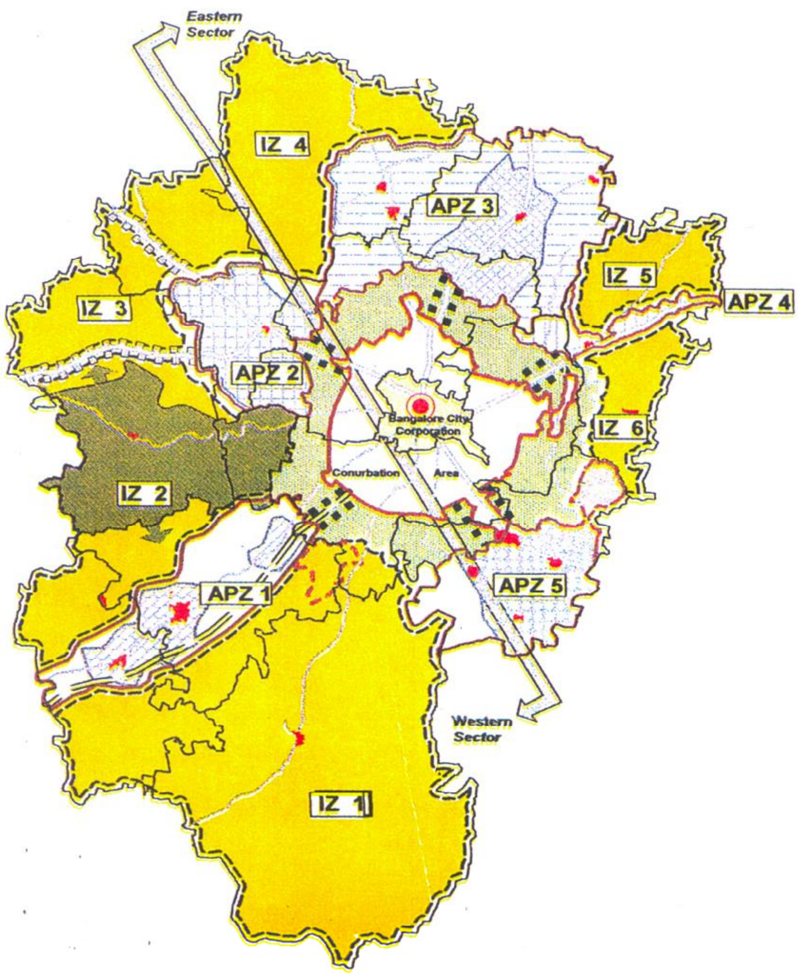


Figure 3: Locations of the APZs and IZs

1.5. ANALYSIS

Weakness

- Delay in the application of Structure Plan policy
- No coordination between Structure Plan policy on industrial development and KIADB plans
- Delay in the implementation of Interim Master Plans

Opportunities

- The western segment can be developed to optimum usage of land and infrastructure
- Development of connectivities such as the STRR, IRR and ring roads will attract development of corridors and employment
- A faster dispersion of population and distribution of population will retrieve pressure on the BMA

Threats

- Chaotic development in eastern sector and insufficient infrastructure on the western segment under utilisation of land and infrastructure
- If activities are not dispersed fast, increased pressure will be felt on traffic and transportation in BMA.
- If industrial atlases are not prepared for BMR there will be no check on the type of industrial activities in the two segments resulting not only in environment degradation but also a heavy toll on the infrastructure available in Bangalore

The urbanisation rate in Bangalore city is more than that of the state. Karnataka has an urbanisation rate of 4% as against Bangalore, which is 88%.

Table 6: Problem matrix

Problems	Impacts	Trends	Remarks
▪ Structure Plan has lost its priorities	Chaotic industrial development and depletion of Infrastructure	The Structure Plan is to be revised taking into account the lost priorities. The trend to transgress original policies/ proposals enunciated is very much there in the urban framework. This trend should be avoided. The policies/ proposals should be active until proved detrimental to urban fabric.	Adequate policies have to be framed to contain imbalance in development. Also, the regional development concept will be lost.
▪ Delay in approval of Interim Master Plan and preparation of Master Plans	The development plans of urban areas in BMR are yet to be approved by government. This will lead to confusion in land management, land use and also apprehensions in the minds of public.	The Interim Master Plans are awaiting government approval. Already there is delay and this has caused uncertainty in urban development. If approval to Master Plans is delayed further, the proposal will lose priority. Everything has to be re-casted and previous exercises will be a wasteful one.	Presently, there is no scope for a regional planning in the KT & CP Act to plan for rectification of regional imbalances. Hence, the model Act prepared by Town and Country Planning Organisation (TCPO) should be included as part of the KT & CP Act with due modification. This will also help in dove-tailing of plans by the district/ Metropolitan Planning Committee.

1.6. IMPACT MATRIX

Table 7: Impact of urban planning on environment

Issues	Environment pollution	Encroachment of land	Blockage of valleys due to development in sensitive zones	Infrastructure development to areas outside conurbation	Industrial pollution
Non-implementation of Structure Plan and Master Plan	High	High	High	Medium	High
Housing shortage in BPL/ EWS scheme	High	High	High	High	Low
Traffic and transportation management	High	Low	Medium	Medium	Low
Non-development of Parks/ playground/and green belt issues	High	Medium	Medium	Low	High
Valleys, rivers, *nalas* and tanks	High	High	High	High	High
Land utilisation	High	High	High	High	High
Utilisation of ground water and sanitation	High	Low	High	High	High
Waste	High	Medium	Medium	Low	High

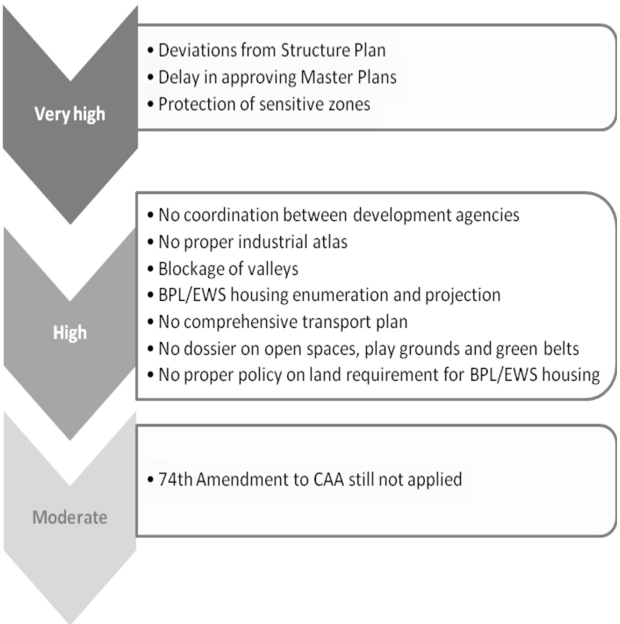


Figure 4: Urban planning prioritisation matrix

The urban planning impact issues have been categorised and prioritised based on SWOT analysis and details. The issues have been put into an urban planning issue activity index. The impact on environment due to urban planning is ranging from high to medium. The priority table indicates that the two top slots of Figure 4 (high or very high priorities) are crowded with a host of critical issues while there is hardly any issue that is only of moderate priority.

Figure 5: Raising the skyline – Low, old buildings giving way, Kamraj Road

2. HOUSING

2.1. INTRODUCTION

Housing, besides being a basic requirement for urban settlers also holds key to accelerate the pace of development. Investments in housing like in any other industry have a multiple effect on income and employment.

Table 8: Population distribution in BMR (in lakh)

BMA[1]			(BMR – BMA) + villages		
2001	**2021**	**2031**	**2001**	**2021**	**2031**
62	100	124	19	60	84

Note: Population is calculated taking a growth rate of 4% as given by the BMRDA.

2.2. POLICY REVIEW

A review of certain policies related to housing problem has been discussed below. Some of the policy highlights are sourced from the articles and draft reviews held in various forums.

> The population and housing projected for 2001 as per the 1995 CDP for Bangalore was 58 lakh and 12,88,889 respectively. But, according to census, the population growth has exceeded the anticipated growth by 4 lakh totalling to 62 lakh people.

2.2.1. Housing policy

In Karnataka the total number of households as per 2001 census is 10.4 million with a total population of 52.9 million and household size of 5.1. The National Housing Policy 1994 and National Housing and Habitat Policy 1998 have emphasised the need to promote the housing activity on priority. The key objectives are:

- To promote the housing sector as an economic activity contributing to development of economic and social infrastructure and employment opportunity.
- To facilitate and encourage the housing development through private enterprises, public agencies and housing co-operatives.
- To streamline the procedure for acquisition, approval and execution of housing projects.
- To strengthen the role of local bodies in promoting the development of housing and related infrastructure.

2.2.2. Slum policy

The slum policy considers the following aspects:

- Improvement in the condition of slums into a normal, hygienic locality by providing basic amenities, reducing congestion and upgrading housing facilities should be the first priority of all public agencies concerned such as Karnataka Slum Clearance Board (KSCB) and the Urban Local Bodies.
- Grant of tenurial rights to residents shall be an important element of the strategy for development of slums. This reduces encroachments and squatter approach. This will induce confidence and also an incentive to maintain their environment clean.
- NGOs involvement in motivating slum dwellers to participate in the slum development programs.
- BDA and UDAs to transfer 5% of land to KSCB free of cost for creation of land bank for relocation of slums wherever necessary.
- Simplification and streamlining of the process of regularisation of slums and acquisition of land occupied by slum dwellers.
- Participation of the community in design, implementation, maintenance and management of slum improvement and housing projects for long-term success. Slum dwellers may have to be relocated because ownership disputes.

Figure 6: Solitary slum shed, Pottery Road

However, when they are relocated it is better to take their aspirations into consideration within the constraints of funds and materials especially in the size and type of houses, community toilets/baths, site and services, etc., which will help in maintaining the environment clean.

2.2.3. Infrastructure policy

- To ensure that the infrastructure facilities in the state are sufficiently expanded and upgraded to meet the growing requirements of industrial, agricultural and population growth.
- To adopt a coordinated and integrated approach to infrastructure development.
- To welcome private investment and participation in developing infrastructure in the state and to stimulate and attract private investment and participation.

Incentives under the policy comprise of:

- Government land may be provided at concessional rate except in corporation and city municipal areas
- Where private investors fail to obtain the land required for projects, KIADB will acquire land charging concessional administrative charges and hand over the same to investors.
- Wherever an infrastructure project by itself is not financially viable, the private investor would be allowed to develop suitable commercial activity to ensure a reasonable composite internal rate of return.

Figure 7: On the way – Metro construction at M. G. Road

2.3. HOUSING DEVELOPMENT

2.3.1. Housing schemes for the poor

- Ashraya sites programme under which the State Government through the Deputy Commissioners identifies the land for formation of sites which are distributed free of cost.
- Ashraya Rural Housing Programme is the most important housing programme for the poor in Karnataka. The unit cost of a rural Ashraya house is INR 20,000 of which INR 10,000 constitutes subsidy and the remaining amount is given as loan from the

Housing and Urban Development Corporation (HUDCO).

- Ashraya Urban Housing Programme where the unit cost of a house is INR 30,000 of which the beneficiary spends INR 5,000 and the rest is provided as loan by HUDCO.
- Dr. Ambedkar Housing Scheme, a State Government scheme, provides houses to members of Scheduled Castes and Scheduled Tribes. The Government meets the entire cost of INR 20, 000 per house.
- Indira Avas Yojana is a centrally sponsored scheme. Here, 80% of the cost is borne by the Government of India and the balance is contributed by State Government. The ceiling on grant of assistance per unit cost under this scheme for construction of new house and upgradation of unserviceable kutcha house is given under the criteria for allocation of resources from Central Government to the States/UTs on the basis of poverty ratio and housing shortage, with each of these variables being given equal weightage. Poverty ratios prepared by the Planning Commission are used for this purpose, while housing shortage is determined on the basis of last census.
- Neralina Bhagya, a State Government program is a scheme for upgradation of thatched roof to tiled roof, for which a subsidy of INR 5,000 is provided per house.

Table 9: Construction and upgrade cost

Activity	Plain areas	Hilly/difficult areas
Construction of a house including sanitary, latrine and smokeless *chula*	INR 25,000	INR 27,500
Upgradation of unserviceable households	INR 12,500	INR 12,500

2.3.2. Agencies involved across Karnataka

There are four main agencies, which are responsible for housing development in Karnataka.

Karnataka Housing Board (KHB)

The KHB was established under Karnataka Housing Board Act 1962 as a successor to the Mysore Housing Board, which was constituted in the year 1956. The primary objective of KHB is to make such schemes and to carry out such works as are necessary for the purpose of dealing with and satisfying the need of housing facilitation. With this directive, the KHB endeavours to meet the housing needs of the people of Karnataka at affordable cost and therefore, it is the most important agency for housing development in Karnataka.

The Karnataka Slum Clearance Board (KSCB)

The KSCB was constituted in July 1975 under the provisions of Karnataka Slum Areas (Improvement and Clearance) Act 1973. The function of KSCB is to cover all the declared slum areas existing in the jurisdiction of City Corporation/ City Municipalities/ Town Municipalities and Town *Panchayats* in the State for improvement/clearance/rehabilitation of slum dwellers.

Rajiv Gandhi Rural Housing Corporation Limited (RGRHCL)

RGRHCL is a Government company established by the Government of Karnataka to cater to the housing needs of economically and socially weaker sections of the society.

Police Housing Corporation, Karnataka

Police Housing Corporation, Karnataka deals specifically with the housing needs of police personnel. Since its scope is limited to its own personnel, its contribution at the macro level is not much. However, its contribution towards specific housing needs is commendable.

2.3.3. Agencies involved in Bangalore

Until 2006 the Bangalore Development Authority played an active role in the housing development of Bangalore.

- 2,750 acres of land have been developed under Arkavathi Layout Scheme in Bangalore North. Under this scheme 2000 sites have been allotted to general public.
- 298 acres of land are being developed under Sir. M. Visveswaraya Layout Scheme. Under this scheme 3000 sites will be developed and allotted as incentive sites.
- 29 acres of land are being developed under BSK VI Stage in Bangalore South and further extensions are envisaged under the scheme. Under this scheme 490 sites will be developed and allotted to general public.

It is proposed to develop an eco friendly layout in Bangalore South *taluk* and an IT corridor layout in Bangalore East.

Table 10: Sites developed by BDA and private agencies as of 2006

Division	BDA	Private agencies
East	4,837	10,402
West	5,060	22,577
North	8,892	2,760,771
South	31,293	31,706
Total	**50,082**	**2,825,456**

The Government of India slum development scheme called the Valmiki Ambedkar Malin Basti Awas Yojana

(VAMBAY) was launched in March.2002. In one year, 10,312 houses are to be built in Bangalore and 19 other towns and cities in the State with a total project outlay of INR 57.65 crore. Of this INR 28.82 crore will be provided by the Central Government, as subsidy and the balance would be borne by State Government. A sum of INR 14.46 crore has been released. Apart from construction of houses, the project involves construction of 279 ten-seater community toilets. In the first phase 84 houses would be built out of which 13 in Bangalore and 71 in other parts of Karnataka.

Table 11: House for economically weaker section (EWS) and below poverty line (BPL)

District	Total number of houses constructed
Bangalore Urban	5,210
Bangalore Rural	607

Source: Karnataka Slum Clearance Board

Table 12: Details of work taken up by Rajiv Gandhi Rural Housing Corporation Limited

Area	Houses allotted under Ashraya Scheme	Houses constructed under Dr. Ambedkar Housing Yojane	Houses constructed under the Indira Aavaas Yojane	Slum Development Board Programme	Total
Bangalore Urban					
Bangalore City	78	342	773	200	1,393
Anekal	32	171	313	0	516
Bangalore Rural					
Doddaballapur	29	138	296	-	463
Hoskote	26	125	297	-	448
Nelamangala	22	102	305	-	429
Ramanagar					
Channapatna	-	-	-	-	-
Kanakapura	-	-	-	-	-
Magadi	-	-	-	-	-
Ramanagar	-	-	-	-	-
Total	***187***	***878***	***1,984***	***200***	***3,249***

Source: RGRHCL (Feb 2008)

2.4. HOUSING REQUIREMENT

2.4.1. Current availability

Table 13: BPL/EWS housing details

	Area	Declared slums	Population
1.	Bangalore Urban	219	369,711
2.	Anekal	4	1,780
3.	Kanakapura	8	3,651
4.	Doddaballapura	11	6,760
5.	Devanahally	9	4,075
6.	Channapatna	6	3,095
7.	Magadi	7	2,149
8.	Ramanagar	8	4,298
9.	Hoskote	2	1,515
10.	Nelamangala	4	1,883
	Total	***278***	***398,917***

At the macro level it is felt that there is no housing demand survey conducted at regular intervals. Hence, it is difficult to assess the housing demand and supply parameters. Also, due to lack of coordination between different agencies involved in providing housing facility the below poverty line (BPL), economically weaker section (EWS), low-income groups (LIG) housing programmes are neglected.

Figure 8: Urban expanse – View from Shivaji Nagar to Nandi Hills

Table 14: Housing stock of BMR

Area	Total/ Rural/ Urban	Total number of census houses	Total number of households	Total number of vacant census houses	Total number of occupied census houses
District - Bangalore	Rural	225,289	163,932	26,453	198,836
District - Bangalore	Urban	1,650,379	1,254,357	144,537	1,505,842
District - Bangalore	Total	1,875,668	1,418,289	170,990	1,704,678
City - Dasarahalli (CMC) District - Bangalore	Total	91,071	70,832	8,843	82,228
City - Byatarayanapura (CMC) District - Bangalore	Total	52,813	40,438	6,652	46,161
City - Pattanagere (CMC) District - Bangalore	Total	30,073	23,157	3,397	26,676
City - Bangalore (M Corp.) District - Bangalore	Total	1,225,307	932,934	92,683	1,132,624
City - Krishnarajapura (CMC) District - Bangalore	Total	50,186	40,208	4,520	45,666
City - Mahadevapura (CMC) District - Bangalore	Total	44,927	34,729	5,185	39,742
City - Bommanahalli (CMC) District - Bangalore	Total	65,885	49,365	7,965	57,920
District - Bangalore Rural	Rural	401,004	302,905	30,460	370,544
District - Bangalore Rural	Urban	112,997	80,687	10,026	102,971
District - Bangalore Rural	Total	514,001	383,592	40,486	473,515

Note: The data above is adopted from Census 2001 when Bangalore Rural district comprised of the present Ramanagar and Bangalore Rural districts. *Source: Census 2001*

Figure 9: Enter development, exit tree – View from Shanti Nagar

2.4.2. Requirements of BPL families

The housing demand in BMR is met by the public and private agencies. The private agencies like the housing co-operatives, housing societies and group-housing agencies generally cater to the housing needs of middle income group and higher income group. The earlier stipulation of earmarking about 10% of land for EWS has been dispensed with since hardly any concern is shown towards EWS housing in private sector. Generally, when the public agencies like ULBs, KHB, RGRHCL, BDA, develop layouts, the group housing reservation of 25% is made for EWS.

Table 15: BPL population in BMR (in crores)

BMA			(BMR- BMA)		
2001	2021*	2031*	2001	2021*	2031*
9.6	15.67	19.4	6.7	21.5	30.03

Note: Calculation based on the same percentage as in 2002

** Projected figures*

15.7% of families in Bangalore urban area are below the poverty line and 35.8% in Bangalore rural areas as on 2002 (High Power Committee for Redressal of Regional Imbalances Report, June 2002). By 2031, 50 lakh (Estimated by Centre for Urban and Rural Infrastructure Planning-CURIP) people can be expected to be below poverty line if the same ratio persists which translates into a housing demand of 10 lakh houses (Assuming the same percentage to continue). The total houses built during the current period are 9,015 say

9,000 units assuming that all the units mentioned in 2.3.3 have been constructed.

As there are no authentic figures available on the number of BPL/EWS families having houses, a reasonable figure of 35% has been assumed as the number of families who have been housed. Based on this assumption 65% will have to be provided with houses/sites. Based on the estimated quantity of BPL/EWS units required by 2031 and reducing it to yearly demand, the annual requirement = 65000/12 = 5,416 numbers which is a tall order.

Working forward on the land requirement by assuming an area of 60 m^2 per EWS plot, the land requirement for EWS is 39,00,000 m^2 (3900 ha/ annum) relating to the projected year of 2031 the area required will be 1, 17,000 ha. This estimated area of 1, 17,000 ha for 2031 has to be distributed in BMR in proportion to the BPL ratio or EWS ratio ranging in the vast BMR spread. It is in this area of housing for BPL/EWS, an imbalance study between the housing available for others and BPL/ EWS should be made to assess the gravity of the situation.

In, the estimated population of BMR is 208 lakh by 2031 and the total number of houses required would be 42 lakh. Out of these 23.89 lakh houses are available in some condition. Deducting this figure, 28.11 lakh houses are required in BMR out of which a minimum of 6.5 lakh houses would be required for BPL/ EWS families.

2.4.3. Implications

The estimated demand for housing implies that nearly 1 lakh houses need to be built every year. The projected water demand for construction is 20 million m^3 annually or 54 MLD. Similarly, the annual requirement of sand is 75 lakh m^3, stone aggregates 50 lakh m^3 and size stone is 50 lakh m^3, clay required for bricks is about 50 lakh m^3 and firewood required for making bricks is about 8 lakh tonnes/year. All these resources create tremendous environmental pressures. There is already a shortage of sand, water, stone aggregates, clay, firewood and the deficit will increase further.

2.5. RESPONSE TO THE SHORTAGE

- Government land to be supplied for composite and joint venture housing schemes in partnership with private sector.
- KHB role and function to be restructured to shift its focus from house builder to land assembler.
- To provide land for group housing for the urban poor at subsidised or controlled price
- Device innovative housing schemes to meet the housing needs of urban poor
- Compulsory acquisition of land in group housing schemes and layouts such as multi-storeyed housing or semi detached houses on Government or acquired land.
- Redevelopment of slum areas by constructing apartments for them.
- Eco-friendly houses using alternate local materials to be encouraged for housing schemes. Specific guidelines for use of recycled water for construction, hollow cement blocks instead of clay bricks, etc., to be considered.

2.6. ANALYSIS

Trends indicate that Bangalore alone has been attracting more than 50% of all the housing and urban investments in BMR. This is in contrast to the idea of decentralisation. Based on the census 2001 data, we find that a total of 39.5 lakh houses are there in the BMR (BMA 34.35 lakh houses and in the remaining BMR – 5.15 lakh houses). With a projected population of 208 lakh in 2031, the total number of houses required would be 42 lakh. This means that nearly 2.5 lakh houses are required by 2031. A special study has to be taken up to assess:

- BPL/APL categories
- Income distribution
- Socio-economic status
- Land requirement
- Location
- Quality economic housing
- The provision of land for BPL/ EWS at the present spiralling of land price will reach a stage when land, even at subsidised rates, may become unavailable. There is need for a clear land policy or nationalisation of land may be the only recourse. The nationalisation of land will end the speculation involving land.
- Land tenancy for slum dwellers in BPL/ APL categories
- Income distribution
- Socio economic status
- Tenure policies will have to be framed.
- An amendment to the KT & CP Act may be brought to provide land for housing development up to 20%

for BPL/ EWS housing. In group housing ventures by private agencies, an amount in lieu of 20% of land based on the market value may be recovered for investment in the land elsewhere for the BPL/ EWS category.

Strengths

There is no dearth of public agencies to provide housing requirements, be it EWS or others. The key strategies suggested in the Structure Plan especially provide land for group housing and innovative housing schemes for poor.

Weakness

The agencies dealing with dwellings for EWS/BPL have not envisaged the future requirement in this sector. The area estimated at 117,000 ha for the year 2031 in the EWS/BPL sector is huge and unless a study is made on the entire land use and availability for such a development, it will not be easy for any agency to provide the required housing. In case of insufficiency of land for EWS/BPL development it may be necessary to think on group housing/sector development houses based on a broad socio economic survey in order to ensure the requisite type of development. For example if group housing is provided in a particular area, the socio–economic activities that are indulged by the identified sector does not favour a group housing scheme, other schemes such as sector development should be taken up. Otherwise, it will only be an exercise in futility. There are plans for many integrated townships on the anvil in BMR. These townships are outsourced to private sector which rarely plan for housing for poor except probably for a relocation scheme for the dislocated population. This is not enough as a housing provider.

Opportunities

There is a move to revise the Structure Plan. The zoning regulations of the Master Plan should have inbuilt provisions to accommodate housing for the poor in plot development/ group housing by the private sector. This may be in the form of land or built houses. It is thus imperative, to frame or revise the zoning regulations. Thus is provided for in the KT & CP Act also. Private participation should be encouraged to develop reclaimed slum areas so that rehabilitation through redevelopment can be made possible. A clear land policy relating to population–income–area available should be made for BMR so that the spiralling prices will be brought down to make it available for the real needy sector of the population at affordable rates.

Threats

Encouragement of housing by private agencies sans the EWS sector will result in encroachment and agitation. The imbalance in housing will increase over the years leading to 2031 if no study is made on providing the requisite 10 lakh EWS housing units by identifying land and type of provision.

- Sand which is an important ingredient for housing will be in great demand in BMR (refer to 2.4.3). Sand mining/ quarrying should be allowed only where replenishment is possible. This is possible in flood prone valleys which will carry sand/silt. This can only be seasonal. The clearing of sand should be allowed only where sand/ silt are mined/ quarried. It is learnt from reports that demand out runs supply. Generally, one cubic meter of earth when filtered yields 0.8 cubic meter of sand. Hence, recovery of sand from soil by cleaning/ washing should be avoided as it is detrimental to the environment.
- Use of recycled water from BWSSB recycling units should be made mandatory for construction purposes. Ensuring the quality of recycled water is critical for which KSPCB, BWSSB, BBMP and departments concerned with housing should device a plan.
- In order to help implement the ban on illegally operating stone crushers, mechanisms need to be devised to inventorise the resource requirement for housing and the source of procurement to be traced. Construction plan sanction by the authorities should strictly monitor that sand, water, stone aggregates used for construction to be procured from legally authorised sources. Mechanisms to authorise these sources also need to be found.
- In tank and lake beautification the tank spread is usually not taken into consideration. The silt on the tank bed is used for beautification. This should be avoided as the character of tank/ lake is lost. The outsourcing of tanks/ lakes for beautification is bad in principle as the tank spread is the property of government. Maintenance by government can assure protection of environment, quality of water ensured by weeding out unwanted growths in the tank and on the tank bed. This renders the environment clean and preserves a pleasing appearance. It also attracts tourism as it could be a quiet relaxation centre instead of money generating pollutant by outsourcing since it could lead to decay of the water spread. The wetland development departments should consider this issue.
- In the BMA urban context, biodiversity hotspots such as Lalbagh, Cubbon Park, etc., have been identified. Defense establishments have vast open areas in places like Jalahalli Airforce area, HAL, etc. There are other hotspots too which have been dealt with in the forest sector. The encroachments or widening of roads for housing sector which cuts into the biodiversity hotspots should be avoided. However, it is easy to say that encroachment into biodiversity hotspots be avoided but when urban development is continuous and not restrained, inevitably some sacrifices will be necessary to ease the traffic. Hence, the containment policy for arresting urban development is very much needed.
- BMR is a fast growing urban situation due to influx from over congestion in BMA. Hence, it is appropriate that a containment policy for growth in BMR and especially BMA is spelt out now. A dossier of biodiversity hotspots in the BMR should be prepared. These identified hotspots in BMA should have separate zoning regulations based on their type and classification.

Table 16: Problem matrix

Problems	*Impacts*	*Trends*
▪ No proper estimation of housing stock made for BPL/ EWS. ▪ Probable areas have not been identified in urban areas to provide for BPL/ EWS housing. ▪ No proper land policy to reserve the land stock in urban areas for BPL/ EWS housing. ▪ Absence of legal reforms for land reservation in housing schemes and to stress the importance of housing to BPL/ EWS in these days of inflation and ill affordability.	Bangalore is stressed to the seams. Every new enterprise creates jobs not only at the higher level but also at the lower levels. It is in this lower levels that affordability will become a problem due to spiralling land prices and inflation. This has an impact on the environment too. Unless new enterprises are shifted away from BMR and BMA to relieve the pressure, BMR will burst at the seams.	The present trend is on group housing and integrated township. However, these hardly recognise the socio-economic factor of housing for the weaker sections. If this trend continues there will be unrest, illegal occupation and land encroachment.

3. RIVERS, TANKS, *NALAS* AND VALLEYS

3.1. OVERVIEW

Development of towns depends on the type of geological features, drainage system and water resources. A study of the terrain and drainage system based on topography sheets, satellite imagery and field reality was made for BMR. As the focus is mainly on urban centres the study has been confined to urban centres.

The study brings out the drainage pattern in BMR urban areas especially the areas earmarked for development in the Interim Master Plan. The drainage study helps in determining blockage of storm water passages and valleys into which they drain.

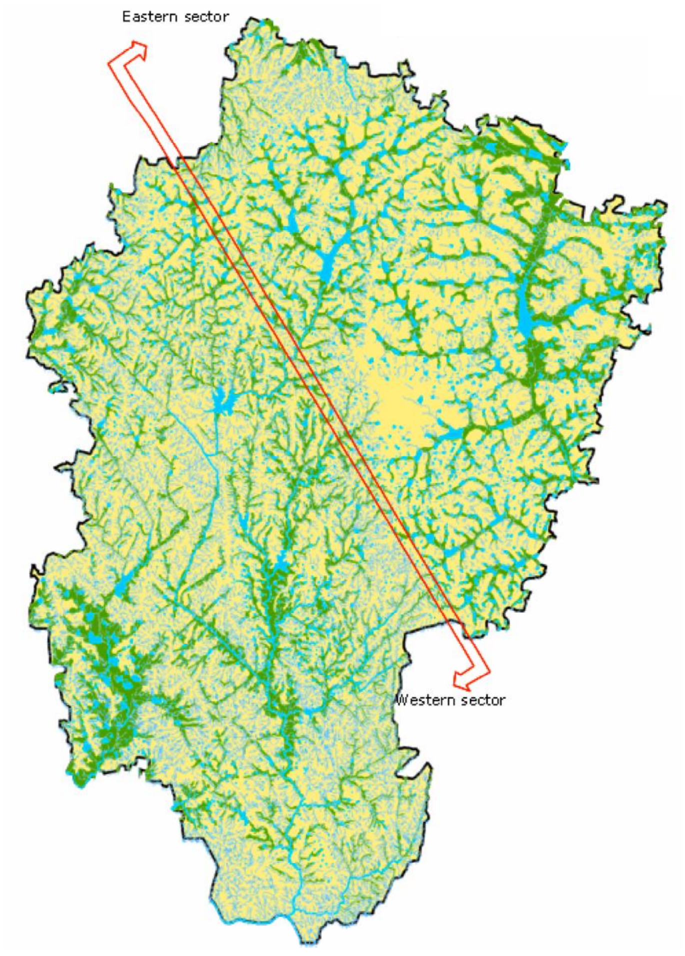


Figure 10: Valleys and drainage network

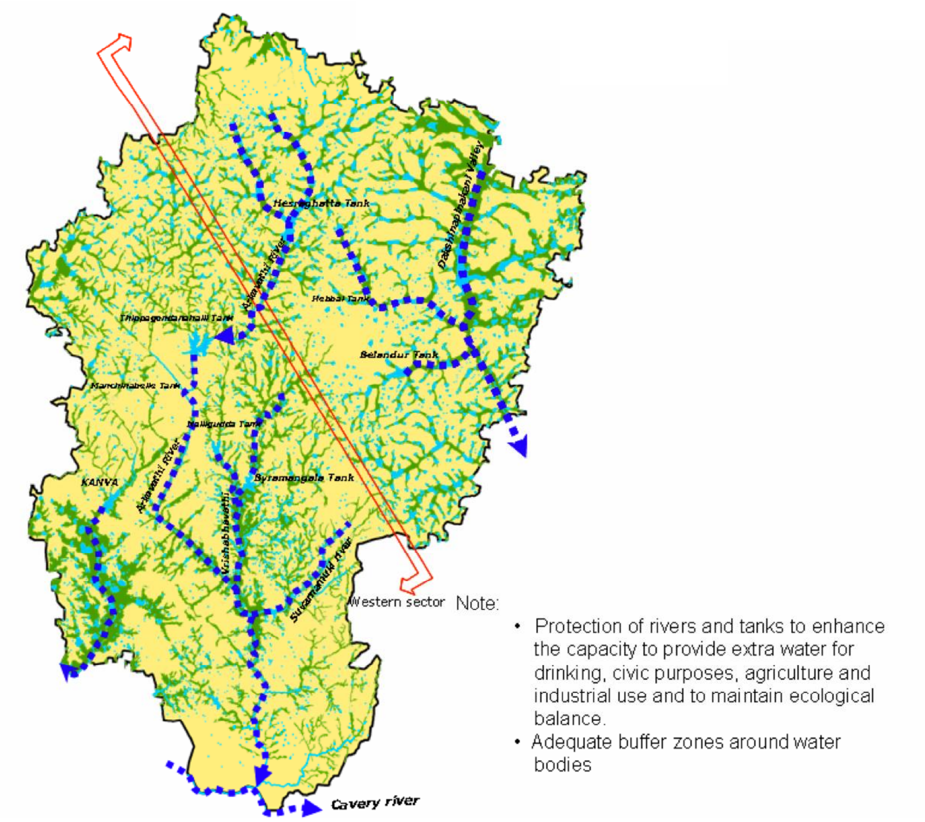


Figure 11: Main river courses and tanks

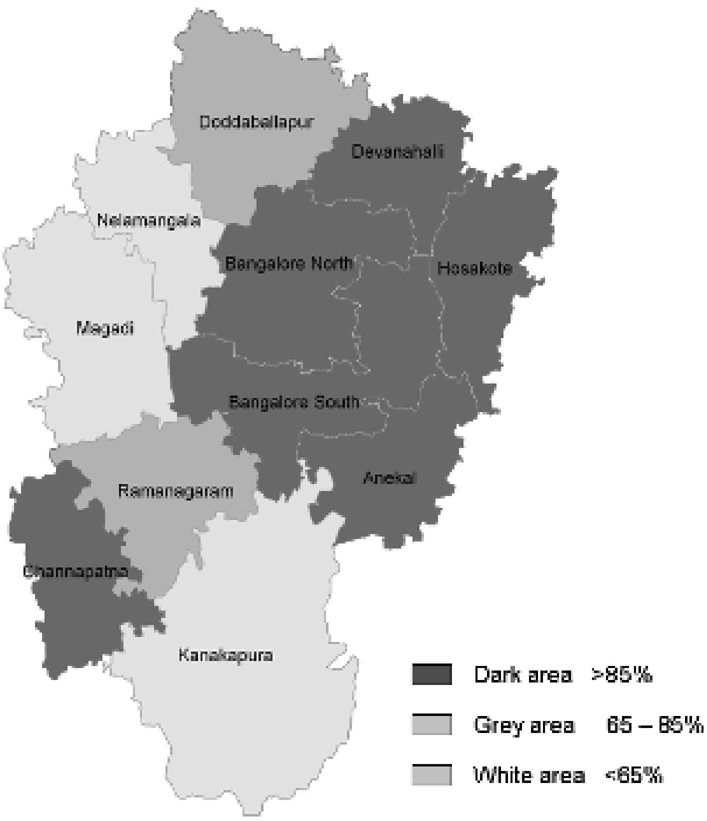


Figure 12: Ground water extraction status

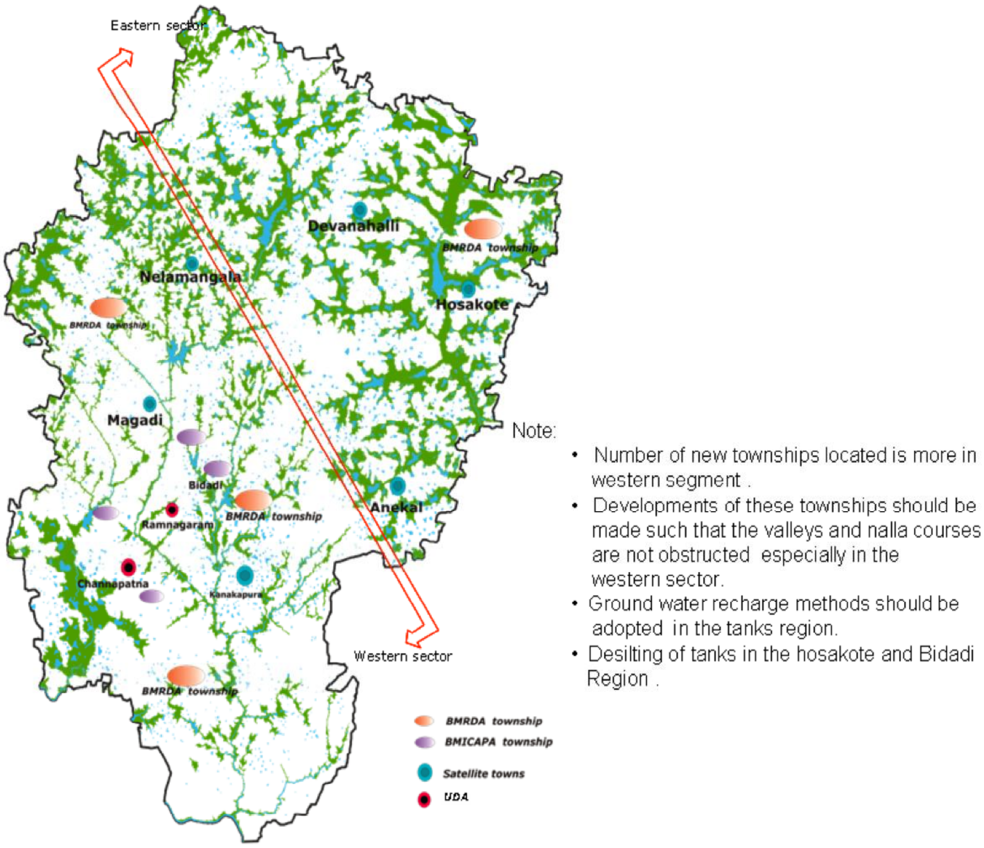


Figure 13: Satellite towns and new townships

The above maps help in interpreting the amount of water that could be made available for BMR. It also helps to determine the direction of flow of storm water through natural drains leading to valleys. This also helps in determining the direction of roads and drains and buffers required. Figure 12 indicates the ground water extraction status in BMR with reference to western and eastern sectors. Ground water extraction is very high in eastern sector. The index indicates percentage of area under dark, gray and white status.

3.2. VALLEYS

BMR is located on a plateau having elevations of 1,067 m to 579 m above MSL with many hillocks and hill stations with elevation up to 1,372 m above MSL. This goes to explain that the drainage of the area is very good and problems are less due to flooding unless the drainages are blocked by indiscriminate development of industrial and residential area.

The general ground slopes from north to south and west to east. Majority of BMR comes under the Cauvery valley basin. A portion of BMR northern and eastern area belongs to Pennar basin. Following are the tributaries flowing in to Cauvery river.

3.2.1. Arkavathi valley

The valley originates in Doddaballapura *taluk* and the course of flow is down north to south into Hesaraghatta reservoir (water supply to Bangalore City), further it flows towards east in to Magadi *taluk* and into Tippagondanahalli reservoir (water supply to Bangalore City). The river further flows down south into Manchanabele dam (an irrigation project) in Ramanagar *taluk* and further crosses Bangalore–Mysore road near Ramanagar town. The river further flows down the south into Kanakapura *taluk* to join river Cauvery at Sangam near Karnataka and Tamil Nadu borders.

Several tributaries join this river on its route. The main tributaries in their respective valleys are as follows:

1. *Kumudvathi valley* – Originates near Nelamangala town and further flows south in to Magadi *Taluk*
2. *Vrishabhavathi valley* – Originates in BMA (in Peenya industrial area) and flows down south to cross Bangalore–Mysore Road and flow down south to Byramangala reservoir (irrigation) and further southwards to join Arkavathi river in Kanakapura *taluk*. This valley carries the perennial flow of major portion of Bangalore city sewerage and most of it is untreated even now.

3. *Suvarna Mukhi valley* – Originates from the hillocks and forest areas of Anekal *taluk* and Harohalli areas and flows eastwards into Vrishabhavathi valley.

4. *Kanva valley* – Originates from Sidda Devana Betta state forest in Magadi *taluk* to flow south in to Kanva dam (an irrigation project) and further flows down south into Channapatna town limits crossing Bangalore- Mysore road, further towards south to join Shimsha River.

Another tributary "Sital kere" *halla* originating and flowing from Chakrabhavi hillock area joins Kanva valley.

3.2.2. Hebbal valley, Koramangala and Challaghatta valley

These valleys are located in BMA urban area which are already fully developed and all the valleys run east to west and in to Andhra Pradesh and Tamil Nadu areas.

Koramangala valley – Starts from Central Business District (CBD) area of Kempe Gowda bus stand to run south to City Market, further east towards old Bamboo Bazaar, J.C. Road, K.H. Road, Hosur Road, Ejipura and on to Bellandur lake. The valley is encroached upon most of the length restricting the width of flow with built up area over the drain walls. This has resulted in flooding in many low-lying areas along the valley. Action is now being initiated to improve and redesign the drainage system by BBMP.

Challaghatta valley – Starts from Munireddy Palya and Palace area (Vasanth Nagar) and runs east towards Ulsoor tank and further down through Ulsoor, Indira Nagar, Golf Course and on to join Domlur lake. The valley runs in fully built up areas with most of the length encroached upon and unauthorised constructions, slums en route, etc. The BBMP has initiated action to redesign and reconstruct the drains to avoid flooding which is prevalent in many areas. BBMP has to finalise its action plan and put it into place at the earliest to avoid flooding disasters. The above 2 valleys join Bellandur tank and the valleys run east to Varthur tank and further flows east in Bangalore North *taluk* to join the Pennar series.

Hebbal valley: Originates from Hebbal tank and flows eastward to join Nagavara tank and on to Hennur area and joins Yelemallappana Kere located on Bangalore – Madras road. This valley joins the valley coming from Bellandur –Varthur lake to join Dakshina Pinakini valley flowing into state of Andhra Pradesh.

3.2.3. Dakshina Pinakini valley

Comprises of Koramangala, Challaghatta, Hebbal valley and the valleys leading from

- Bagaluru kere – Budi Amani kere to flow south east
- Doddajala kere – Bandi Kodigenahalli kere to flow south east
- Hosakote kere on to flow forming Dakshina Pinakini valley

3.2.4. Uttara Pinakini valley

On a small portion of the BMR located on northwest side of Doddaballapura in Chikkaballapur *taluk* this valley runs from south to north and towards Andhra Pradesh. The valley originates in Ghati Subramanya forest area and runs north towards Gauribidanur and into Andhra Pradesh.

3.3. DRAINAGES

3.3.1. Drainage system of Ramanagar

Ramanagar town is located in a trough surrounded by granite hillocks on all sides. The main valley, Arkavathi river flows in the middle of the zone from northwest to southeast to further flow west towards Kanakapura. The whole terrain is of rolling type with sufficient slopes and with good red soil and rocky out-crops. All the storm water runs in to Arkavathi river. There are no flood zones barring a few areas on the river banks.

A medium irrigation dam under "Manchanabele Project" is built across this river on the west side of Ramanagar town about 10 km on the upstream of the river. The canals run in the LPA irrigating few areas. The river goes almost dry during summer.

3.3.2. Drainage system of Channapatna

The topography of this zone is mostly rolling plains with general ground sloping from north to south. The soil is mostly red soil with occasional granite rocky out crops. The Kanva river runs from north to south and passes through the town at south edge to run further south to join Shimsha river.

A medium irrigation dam is constructed across this river located about 8 km to north of the town. Two irrigation canals (left bank and right bank) run in the northern portion of LPA limits. The catchment area consists of mostly coconut orchids, sugar cane and other crops.

Kanva valley runs from north to south in to the town to cut across Mysore–Bangalore road and further runs south to join Shimsha river. The valley is well defined and water flows smoothly in to the river except for an occasional flooding in some places along the bank.

The storm water drains will have to be led ultimately to Kanva river only. Buffer zones with roads on both sides of Kanva river is proposed to avoid encroachments, pollution and for safeguarding the river.

3.3.3. Drainage system of Bidadi

General slope of the zone is from west to east and north to south. Vrishabhavati river runs through this zone from north to south cutting across the whole area and further joins Arkavathi river on the southern side. Another minor river Suvarmamukhi running from west to east joins this valley at southern edge of the zone. One medium irrigation tank has been constructed at Byramangala village which irrigates lands in Ittamadu, Byramangala, Abbinakuppe and other villages. The area is plain rolling and all the rainwater safely discharges in to Vrishabhavathi valley. There are no flood zones barring a few areas on the riverbanks.

Byramangala reservoir constructed across Vrishabhavathi valley receives almost 50% of Bangalore city's sewage making the reservoir always full and over flow all round the year. Due to perennial inflow of sewage the tank is getting silted up. All types of crops cannot be grown in this zone. Most of the lands are not cultivated for want of labour and proximity to urban areas excepting coconut gardens, etc. The reservoir is totally contaminated, unfit for washing/drinking etc., and is a health hazard. It is also learnt that tube wells on this area are also getting contaminated. Therefore, the preservation of the agricultural land/wet land is to be reviewed in the light of the above facts.

It is proposed to lead storm water drains in to the main valley (Vrishabavathi river). It is also proposed to provide sufficient buffer zone and roads on either side of the main valley for protection as well as against contamination and encroachments.

3.4. ANALYSIS

Strengths

The main strength is that BMR is a plateau having elevations ranging from 1067 m to 579 m above MSL. Hence flow of drainage is not a problem if the slopes are protected and flow into valleys is not obstructed.

Weakness

- Vrishabavathi valley carries the major portion of Bangalore city's sewage, most of it is still untreated flow.
- Valleys in the BMR especially in BBMP area are almost fully developed. This has restricted the width of flow and has caused flooding.
- Flooding is heavy especially in the slums located en route and in low-lying areas.
- Urban concrete jungles cover most of BMA in the form of buildings, roads, pavements and lined drainage system. This has depleted the water table due to excess rainwater runoff.

Threats

- The envisaged population by 2031 is 208 lakh. BMA is expected to have a population of 124 lakh. The quantum of encroachment in valleys and the amount of untreated sewage is huge. One can imagine the disaster that could occur due to over pollution resulting in epidemics.
- BMR-BMA will have an adverse cumulative effect due to free let off of raw sewage in the BMA.

Opportunities

- Buffers for the natural drains should be maintained at any cost. The drains should be re-designed to accommodate the free flow. The drains should also be covered effectively. The buffers for drains should never be allowed to be encroached upon.
- Sewage treatment plants along the drain valleys which are polluted due to sewage let-off should be located so that only treated sewage is let off into the BMR-BMA valley area.
- Re-designing of storm water drains and remodeling should be an exercise in priority to match the rate of development. Any mismatch will result in loss of life and property.
- A disaster management cell to deal with calamities due to rainwater floods and sewage flow epidemics should be created at the earliest.

The cause and effect caused as a result of encroachment into drainage network, exploitation of ground water to the environment needs to be assessed, as it is an important factor for water supply as the envisaged population of 208 lakh in BMR has to be thought of. Even if the requisite water is supplied, it means that an equivalent amount of untreated sullage and sewage are discharged. Also, rejuvenation of tanks and lakes is needed to protect the ground water. Hence, it requires not only a Management Action Plan (MAP) but also an Action Management Plan (AMP). This is the reason for creation of R & D wing urgently.

Table 17: Problem matrix

Problems	*Impacts*	*Trends*
▪ Untreated sewage flowing into valley zone ▪ Restriction of width of flow ▪ Depleted ground water table ▪ Flooding en route especially in low-lying areas.	Environment pollution, epidemics outbreak due to expected heavy population of 208 lakh and the consequent possibility of discharge of sewage into valley zone.	Allowing change of land use in the valley zone will destroy the intended buffers.

The Karnataka State Pollution Control board has been directed to:

- Not to 'issue any consent to any new industry, industrial operation, industrial process or an extension or addition there to in Zone-2 and Zone-3 as per schedule mentioned above.
- To allow in Zone -4 as per schedule mentioned above, only those new industries listed in green category subject to adoption of rain water harvesting
- Ensure compliance to the consent conditions so that the industries do not let out untreated industrial effluents in the said catchment and in particular in Zone 2, 3 and 4 as per schedule mentioned above.
- To conduct regular water analysis in both Arkavathi and Kumudvathi Rivers, TGR and tanks within the TGR catchment.

Some of the action plans suggested in a report prepared by BMRDA are as under.

- Declaring the portion of TGR catchment as ecologically sensitive zone.
- Improvement of drainage through following measures:
  - (a) Clean up the main river course of Arkavathi and Kumudvathi by removing weeds and obstacles to improve the flow into TGR.
  - (b) Improvement of minor streams in the catchment
  - (c) Prevention of further development and exploitation of ground water.
  - (d) Revival and rejuvenation of tanks in TGR Catchment
- Prevention of non-agricultural activity in BDA's green belt area and other areas falling outside the LPA of Nelamangala Planning Authority in TGR catchment.
- Curtailment of industrial activity and restrictions on development of new layouts in TGR catchment.
- Consortia approach for waste management by establishing common effluent treatment plants on either side of Arkavathi River and treated effluent to be used for captive consumption or irrigation in co-ordination with the department of forests, ecology and environment.

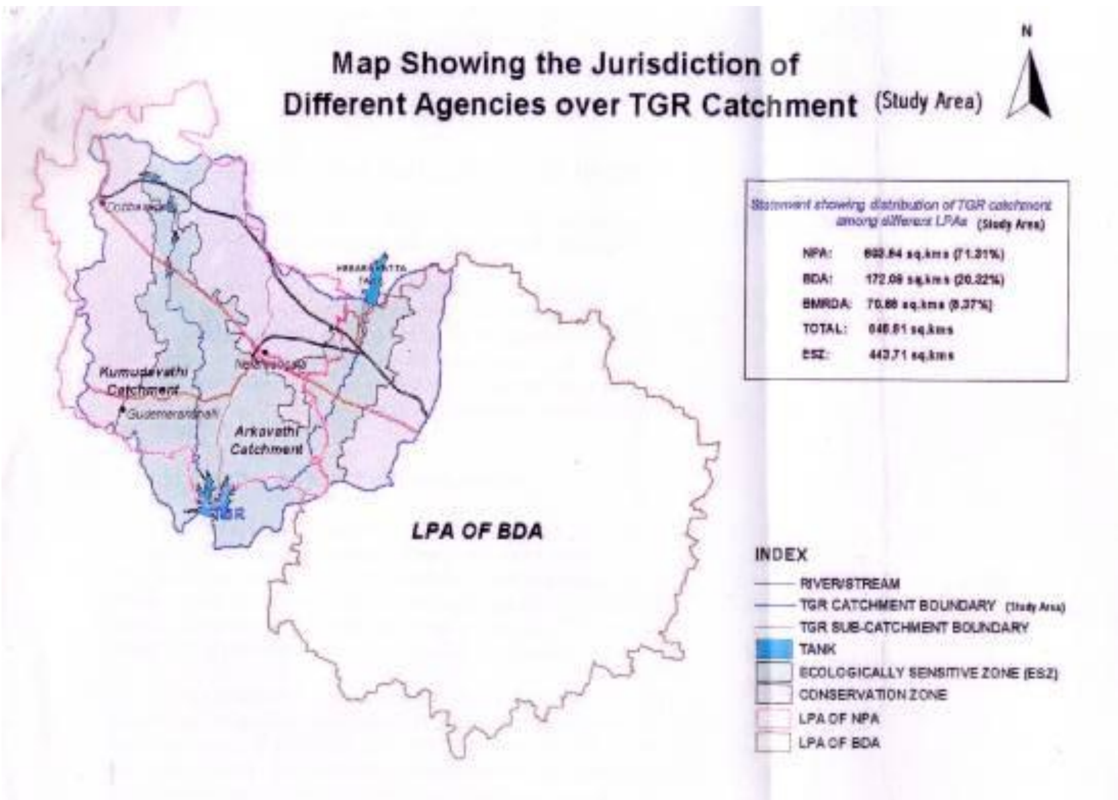


Figure 14: Jurisdiction of different agencies over TGR catchment

4. TRAFFIC AND TRANSPORTATION

4.1. BACKDROP

The most important prime factor for any development on sustainability basis is connectivity. This is more so in BMR as several satellite towns and townships have been planned along the corridors. As an offshoot the movement within the BMA has to be very efficient as otherwise the travel time between BMA and BMR or vice versa will be met with delays. Traffic management will be difficult. In fact, dynamics of development should not get bogged down due to slow movement and connectivity.

Figure 15: Wheels and hoofs: Bangalore accommodate different speeds – Vehicles at J.P. Nagar

4.2. CONNECTIVITY AND MOVEMENT

Figure 16 below indicates the connectivity proposed in BMR. This connectivity when implemented will vastly improve the regional accessibility.

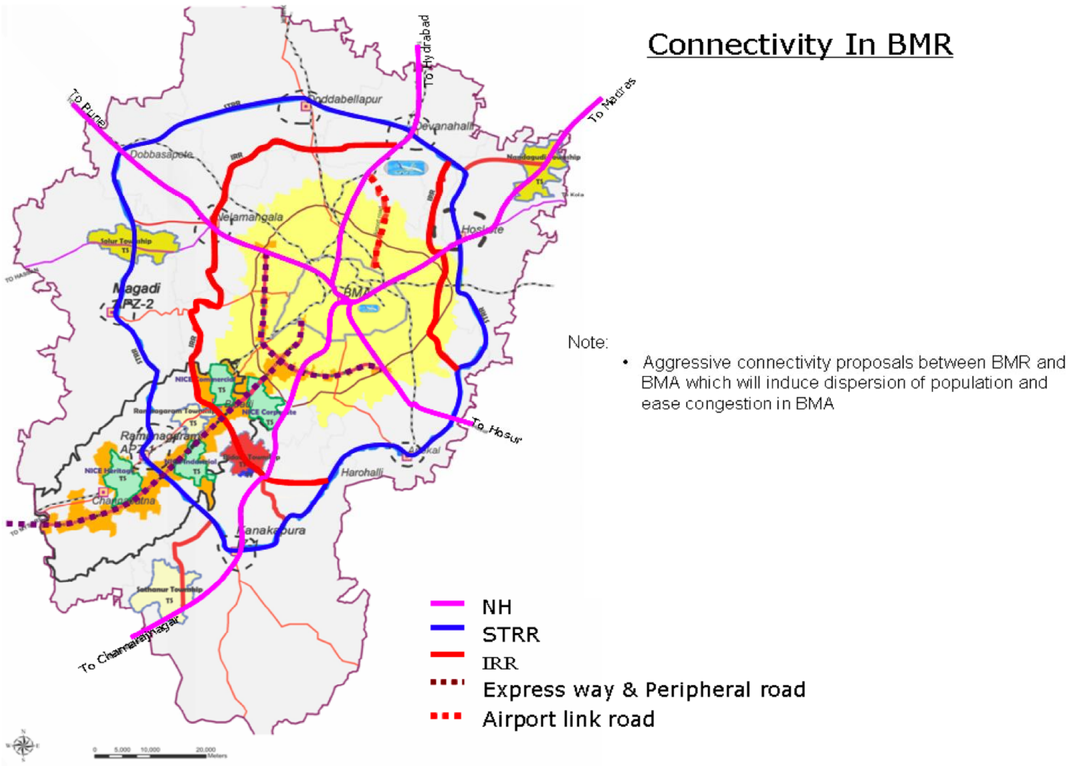


Figure 16: Connectivity in BMR

The important connectivities identified are:

1. BMA Northern Peripheral Road (BMA-NPR)
2. BMA Southern Peripheral Road (BMA-SPR)
3. BMR Intermediate Ring Road (BMR-IRR)
4. BMR Satellite Town Ring Road (BMR-STRR)

BMA has a radial road network. This inevitably leads to passage of vehicles from BMR to pass through BMA as all the work areas are located in BMA. This has lead to considerable congestion and pollution. Further, most of the radial roads in the category of NH and SH do not have service roads. The congestion and pollution load is high when we consider the fact that about 30,000 vehicles account for inter-city traffic in BMA radial roads and main roads with no diversion to service roads.

The traffic in BMA-BMR is of a mixed type with all types of vehicles such as fast moving, slow moving, very slow moving, heavy duty vehicles, 2-wheelers, 3-wheelers, pedestrians and animals too. One can observe the chaotic movement of vehicles with hardly any traffic sense or discipline. This chaotic movement has led to traffic jams, accidents and delays. Traffic congestion and pollution is generally the result of:

- Fast growth and development
- Non-conforming policies
- Indiscriminate change of land use in rural tract
- No estimate on the infrastructure required for rapid development
- No coordination between vehicle registration and capacity of road (About 3 lakh vehicles are being registered in BMA and BMR annually out of which nearly 75% are two-wheelers, 15% cars and light vehicles, 5% heavy vehicles and 5% others)
- Absence of traffic planning and research cell
- Grade separators not planned to disperse traffic. Infact many grade separators have become traffic jam points. (e.g. Anand Rao Circle fly-over, Richmond Circle fly-over) The end points of grade separators have become vehicle accumulation points.
- About 25 to 30% of truck traffic passes through the city area for want of by-pass roads
- Lack of adequate infrastructure and freight transport facilities causing parking and traffic congestion problems along the arterial roads.

4.3. LAND USE AND TRANSPORTATION

Land use and transportation is a very important link in transportation planning and studies. There are two ways to interpret the connection between land use and transportation. One is to consider the land use for origin or destination of traffic, the other is to consider land use as utilisation factor for determining the adequacy or inadequacy of land.

Table 19 indicates the land that requires to be utilised (at the minimum) to maintain the requisite capacity and flow on these roads. Land required (minimum) for roads = {(419 + 689) X 0.045 + 1406 X 0.025 + 54 X 0.012 + 109 X 0.030}. 30 meters is, however, not maintained in the municipal limits. However, it is taken for calculation purpose. Land required = **60.7 km^2 = 6,072** ha which is about 0.76 % of the total BMR. The area actually existing under roads however has not been estimated since the width of the road category wise data has not been prepared by the concerned authorities.

Table 18: Road length in BMR

Area	Category of road					
	NH	SH	MDR	ODR	VR	Municipal limits
BMA	143	187	335	-	-	-
BMR – BMA	276	502	1071	54	565.3	109
Total BMR	**419**	**689**	**1406**	**54**	**565.3**	**109**

Source: Census Hand Book, 2006

Table 19: Road width standards

Category of road	Width in meters	
	Rural limits	Urban limits
NH / SH	45	30
MDR	25	20
ODR	15	15
VR	12	10

Source : IRC Standards 1980

Table 20: Vehicle strength in BMR

As on	Urban	Rural	Total
31/12/2003	-	-	1,991,234
31/12/2004	20,67,949	39,531	21,07,480
31/3/2005	21,86,596	46,332	22,32,928
31/3/2006	24,83,824	1,33,541	25,17,365

Source: Department of Transport

Table 21: Break up of vehicles in BMR

Type	Number	Passenger Car Unit (PCU)	Value
Motor cycles	18,59,994	0.5	9,29,997
Cars	4,01,109	1	4,01,109
Buses	21,913	3	65,739
Tractors and trailers	21,781	4.5	9,80,145
Heavy vehicles	94,181	3	2,82,543
Total PCU			***26,59,533***

As stated earlier, nearly 30% of vehicles ply on radial roads and 25% of freight traffic moves on the by-lanes of BMA. The capacity of roads is strained to the limit. If this increase in traffic population continues it will be impossible to use the intra-city roads. For example from M. G. Road – Dickenson intersection along the M. G. Road 2-wheelers use the footpath meant for pedestrians forming crowd resulting in high air pollution and noise pollution. The travel speed reducing to less than 1.5 km/h, danger to pedestrians and danger of vehicle occupying 10% of the road available.

4.4. FACTORS AFFECTING SERVICE LEVELS

The factors which affect the capacity and level of service are one hand related width, surface condition lateral clearance, alignment and grades of roads and, on the other hand, traffic factors such as composition of traffic. The compounded effect of roadway factors and traffic factors is considerable.

Table 22: Population and vehicles in BMR

Taluk		Population	Vehicles
1.	Channapatna	2,52,574	9,211
2.	Devanahalli	1,85,326	11,779
3.	Doddaballapura	2,68,332	12,692
4.	Hoskote	2,22,430	35,284
5.	Kanakapura	3,37,208	11,747
6.	Magadi	2,02,417	4,875
7.	Nelamangala	1,74,880	10,251
8.	Ramanagar	2,38,347	12,759
9.	Anekal	2,99,428	1,16,478
10.	Bangalore North	8,30,061	3,65,105
11.	Bangalore South	5,17,718	5,90,499
12.	Bangalore East	4,92,206	5,14,778
13.	Bangalore City	43,97,711	9,57,713
Total		**84,18,638**	**26,53,171**

The number of vehicles in *taluks* of Anekal, Bangalore North, Bangalore South, Bangalore East and Bangalore City are very high. In fact the total vehicle population in the above taluks is a staggering 25 lakh which indicates a vehicle population ratio of 1:2.5 and the need for a very comprehensive traffic management plan. It also is a pointer on the effect of vehicles on the roads in these areas.

Practical capacity of two – way urban roads

The urban streets are basically arterial / sub-arterial streets and local streets. On these roads, the main controlling factors on the capacity of traffic flow is the intersection points. These intersections are critical points. Normally the level of service (LOS) is level E or F whose operating characteristics are unstable flow, congestion, forced flow, jammed conditions with an average overall speed of 25 to 15 km/h.

The Level of Services is A to F with a gradation characteristic.
A: Relatively free flowing
B: Stable flow
C: Stable flow with acceptable delays
D: Approaching unstable flow with tolerable delay
E: Unstable flow with congestion and intolerable delay
F: Forced flow with jammed conditions.

Many of the local streets and sub-arteries in the BMA are single lane or two lanes. An orderly lane system hardly exists. The table below indicates the suggested design service values for Indian conditions for single and two lane roads.

Table 23: Service volumes for plain terrain

Type	Suggested service volume in PCU/day
Single lane	2,000
Two lane	15,000

Comparing this with the figures in
Table 20 and number of vehicles in BMA

- Total number of vehicles plying in BMA is 25, 44,573
- Total number PCUs in BMR roads 26,59,533

The figure reflects the gravity of situation in BMR. If this situation persists, then the level of service will be well below the least i.e. level F. The average overall speed will be less than 10 km/h. Further, the latest reports indicate that there are 30 lakh vehicles plying in BMA roads and more than 100 vehicles are being added everyday to this number.

Opportunity

It is a peculiar situation that the opportunities have to be discussed after the threats. This is so since opportunities have to be carved out based on the threats. Traffic problem should be seen as an opportunity to evolve road widening and improvement strategies to ease traffic flow. It should also be seen as an opportunity to minimise the traffic problem. For example Avenue Road width is hardly 5 m wide. If a redevelopment /rehabilitation scheme is drawn for the area by convincing the residents for a demolition scheme with attractive incentives to re-locate the distributed owners, the problem of congestion in the stretch up to majestic area can be solved. There are proposals for constructing fifty-four skywalks for BMA as indicated by the BBMP.

Some suggestions for free flow of traffic are given as below:

- Signal free passage for all major connecting roads in BMR such as STRR, IRR, peripheral roads, outer ring road, Core Ring Road and all arterial roads in the city.
- Non – traffic interference for pedestrian crossings
- Skywalks with escalator facility and subways at intersections for pedestrians should be a priority along with any road improvement undertaken.
- Existing Skywalks should be replaced with escalator facility as they are being under used due to psychology of Human mind to avoid climbing the stairs.
- Planting of proper shrubs, trees and plants along medians to minimise noise and air pollution.
- Compulsory bus bays along bus routes to avoid queuing and traffic congestion.
- Truck terminals at suitable points along major connecting roads to park / download and convey to other points through mini luggage vans.
- Levy of additional fee for entering CBD.
- Deterrant measures for traffic violations such as blocking lanes, using wrong lanes, crossing of yellow lines, not slowing down at zebra crossings, violation of lane discipline on highways and major arteries.
- Provision of 2 and 3 wheeler track and Bus Bays in new layouts.
- Synchronisation of traffic signals

4.5. ANALYSIS

Strengths

- Regional accessibility will improve on account of the four concentric roads proposed
- Express Way proposed to link the International Airport Devanahalli from Kacharakanhalli via Hennur – Banaswadi Outer Ring Road
- Ongoing works on improving the capacity of major Radial Roads (NH4, NH7 and 4-laned SH17)
- Introduction of modern technology in improving intersection

Weaknesses

- Inadequate parking plans
- Road improvement proposals and new roads are not on fast track and inordinate delay in road projects.
- Impediments to Express Way from Bangalore to Mysore. It is nearly 10 years since the project started.
- Inadequate legal protection for acquisition of land and implementation of infrastructure development projects especially roads.
- Non-coordination between local authorities and electric supply/ distribution organisations resulting in obstacles for road widening schemes and high cost shifting the power supply equipments.
- No re-development scheme planned in the congested wards of BBMP. (In fact re-development schemes with incentives will help in improving the inter city traffic movement).
- The width of planned "magic boxes" boxes does not hold for 2-way traffic. A minimum width of 7.5 m may really solve the problem of ensuring through passage of traffic at least to an adequate distance.
- No coordination between stakeholders dealing with land use transportation (work-home relationship), capacity of roads and traffic management
- Absence of R & D cell
- Heavy silting of road drains leading to flooding and accidents
- Pedestrian woes are not addressed. Footpaths are not properly laid and maintained forcing pedestrians to use the road instead (see also Chapter 6 "TRANSPORT", section 2.4). Barricades between road and footpath could ensure that pedestrians do not spill over on the road wherever footpaths are adequate.

Figure 17: Obstruction of traffic, J.C. Nagar

Table 24: Problem matrix

Problems	Impacts	Trends
▪ Very high vehicle registration. ▪ Absence of adequate public transport. ▪ Road network capacity inadequate. ▪ High share of 2-wheelers ▪ Promotion of cycle tracks.	▪ Reduction in travel speed and increase in travel time. ▪ High air pollution ▪ Low level of service ▪ Spillage of vehicle parking into side roads affecting traffic movement ▪ Pedestrian movement is chaotic.	▪ There is a positive step in increasing the connectivity facilities and increase of road width. The flyovers, elevated roads and metro are all on the anvil. However, all this is concentrated with an eye on the travel time to International Airport. The same zeal should be shown to other parts of BMA and BMR. ▪ As the 4-wheeler traffic and motorised 2-wheeler traffic has increased, promotion of cycle tracks by providing cycle tracks along the roads.

5. LAND USE, UTILISATION AND ZONING

5.1. LAND USE AND UTILISATION

Land use and land utilisation are the two important parameters determining land availability and zoning. The term land use is connected to zoning while land utilisation is connected to availability. Land use is related to the Master Plan and determines the zones such as residential, industrial, roads, parks, playgrounds and open spaces. While land utilisation determines the quantum of land available for development.

Table 25: Land utilisation analysis

Land utilisation	Area in km^2	Percentage
Agriculture	5,349.9	66.8%
Forest	828.364	10.4%
Lakes, rivers & streams	339.5	4.2%
Rocky/stony	302.45	3.8%
Land with shrub	394.27	4.9%
Main/Industrial/Wasteland	93.6	1.2%
Habitation	667.1	8.3%
Water logged area	33.67	0.4%
Total	**8,009.73**	**100%**

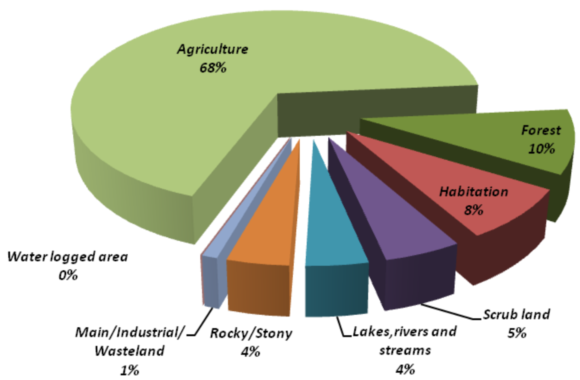


Figure 18: Land utilisation in BMR

Land that is not available for development is in the category of forest, cultivated land, rocks / hillocks and water bodies. Conversion of agriculture land to non-agricultural purpose leads to depletion of agriculture land but makes available for development. It is here that judicious approach has to be made to determine whether valuable agricultural land should be allowed for conversion to non-agricultural (NA) purposes. The land which cannot be cultivated can be made available for development. Water logged area is eco-sensitive hence this land should not be used for development. The land available for development is as at shown at Table 25.

Table 26: Land available for development

Land utilisation	Area in km^2	Percentage
Agriculture	5,349.90	66.8%
Land with scrub	394.27	4.9%
Water logged area	33.67	0.4%
Total	**5,777.84**	**72.14%**

Figure 19: The up and the down side: Flyovers drastically change the perception of living space – Construction at Wheeler Road

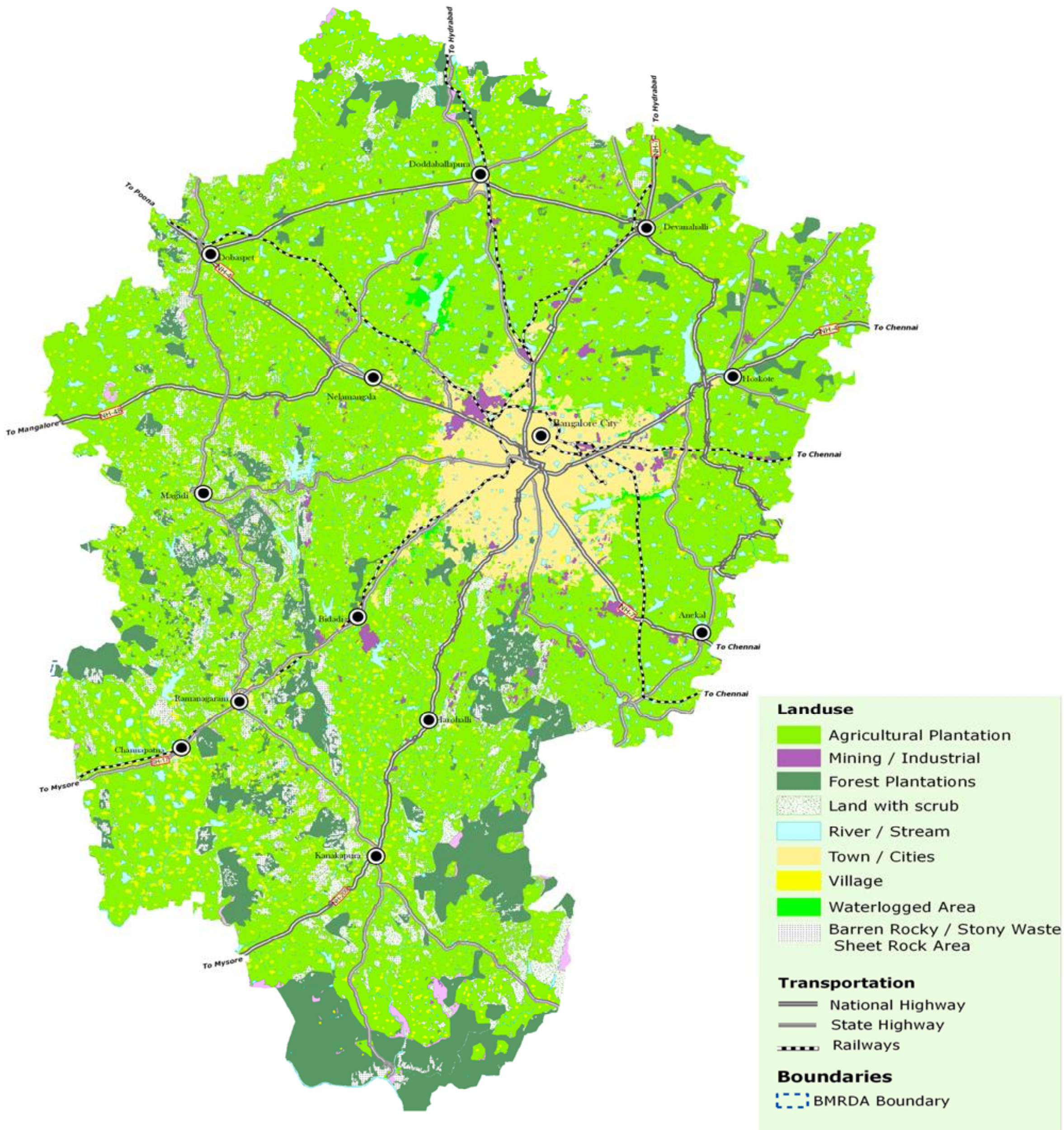


Figure 20: Land utilisation in BMR

5.2. CARRYING CAPACITY

Agriculture land is precious and valuable. To reduce agriculture land for the sake of development is not advisable. The calculation in Table 27 indicates the quantum of land available for development is in excess of the requirement. However, it should be noted that the land required for development involves conversion of valuable agricultural land. Indiscriminate conversion may affect the environment and also productivity. Hence, a proper study has to be conducted to prepare an urban land use requirement atlas for BMR. The population envisaged in BMR is 160 lakh by 2021 and 208 lakh by 2031. Bangalore city has the highest density at 194 persons/ha, the ideal being 100 persons/ha. Bangalore North, Bangalore South and Bangalore East have a density of 14.7, 9.3 and 17.8 persons/ha respectively. The BDA has a Local Planning Area (LPA) of 1,307 km^2 out of which 421.41 km^2 has already been developed. Out of this 1,307 km^2 of land 649.24 km^2 is under agriculture and if converted to NA purpose it may be made available for development. In the Master Plan 2015 of Bangalore, 564.63 km^2 has been proposed for development to accommodate a population of 98.44 lakh by 2015 at a gross density of 174.

Table 27: Land availability

Parameter	*Value*
Area available for development	5,744 km^2
Area already developed under habitation category	667 km^2 (66,710 ha)
Actual land required for a population of 208 lakh	(2,080 – 667) = 1,313 km^2

Table 28: Population density

Bangalore Rural and Ramanagar	*Bangalore Urban*	*Bangalore City*
3.23 pers./ha	29.85 pers./ha	194.35 pers./ha

Table 29: Land use in 2015 as per Master Plan

Proposed land use (2015)	*Area in km^2*
Residential	243.7
Commercial	16.4
Industrial	38.4
Open space	77.9
Public & semi public uses	49.0
Transport & communication	117.0
Unclassified	22.1

The population to be accommodated by 2031 would be 208 lakh in BMR. In BMA, the population that has to be accommodated would be 124 lakh by 2031, i.e., an extra population of (124 – 98.5 = 25.5 lakh).

Hence, the area within BMA appears sufficient at a high density of 174.34 persons/ha. If such high density is accommodated, it will result in more concrete surfaces, pollution of the environment, higher traffic volume, encroachments and infrastructure deficiencies especially in water and power. Hence, it may not be feasible to accommodate the population of 25.5 lakh in BMA by 2031. Even a dispersal of 25 lakh population and the expected population of 84 lakh in BMR that will add up to a crore and more is also a factor that has to be given thought of.

Table 30: Projection of accommodation capacity

Population that could be accommodated in BMA	= 174.34 X 564.63 km^2 = 98.44 lakh (98.5 lakh)
Area required @ 174.34/persons / hectare	= 14,627 hectares. i. e., 146.27 km^2
Area available	= 649 km^2

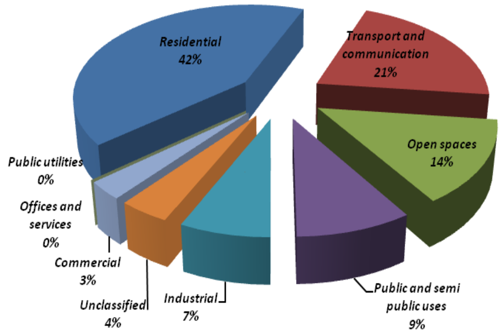


Figure 21: Proposed land use for Bangalore in 2011

Table 31: Optimum population in BMR

Population status	*Remarks*
Present population 67 lakh (BMA) 2001	There is no question of dispersing this population elsewhere
Population by 2031 124 lakh (BMA)	The present situation in BMA is more traffic congestion than population. An increase in traffic congestion will affect people and their movement. Hence, it may not be feasible to encourage population increase in BMA.
Present population in (BMR – BMA) 19 lakh	The situation is not grim but there is a possibility to increase / disperse population to this area
Population by 2031 84 lakh plus a population of 25 lakh that may have to be dispersed out of BMA	Our calculation earlier does not take into account the availability of land for lower densities. This means, again a situation like in Bangalore may result. However, as (BMR – BMA) area is scattered, it is again a problem to attract population to this area as the infrastructure facilities in the eastern sector are poor.

This suggests that 124 lakh is not feasible in BMA and 84 lakh is not feasible in (BMR–BMA). Hence, an in-depth study will have to be made on land availability and dispersion.

5.3. ZONING AND ZONING REGULATIONS

In the above context Zoning and Zoning regulations play an important role. Zoning of land use should be carefully planned so that it shall not attract more population than necessary beyond 2031. This means, many disincentives should be provided not only in the zoning of land use but also in Zoning Regulations. In effect, a blanket ban has to be enforced on further development in BMR beyond 2031 and thrust should be given for the development other regions of Karnataka. Manufacturing industries or IT/BT should not be allowed in BMR as it will only make life uneasy in BMR. The integrated township planned in BMR will help mitigate congestion in BMA. However, zoning regulations for integrated township should have an in built provisions for absorbing displaced population and the industrial policy of providing housing in situ should be part of the Zoning Regulations. Another factor that has to be a part of Zoning Regulations is provision of land/units for EWS and low-income group. Only, then the housing issues can be solved.

5.4. ANALYSIS

Table 32: Problem matrix

Problems	Impact	Trends	Remarks
▪ High density zones ▪ Conversion of valuable agricultural land to non-agricultural purpose. ▪ Modification in Zoning Regulations. ▪ Escalation of land value. ▪ Assessment of land required for the BPL/ EWS sector.	High density zones are the cause of creation of concrete jungles; environment pollution and increase of traffic lands abutting main roads have astronomical land value. For e.g., along M G Road and other such main roads the value ranges from INR10,000/- to 12,000/- per square meter. Such spiralling land values also affects the land value of adjacent lands and land dealing will become a speculative trade among the selected few. The chances are that land will become a ransom commodity. A separate assessment of land required for BPL/ EWS is very necessary and simultaneously deterrent hold on land values from spiralling should be framed.	The present trend especially in the proximity areas of EBD is to go in for group housing; hardly any contribution for BPL/ EWS housing is thought of. This is also the case in residential layouts. This will lead to situation "land/ shelter/ for the selected affordable". The other perceptible trend is to rehabilitate the slum dwellers in their own area through private public partnership. This is laudable indeed. This concept should be extended to future housing for weaker sections also.	There is a drastic need for drastic reforms in the Land Acts. The aim should be to eliminate land as a speculative commodity and bring the land prices down to affordable rates. This requires the political will.

6. PARKS, PLAYGROUNDS AND OPEN SPACES

6.1. UTILITY

The utility of parks, playgrounds and open spaces is often lost on us. Before dwelling on the utility and usefulness, a clear understanding is necessary. In fact, if one refers the KT & CP Act Rule No.30, open spaces are specified as sports grounds, stadium, playgrounds, parks and other recreational uses, cemeteries, crematoria etc. Hence, they are simply classified as open spaces. As can be seen from categorisation, the open spaces are important not only for recreation but also as final resting place. It functions as lung space providing for fresh air amidst pollution outside the park area.

Generally, under the Zoning Regulations prepared under Master Plans for urban areas declared as Local Planning Areas (LPA), 15% of land is earmarked for open spaces in all layouts / Group housing schemes. Other than this in the Master Plan itself the areas are earmarked for parks. However, areas earmarked are never acquired by the concerned authorities. In fact, these areas are not utilised fully either by the authorities or allowed to be used by the owners. Thus, the efficiency and utility of earmarking open spaces in our Master Plans is totally lost.

The parks that exist are either those that have been earmarked almost a century ago such as Cubbon Park or Lalbagh and the city level parks in urban centres. A few more parks have been added in several BBMP divisions with private partnership. The other open spaces that have come up as parks are the relinquished areas in layouts / group housing schemes executed by private bodies or housing agencies / development agencies such as KHB / BDA / local authority. However, it is quite shocking that the areas are rarely earmarked for burial grounds / crematoria.

6.2. GREEN BELT CONCEPT

The concept of green belt is much misinterpreted and is used and misused in many contexts. Green belt, in actuality, is a permanent stretch of agricultural/ forest / wet land that separate settlements and no development is envisaged in this stretch. However, in our planning context, it is termed as the area between LPA and conurbation. Figure 22 below represents the utilisation of land as per the Structure Plan of BMR. It clearly shows the area beyond conurbation as green belt.

6.3. LAND UTILISATION

The Structure Plan for BMR recommends that "within the greenbelt and with reference to delineated settlement boundaries (village *gramathana* limits) there should be a policy to ensure that:

- Until separate plans are approved for each village, uses to be permitted only within the existing development guidelines which seek to upgrade the existing socio- economic conditions.

- Outside the village limits (*gramathana*) only uses to be permitted that is in accordance with the Structure Plan policies and or other detailed development plans. Otherwise, no change of use should be permitted.
- Permission for sub-division of land outside settlement areas should only be such that no plot becomes less than one hectare in size. This would enable the construction of farmhouses up to 2–storey and a plinth area not exceeding 500 m^2 or 5% of the total net plot, whichever is less.
- Local authorities should take a leading role in setting up of a "Greening Plan" in their area. Local communities should be encouraged to take action in creating and maintaining the local green areas.
- Community action helps in maintaining and developing neighbourhood parks and other common amenity areas.

The agriculture land, which should be a permanent green belt, is susceptible to change of land use from agriculture to other uses. As the population increases due to growth and migration the area marked as agriculture starts getting depleted as it is encroached upon in the name of development. There is no chance of a permanent green belt as and when agriculture land within LPA gets filled up by development, LPA is further expanded which means more agriculture land gets absorbed into development.

Table 33: Projected land requirement of BMA

Specification	*Area in km^2*	*Distribution*
Conurbation	800	61.2%
Agricultural land	419.50	32.1%
BMICAPA	87.50	6.7%
Total	**1,307.0**	**100%**

Source: Master Plan – 2015, Bangalore

This leads to inevitable conclusion that to protect the green belt, growth of population in BMA should be stopped. In BMR, the population envisaged should never be exceeded, as again the vicious circle of change in land use in the name of development or in the guise of change in land use will deplete the valuable agricultural land and the concept of greenbelt / open space is totally lost. A strict policy should be that the land in agriculture zone or green belt of the Master Plan should never be allowed for change of land use. This alone will help in controlling the chaotic development in BMA and BMR. In fact, legislation should be passed to prevent the change of land use in green belt areas.

Figure 22: Land utilisation in BMR

6.4. PROVIDERS AND FACILITATORS

The zoning regulations under Master Plans provide for relinquishing the open space marked as parks in layouts / group housing schemes to the local authority for maintenance. The local authorities hardly create any open space on their own. In the master plans, areas are marked as parks but hardly any effort is made to acquire and develop those areas. In fact, this alone is a single contributor to failure of Master Plan.

With a growing metropolis and urban centre in BMR, the requirement of open space for the purpose of playgrounds and burial grounds /crematoria is hardly addressed either in the Master Plans or by local authorities. It is not sufficient if a couple of stadiums are built for mass usage as playgrounds. Smaller categories of playgrounds should become the part of neighbourhood.

Educational institutions and playgrounds

Educational institutions are the best providers for playgrounds. The number of schools in BMR is quite large and the student strength is huge. Unfortunately, the status of these schools/ colleges with regard to buildings and playgrounds is not available. An attempt should be made to list the above details for an insight dearth of playgrounds.

Table 34: Number of educational institutions in BMR

District	Primary School	High Schools	Pre-university	Government Colleges	Private Aided colleges	Medical Colleges	Polytechnic	Engineering universities	Dental colleges
Bangalore Rural	2,811	333	27	6	4	0	4	4	0
	240,276	94,883	14,033	4,428	4,065	0	516	1,501	0
Bangalore Urban	7,390	2,564	368	11	NA	8	63	56	16
	1,680,656	462,088	122,982	1,2045	NA	NA	9,484	21,515	NA

Source: District at a glance, 2005 – 2006

6.5. OPEN SPACES AS BURIAL GROUNDS AND CREMATORIA

This is one field where actual details are hardly known. The population in BMR is projected at 208 lakh by 2031. Adequate planning has to go into the provision of open spaces as burial grounds / crematoria.

Crematoria are not much of a problem as the existing burning *ghats* could be converted to crematoria. But, where burial grounds are concerned, it is not the case. Burial grounds also tend to get overcrowded and congested. As the BMR-BMA goes on developing due to influx of population, open spaces for burial grounds/crematoria should be planned at convenient points. In the Master Plan, the areas earmarked for open spaces are not even considered for allotting to burial grounds.

6.6. ANALYSIS

6.6.1. Land use and zoning

Strengths

The Master Plans for urban centres in BMR are already prepared and hence, zoning of land use in urban areas will not be an issue. Areas have been earmarked for industrial purpose in BMR. Integrated townships have also been earmarked in the Master Plans of BMR. These townships should be able to absorb the displaced population and also be able to induce the population dispersion from BMA.

Weakness

- Assessment of land availability.
- Zoning regulations have not been taken care of traffic problems.

Opportunities

- With the opening of the new airport there is hectic activity to improve connectivity. Improvements to connectivity should not be viewed with only airport as focus but also it should be comprehensive so that overall connectivity and commuting will improve in BMR especially BMA (a concise plan is available in section 4 of this chapter).
- Land availability for EWS/BPL requires a thorough study. A glimpse has been given in the chapter on housing. Only such a study can enable the apportionment of land for housing to EWS/BPL. An inbuilt legislation for reservation of land for EWS/BPL should be brought into group housing norms and plot development.

Threats

The main threats are the issues of housing and traffic planning. In housing, the gravity of situation involved in providing housing for EWS/BPL populace may be underestimated. This may lead to mass encroachments. The agencies involved in providing housing for EWS / BPL population should be streamlined and should undertake the issue of housing to this section seriously by conducting detailed studies.

As already pointed out, the level of service on BMR roads especially BMA is very poor. A time may come when the vehicle speed may reduce to below 10 km/h. Hence, a new policy may have to be spelt out to

- Arrest population and traffic growth in BMA
- Determine the BMR population content beyond which no more influx / growth should be permitted.
- A high order of improvement in BMR – BMA intra road network

6.6.2. Parks, playgrounds and open spaces

Strengths

The Master Plan earmarked open spaces. These should be made use of by acquiring them. The open spaces earmarked for parks by private developers should be taken over by the local bodies, as it is an asset to the local body.

Weakness

The areas earmarked as open spaces in the Master Plan are hardly made use of. Change of land use in green belt should not be allowed as is being done now under the KT & CP Act. Specific areas such as:

- Open space for regional park
- Open space for district park
- Open space for burial grounds
- Open space for playgrounds are not made in the Master Plan. This ought to be done in the Master Plan
- Department of youth services and department of education should initiate programmes to develop the playgrounds

Opportunities

- Private–public partnership should be promoted in the development of open spaces.
- Department of youth services and department of education should initiate study on development of a database on student strength and playground vis-a-vis educational institution.
- Legislation should be passed to define green belt and arrest development in this area. It should become a part of the study in the revision of structure plan.

> KT & CP Act has to be extended to the whole state as the areas adjacent to declared LPAs tend to get converted to urbanisable land causing deficiency in providing basic infrastructure leading to unhealthy environment.

Threats

All educational institutions should compulsorily provide for playgrounds, if not on their campus elsewhere, by acquiring land marked as open space in Master Plan. No educational institution should be permitted unless it provides for playground of prescribed standards. In brief, major issues related to the problems in urban planning sectors are given in the table below.

Table 35: Problem matrix

Problems	*Impact*	*Trends*	*Remarks*
▪ Areas earmarked for open spaces in the Master Plans are never utilised for the purpose. ▪ Green belt concept is misinterpreted. ▪ Institutions educational or Industrial should be compelled to provide for playgrounds. ▪ In Master Plans open space as Burial Grounds should be clearly marked and taken over by the ULBs.	▪ In the Master plans Land use should be earmarked such as residential, commercial public/ semi-public, industrial and open spaces. The areas earmarked are hardly ever taken over and as per the KT & CP Act, the ascribed land use lapses after a period of five years. ▪ Green belt misinterpretation leads to more and more area to become urbansiable. This means loss of agricultural land to urban invasion.	▪ The trend of lapse of land use if it is not acquired by ULBs is not only a mockery to the Master Plan but also harassment to the owners due to non-acquisition. To check this trend, there is need for a drastic change in the methodology of preparation of Master Plan and its contents. ▪ Green belt concept should be clearly defined. The absence of definition has led to large scale change of land use not only in BMR but in the entire state.	Any Master Plan should be people friendly and contribute towards development. Further, In the KT & CP Act, the rules for Master Plan preparation and implementation are yet to be framed.

7. SOLID WASTE MANAGEMENT

7.1. INTRODUCTION

Management of solid waste is one of the primary responsibilities of urban local body. The Karnataka state government has formulated a State policy to comply with the MSW 2000 rules and to aid in effective management of solid waste. Solid waste management involves four main components namely, primary collection, transportation, treatment and disposal. Each of these components has a bearing on environment.

Table 36: Waste generation and collection

Area/taluk	Generated in Mt/d	Collected in Mt/d	Collection efficiency
Bangalore Urban			
BBMP	2,374	2,300	96.9
Bangalore Rural			
Anekal	10	6	60.0
Doddaballapura	38	21.7	57.1
Devanahalli	10.7	8	74.8
Nelamangala	16.2	15.5	95.7
Ramanagar			
Channapatna	24	20	83.3
Kanakapura	19	12	63.2
Magadi	12.4	9	72.6
Ramanagar	39	30	76.9
Total	**2,543.3**	**2,422.2**	**95.2**

Source: SWM Action Plans & Bangalore CDP prepared under JNNURM

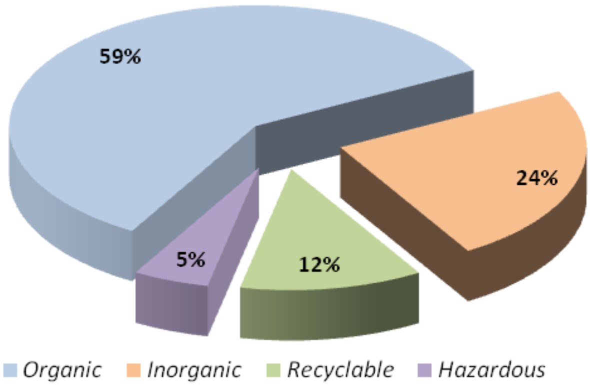


Figure 23: Composition of waste

It is estimated that a total of 2,543 tonnes of solid waste is generated in the BMR every day with the collection efficiency of about 95%. The waste generated mainly consists of organic waste from the households. BMA is the major contributor of waste generated. Table 36 indicates the waste generation and collection efficiency in the BMR. As seen in Figure 23, the organic waste forms the major part of the waste collected of 59% and recyclables constitute only 12% of the waste followed by hazardous waste forming 5%. It is seen that inorganic waste constitutes 24% of the waste which leads to the thought that segregation of waste may not be fully efficient.

7.2. PRIMARY COLLECTION

Door to door waste collection is initiated in most parts of BMR. But, the effective implementation is found to be only 50%. It is observed that the frequency of collection is not sufficient. In some parts of BMR the dustbins are still being used for primary collection of waste. Especially in slum areas the primary collection system is inefficient and needs improvement.

7.3. WASTE SEGREGATION

The Municipal Solid Waste Rules prescribe for segregation of waste at source. But in almost all areas under BMR, the waste collected is a mixture of organic, inorganic, recyclables and in some cases even the household hazardous wastes like CDs, batteries, metal scraps etc. Though some amount of segregation is happening at the disposal site, it is negligible. This has a major negative implication on soil and ground water quality.

7.4. WASTE TRANSPORTATION

In most parts of BMR, the waste is being transported through tractor/ trailers or dumper placers. These vehicles are mostly top covered. There is insufficiency of transportation vehicles in most of the ULB's and hence, the vehicles make more than 3-4 trips every day to transport the collected waste.

Table 37 gives the details of the vehicles deployed for transportation of waste and also the number of trips each of these vehicles make to transport waste.

Table 37: Mode of transportation of waste

Taluk	Transportation vehicle	No of vehicles	Avg. lead to landfill in km	No. of trips
Bangalore Rural				
Anekal	Not available	Not available	Not available	Not available
Doddaballapur	Tractor trailer	2/3	Not available	4
Hoskote	Not available	Not available	Not available	Not available
Nelamangala	Not available	Not available	Not available	Not available
Ramanagar				
Channapatna	Container, dumper, placer	3	10	1
Kanakapura	Tractor trailer	4	5	3
Magadi	Tractor trailer	2	1.5	2
Ramanagar	Truck, tractor, dumper, placer	2	Not available	2 trucks, 2 tractors, 1 dumper placer

7.5. WASTE DISPOSAL

The ULBs are mandated to dispose the inert waste in sanitary/engineering landfills and the organic waste to be used for composting / palletisation. It is seen that the waste is being disposed of in an unscientific manner by dumping it in open spaces. This is mainly due to lack of availability of land fill sites. In most places we find that the land fill sites have not been earmarked due to litigations.

The city has treatment and disposal facilities with combined capacity of 2,000 and 1,600 MT respectively. BBMP is developing the engineered sanitary landfills with private participation. These integrated waste processing and landfill facilities at Kannahalli and Mavallipura are being implemented under a build-operate-transfer concession framework. A waste to energy plant is also being developed by the private developer. In some places care has been taken to use impervious layers at the bottom of dumping pits to prevent leaching but, in many places the waste is dumped without taking any care which is harmful to both the soil and underground water.

Table 38: Status of landfills in Bangalore Rural and Ramanagar district

Taluk	Procurement	Functioning	Remarks
Anekal	In progress	No	
Channapatna	Procured	Yes	Currently non functional due to land litigation
Doddaballapur	Procured	Yes	
Hoskote	In progress	No	Litigation
Kanakapura	In progress	No	Litigation
Magadi	Procured	Yes	
Nelmangala	In progress	No	Litigation
Ramanagar	Procured	Yes	Currently non-functional due to land litigation

Figure 24: Construction waste advancing on Bellandur tank bed

As seen from the table, it is clear that in most parts of BMR, the land fill sites have not been procured and put to use. Hence, it is inferred that the waste collected is being disposed off unscientifically by dumping in open spaces adversely affecting the environment.

The MSW rules 2000 have laid certain guidelines regarding the design and selection of landfill sites. Some of the key guidelines are:

- Landfill must be designed for a period of 20-25 years
- Should be located preferably within 5 km of the current city limits
- A 500 m wide buffer zone should be maintained surrounding the landfill sites

On evaluating the current landfills in BMR against these guidelines we find that

- The landfill sites proposed and also those which are functioning currently are designed for a design period of 20 years. However, it is feared that these landfills will fail to cater to the needs of 20 years from now. This is mainly because, the landfill sites are designed to take in only the inert waste but the current practice is that apart from inert waste, green waste and recyclable waste is also being disposed into these landfills in most cases. This, on a longer run will eventually result in the failure of landfills.

- In most cases, due to scarcity of land and also due to existing land prices, it is difficult to locate the landfills within 5 km from the city.
- Though it is suggested to have a buffer zone of 500 m around the landfill sites, we do find violations in many places leading to development of residential layouts in close proximities to the compost/ landfill areas (Directorate of Municipal Administration, Bangalore).

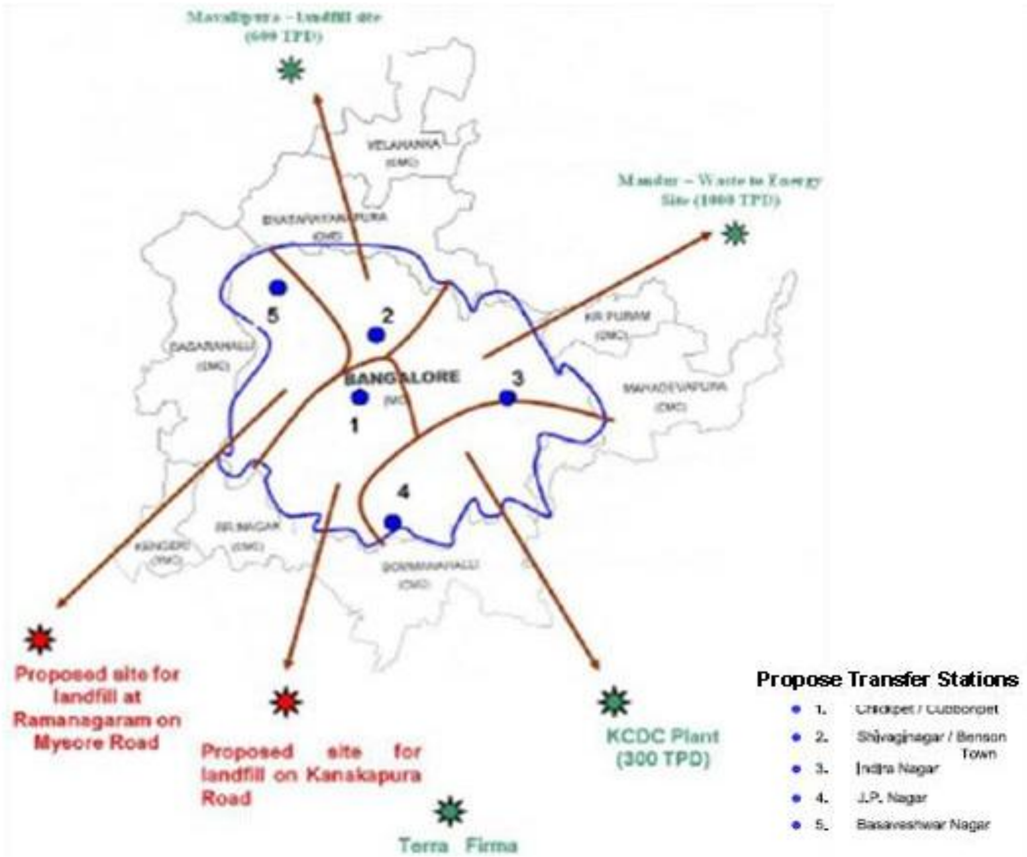


Figure 25: Proposed location of disposal sites and transfer stations within BMR

7.6. CURRENT AND FORTHCOMING INVESTMENTS

Government of Karnataka has allocated funds for formulation and implementation of solid waste management action plan under the eleventh and twelfth Finance Commission grants. KUIDFC, under the KUIDP programme has under taken various IEC activities for effective implementation of SWM Action plan. Under the JNNURM, BMP is developing engineered sanitary landfills with private participation. These integrated waste processing and landfill facilities at Kannahalli and Mavallipura are being implemented under a build-operate-transfer concession framework. A waste-to-energy plant is also being developed by the private developer.

7.7. ANALYSIS

Based on the analysis of various SWM action plans formulated by individual ULBs within BMR and the City Development Plan for Bangalore prepared under the JNNURM, the findings of the SWOT analysis of the existing SWM practice is inferred.

Strengths

- Regular clearance of solid waste from households.
- Lesser clogging of drains due to regular desilting

- Regular street sweeping leading to lesser dry dust settlements on main roads

Weaknesses

- Lack of awareness and absence of comprehensive segregation of waste at source
- Lack of manpower and infrastructure
- Spilling of waste during transportation by uncovered vehicles
- Absence of transfer stations for transferring MSW into bigger vehicles for transportation to the treatment and landfill facilities;
- Inadequate waste treatment capacity as compared to the quantum of waste generated
- Dumping of MSW in drains, along roads and in low-lying areas
- Absence of capacity building for *pourakarmikas* regarding waste handling
- Non-use of compactors while filling waste into vehicles for transportation to increase carrying capacity

Opportunities

- Waste minimisation at source
- Use of new technology/equipments for street sweeping and collection and transportation of waste enabling compaction of waste collected to one eighth its volume at the source of collection itself. This will ensure ease in transportation of waste.
- Scope for Public Private Partnership
- Generator of waste to pay for management
- Development of scientific MSW treatment (including waste to energy projects) and disposal facilities
- Material for Reuse and Recycle
- Better methods of inculcating awareness on segregation and offer of incentives

Threats

- Limited participation of the community in sharing the costs for SWM
- Non availability of land for landfill
- Laxity in enforcement of regulations.

8. RECOMMENDATIONS

Overview

The status report on BMR with emphasis on BMA with reference to urban planning has been dealt related to the following aspects:

- Structure Plan and Master Plan
- Urban planning and housing
- Rivers, tanks, *nalas* and valleys.
- Traffic and transportation
- Land use and zoning
- Parks, playgrounds and open spaces

The status report gives an insight on the status of environment with respect to above aspects in the BMR. A SWOT analysis on the status has been made to indicate the areas where actions or action management plans are required. The report highlights the problems and suggests the type of solutions and options available. Based on these projections, solutions and options a detailed project and feasibility report has to be prepared. It is learnt that the structure plan is proposed for revision. Many of the projections/ solutions/ options suggested in the status report can be dealt in detail in the structure plan revision to define the clear-cut policies. It is hoped that this status report will form a foundation for action to the multitude of problems facing BMR in the years to come. The following points noted below with respect to parameters considered for the status report highlight the critical aspects for which detailed and feasibility reports, Management Action Plan have to be prepared.

Structure plan and master plans

The Structure Plan slated for revision should make a detailed study on the deviations done and its consequential impacts. Mere revision of or modification of the existing Structure Plan policies will not do good. Following are the suggested stages in the Structure Plan revision:

- A review of the deviated policies, their impacts and the status report (one volume)
- Discussion on the status report and suggested remedies and vision after interaction with all the stakeholders (one volume)
- Revised Structure Plan (one volume)

Amendments to the KT & CP Act with special provision for housing the urban poor should be taken up immediately.

Urban planning and housing

A detailed analysis of housing need and land requirement locationally and functionally has to be identified for the BPL section of populace. Treated wastewater may be made mandatory for house construction. This can lead to conservation of more than 10% of fresh water. An area of about 75 acres should be earmarked for MSW processing and sanitary landfill while planning any new settlement which accommodates more than 5 lakh population. Adequate buffer zone should be notified around such MSW sites.

Rivers, tanks, *nalas* and valleys

- A disaster management cell to deal with calamities during rainy season.
- Water table improvement by providing filter wells along drains.
- Creation of an environment cell to exercise authority over supervision and management of environment.
- Re-designing of storm water drains and remodeling on a war footing.

Traffic and transportation

- Road widening strategies through re-development and/or rehabilitation should be examined thoroughly ward wise in BMA. A study team should be formed to analyse the situation comprehensively involving social, financial and physical aspects.
- A regional impact study on Bangalore International Airport should be made to assess the traffic hazards in the years to come supplementing the present hazards
- Signal free roads on arterial and major roads to reduce the travel time
- Creation of additional Satellite Bus Stations in all the corridors of development
- De-silting of all road drains and re-design

Water supply and sanitation

Water supply and sanitation has been dealt in a linked manner restricting to weaknesses in the existing system as a detailed study of the status has been undertaken separately. The following are some aspects where stress has to be applied during development.

The housing demand of 1 lakh houses per annum shall generate the need for augmenting the wastewater treatment at the rate of 50 MLD every year.

- Potential for making mandatory the usage of recycled water.
- A clear mapping of the existing pipe lines and sanitary lines so that the road works and development works are not hampered.
- Divert and restrict development in the eastern sector of BMR.
- Containment of discharge of sewage and solid waste into roadside and storm water drains to prevent the spread of epidemics and water borne diseases.
- Public awareness campaigns.

Land use and zoning

- Extension of KT & CP Act to the entire state.
- Revision of KT & CP Act and frame proper rules.
- Contain indiscriminate conversion of land from agricultural use to non-agricultural use.
- A separate study on land use, land availability and dispersion.
- A policy on control of land pricing or nationalisation of land as an alternative. A serious discussion and policy framing should be taken up at the earliest.
- Industrial leases to be prepared for the entire BMR.
- Green belt concept should be clearly defined and should hold common for Land Revenue Act as well as KT & CP Act.
- Industrial land should not be acquired from the green belt.

Parks, playgrounds and open spaces

- Open spaces for burial grounds should be earmarked in every Master Plan.
- An inventory on educational institution and the playgrounds associated with them should be made.

Solid waste management

As solid waste management is taken up separately for status reports only certain aspects of consideration are highlighted

- Capacity addition to the tune of 250 MTD facility every year needs to be planned to cater to the growth of BMR
- Public awareness on segregation of solid waste.
- Use of modern technology for compacting solid waste and transporting the same to land fill sites.
- Nearly 2% of the sand requirement/ brick material can be obtained from processing of inert

Chapter 11

Socio-Economic Development

CONTENTS

TABLES

FIGURES

1. CURRENT STATUS

1.1. INTRODUCTION

Poverty and affluence are the two main contributing factors to our environmental problems. While poverty is considered a contributor of pollution, consumption habits of the affluent are so copious that they exert greater pressure on the ecosystems (Rees and Wackernagel, 1994). Poverty and affluence are strongly correlated with the pace of economic development which reflects on the socio-economic profile of a population. Rapid urbanisation contributes significantly to changes of the socio-economic fabric and mega cities are the most affected. The rapid growth of large cities as islands of development bring about a rural-urban dichotomy. Bangalore has been experiencing innumerable urban management issues. Next to Mumbai it has a conducive investment environment for global corporates. As a result, Bangalore has acquired the unique distinction as millionaire's paradise. All these characterisations are leading the city to experience rapid variations in socio-economic development.

This chapter aims to analyse the socio-economic development of Bangalore Metropolitan Region (BMR). It proposes to answer the questions of (a) characteristics of the population in terms gender, growth, age distribution, spatial distribution, (b) economic characteristics in terms of workforce, occupation, spatial distribution, (c) environmental problems emerging out of the existing socio-economic scenario and (d) what are the policy directions and institutional arrangements for efficient management of environment in BMR.

Figure 1 and 2: Looks deceive: The structure actually did not change much – Brigade Road in 1946 and 2009

1.2. POPULATION CHARACTERISTICS

The current socio-economic fabric of Bangalore city has the following four categories – high, middle, low income and slum households which may be to a great extent identified as below poverty line households. These categories have their unique concentrations, characterisations and requirements in terms of housing, transport, education, health, water and sanitation, commerce, leisure time and recreation activities. A set of socio-economic and environmental indicators derived for the city and its region on the basis of a sample survey (AusAID 2001) substantiate such distinctions both functionally and spatially in the city and its regions. Accordingly, the city is characterised as having high educational attainment, skilled workers, middle and higher income group with relatively adequate water supply and sanitation and a system for management of solid waste. While rural track is identified as an area with low education attainment, unskilled workers, low income and poor piped water supply and sanitation with inefficient solid waste management. The peri-urban area has been characterised as in-between category (refer to Table 1). The analysis is based on a household sample survey conducted in 2001. The table below gives a comparative scenario of the city, the peri-urban area and villages in terms of basic facilities characterising the socio-economic fabric.

A similar socio-economic and ecological characterisation of the city has revealed that Bangalore is a multi-religious, multi-linguistic migrant city having 62 percent of households as migrants. Bangalore is predominantly a city of the middle-income group (59%) with migrants performing better than residents in education, employment, income generation and asset ownership

Table 1: Households in BMR by socio-economic and environmental characteristics

Variable	City in %	Conurbation in %	Greenbelt in %
Education			
Illiterates	13	21	30
Primary	4	5	9
Higher primary	23	25	34
Secondary	31	33	19
intermediate	7	6	2
Graduation and post graduation	15	9	6
Professionals	7	1	0
Workers			
Unskilled	27	36	81
Skilled	73	64	19
Household income (INR/m)			
Less than 2,000	10	14	20
2,000 - 6,000	59	77	72
More than 6,000	31	9	8
Water supply			
Piped water supply	73	8	6
Other sources	27	92	94
Sanitation			
Toilet facility	66	47	26
Open defection	1	35	70
Shared facility	33	18	4
Solid waste disposal			
House collection	36	0	0
Dustbin	57	31	3
Open space	7	69	97

Source: AusAID 2001, Sastry 2006

BMR with an area of 8,022 square kilometres had a population of about 8 million in 2001 and distinctly almost 27% of the population is living in rural areas (refer to Table 3). The main development question here is whether the entire BMR should become urbanised or whether the existing rural areas should be retained as enclaves. From the ecological point of view it is preferable to retain the rural enclaves to maintain the urban ecosystem's balance because the urban area always depends on its rural hinterland to meet its day-to-day demands. Therefore, a symbiosis between the city and its rural region is very much pronounced in order to maintain the city-region balance. However, the rural region in BMR should be maintained with utmost care as it is highly vulnerable to unplanned growth due to very high land value and since it has its own distinct land use pattern like agriculture based activities and services, consumption habits and more significantly unique religious and cultural practices which are different from the urban system. The economic contribution of the rural population of BMR is meagre by virtue of low educational attainment and lack of skill. It is more prominently associated with the informal sector and leads lives quite different from urbanites. It should be a priority to provide the rural population with adequate sanitation and solid waste management systems.

In order to design appropriate developmental policies it is important to know the nature and pattern of migration hence, the outcome of the analysis on migration is discussed here. BMR has a high population growth of 2.96% per annum of which migration (45%) forms the most prominent component followed by jurisdictional changes (33%) and natural increase (22%). According to 2001 census, almost 49% of migrants are male. Not surprisingly, with 46% occupation emerges as the major cause for migration. Family movement accounts for 13% and education for only 4%. There is an observable decline in the share of migrants during 1981 to 2001 under employment, education and family movement categories, while a significant increase is evident under others. A concerning fact is the significant increase of 'other' migration reasons which may include repatriation, droughts and floods, man made disasters and displacement due to development projects (Ram, 2005). Interestingly, 60.3% of migrants are from with in the state of Karnataka and 15.1% of them are from with in the district. Hence, migration due to employment has been rated very high in the immediate future as compared to previous decades. Similarly, Bangalore being a top class education centre, migration due to education needs is expected to assume higher proportions.

Table 2: Reasons for migration into BMR

Reason for migration	Migrants			
	1981	1991	2001	2011 (projected)
Employment	51%	49%	46%	55%
Education	8%	7%	4%	10%
Family movement	22%	23%	13%	25%
Marriage	1%	1%	1%	2%
Others	22%	23%	36%	8%

Source: Census 1981, 1991 and 2001

73.3% of BMR's population is concentrated in urban settlements. The urban population is particularly densely concentrated in Bangalore city followed by Bangalore north and Bangalore south *taluks*. The rural population is only 26.7% and higher concentrations are found in Anekal *taluk* followed by the entire Bangalore rural district. This district is adjacent to Bangalore Urban district but dominated by rural characteristics. In terms of population growth, Bangalore city, Anekal and Nelamangala have recorded higher population growth followed by Doddaballapur, Devanahalli, Hoskote and Ramanagar. The possible justification for high population growth in Anekal and Hoskote is that they are in an IT zone, while Nelamangala and Ramanagar are in the prominent transport corridors. Doddaballapur is a fast developing industrial town with high concentration of silk manufacturing and trade. Devanahalli needs a special mention for its recently commissioned international airport and its role as important transport corridor (refer to Table 3). Negative population growth in Bangalore South and North *taluks* is mainly attributed to change in the area. (Almost 59 settlements in Bangalore North *taluk* and 62 settlements in Bangalore South *taluk* which were outgrowths as per 1991 census have become part of Bangalore city in 2001 census report (Bangalore district Census Handbooks, 1991 and 2001).

Bangalore city, Bangalore North and South *taluks* have high population densities. A surprising fact is that the sex ratio is unfavourably skewed in the city area. A higher rate of male migration from rural and into urban areas could explain this phenomenon. The analysis presented here is based on census data of 1991 and 2001. Conforming to expectation, urban *taluks* have higher literacy rates of both males and females.

Figure 3 and 4: A changing face – M. G. Road in 1953 and 2009

Table 3: Population characteristics of BMR

Taluk	Area in km^2	Population, 2001				Population characteristics				
		Total in 000's	% Urban	% Rural	Growth 1991-01	Density	Sex ratio	Literacy		
								Total	Male	Female
Section of 255 km^2 of Bangalore North + South		4,040	100	0	65.4	17,268	917	82.2	87.2	76.6
Bangalore North	902	830	74	27	-11	1,473	883	80	86	72
Bangalore South	709	1,010	69	31	-1	1,268	896	79	85	72
Anekal	528	300	19	81	35	564	883	70	79	61
Kanakapura	1,590	340	15	85	7	212	941	56	65	46
Hoskote	546	220	16	85	18	407	931	69	78	60
Devanahalli	457	180	27	73	15	414	945	68	78	58
Doddaballapur	798	270	30	70	19	344	951	69	79	59
Nelamangala	524	170	12	88	22	343	955	72	81	63
Magadi	798	200	12	99	4	250	988	62	73	52
Ramanagar	625	240	34	66	16	377	952	65	73	56
Channapatna	545	250	24	76	6	465	988	62	71	53
Total BMR	**8,022**	**8,050**	**73**	**27**	**30**	**1,045**	**918**	**81**	**85**	**73**

Source: Census of India, 2001 and 1991, District Population booklet, Bangalore District, Bangalore Rural district, Karnataka, Government of India, New Delhi

In terms of age distribution almost the entire BMR has a unique pattern with the age group of 40 forming the most dominant group (75%). However, as one moves away from the city towards neighbouring districts younger age groups are becoming more pronounced (refer to

Table 4). The 0-19 age group (with an exception of 0-6 age group) is the potential student group that demands infrastructure for educational needs. Given that literacy levels in this region are low, adequate educational institutions emerge as a priority. Almost 38% are in the 20-39 years age group which would require employment opportunities which is a crucial and challenging policy issue for both government as well as the private sector.

Table 4: Age distribution of BMR's population

Age group	Bangalore city in %			Bangalore Urban in %			Bangalore Rural and Ramanagar in %			BMR in %		
	All	Male	Female	All	Male	Female	All	Male	Female	All	Male	Female
0-19 years	35.9	35.3	36.6	38.3	37.2	39.6	40.3	40.5	40.41	37.5	36.9	38.2
20-39 years	39.1	39.2	39.0	40.0	40.6	39.4	32.5	32.0	33.1	37.9	38.0	37.7
40-59 years	18.3	19.1	17.6	16.0	16.8	15.1	18.2	18.8	17.6	17.7	18.4	16.9
60-80 years	5.9	5.8	6.1	4.9	4.8	5.1	7.8	7.6	7.9	6.1	5.9	6.3
80+ years	0.7	0.6	0.8	0.7	0.6	0.7	1.2	1.1	1.3	0.8	0.7	0.9

Source: Census of India, 2001

Almost 38.4% of BMR's population is engaged in economically productive activities with higher male work participation and a meagre female participation. However, there are observable improvements in female work participation between 1991 and 2001. Significant increases are evident in Bangalore, Bangalore North, Bangalore South, Kanakapura and Doddaballapur which is indicative of a trend towards gender equality. The share of workers in agriculture has reduced considerably (23% to 16%) from 1991 to 2001 with a corresponding increase in non-agricultural occupations (77% to 84%).

Spatially, work participation is more prominent in Devanahalli, Ramanagar, Doddaballapur and Channapatna. While improvement in work participation is more prominent in Bangalore city, Bangalore North and Bangalore South and Nelamangala, an interesting decline in work participation is evident in Anekal and Magadi. Prominent changes in non-agricultural work participation are an indicator of ongoing rapid urbanisation as evident in Anekal, Nelamangala, Hoskote, Devanahalli, Ramanagar, Kanakapura and Doddaballapur (refer to Table 5). While Anekal and Hoskote are in the IT belt, Nelamangala and Devanahalli are in the main transport corridor and Ramanagar, Kanakapura and Doddaballapura are in the industrial zone.

Figure 5: Labour colony in Banashankari

Table 5: Distribution of work participation in BMR (1991 and 2001)

Taluk	Total in %		Male in %		Female in %		Agriculture in %		Non-agriculture in %	
	1991	2001	1991	2001	1991	2001	1991	2001	1991	2001
Bangalore	33.0	38.5	52.6	57.6	11.3	17.5	1.5	1.1	98.5	98.9
Bangalore N.	34.2	38.0	54.3	55.4	12.0	18.2	15.5	14.3	84.5	85.7
Bangalore S.	34.7	37.8	53.7	55.0	13.7	18.7	18.9	11.7	81.1	88.3
Anekal	40.4	36.7	57.0	54.0	21.9	16.1	58.4	33.3	41.6	66.7
Kanakapura	36.7	38.1	56.4	52.2	15.4	23.1	77.1	68.8	22.9	31.2
Hosakote	37.2	38.7	55.5	54.7	17.7	21.6	70.1	57.7	29.9	42.3
Devanahalli	39.4	40.5	56.2	55.6	21.8	24.4	73.9	62.6	26.1	37.4
Doddaballapur	37.3	39.5	56.7	56.2	16.7	21.9	65.3	56.7	34.7	43.3
Nelamangala	34.1	36.9	53.6	52.0	13.7	21.1	73..6	59.0	26.4	41.0
Magadi	37.1	36.1	55.2	54.3	18.3	17.6	77.3	73.7	22.7	26.3
Ramanagar	39.3	39.9	55.6	54.6	21.8	24.5	63.0	51.7	37.0	48.3
Channapatna	36.7	39.0	54.1	54.8	18.5	23.1	68.0	60.9	32.0	39.1
BMR	**34.6**	**38.4**	**53.7**	**56.4**	**13.4**	**18.6**	**23.0.**	**16.0**	**77.0**	**84.0**

Source: Census of India, 2001 and 1991, District Population booklet, Bangalore District, Bangalore Rural district, Karnataka, Government of India, New Delhi

1.3. CHARACTERISTICS OF SLUMS

Similar characterisations can be found in the case of slums in BMR. The highest concentration of slums is in the intermediary zone of the city which accommodates the largest portion of huts and dwellers. Limited land area, high land value and commercial concentration have a clear effect on the characteristics of slums in the city core. An intra-ecological analysis revealed that while the number of persons per hut is highest in the intermediary zone, the sex ratio is highest in the core zone and scheduled caste population is highest in the intermediary area and least in the core (refer to Table 6). This may be due to higher involvement of female workers in commercial activities and greater indifference about caste identity has led to higher concentration of scheduled caste population in the intermediary zone.

Figure 6: Slum on Pottery Road

Table 6: Slum characteristics in Bangalore in 2008

Region	Number of huts	Persons per hut	Population	Male	Female	Sex ratio	Scheduled caste	Schedule tribe
Bangalore City	51,338		3,69,711	2,02,607	1,67,104		1,54,111	63,466
Core	18.1%	5.85	14.7%	13.8%	15.8%	950	16.9%	10.6%
Intermediary	42.0%	8.04	46.9%	47.4%	44.6%	776	44.2%	49.0%
Periphery	39.9%	6.93	38.4%	38.8%	39.5%	839	38.9%	40.3%

Source: Karnataka Slum Clearance, Board, 2008

1.4. HUMAN RESOURCE DEVELOPMENT

Human resource development reflects the state of well being of both body and mind of its residents. Environmental problems emerge from both over- and under-development. Also the Karnataka Human Development Report of 2005 reveals that there are far more males in the urban area and that overall and female literacy in the urban district is high as compared to Bangalore Rural and Ramanagar. As discussed earlier, it is also evident that the female work participation is increasing which is interpreted as a trend towards gender equality. This has led to unique characterisation of the urban district with a high population, low sex ratio, high density and high literacy levels. Similarly, Bangalore Rural and Ramanagar districts are comparatively low in all the said characteristics except for population. Hence, the main developmental question as to whether uniformity in development levels of rural and urban districts should be promoted or whether rural enclaves in BMR should be maintained without degeneration into slums (refer to Table 7).

Looking at health, the overall health index derived on the basis of life expectancy at birth and related infrastructure is unsurprisingly highest in Bangalore Urban followed by Bangalore Rural and Ramanagar. Similarly, other health related indices like life expectancy, number of beds per lakh population and population served per medical institution are also highest in Bangalore Urban district. Other indicators like crude birth rate (CBR), crude death rate (CDR), infant mortality rate (IMR) and fertility rate (FR) are least in the urban area which is an indication of progress. Similarly, the gender development index, an indicator of more equal opportunities for both genders is highest in Bangalore Urban district. This implies better gender equality in occupations as compared to Bangalore Rural, a fact that is hardly surprising (refer to Table 7).

The education index is also high in Bangalore Urban district which is reflected by a high total as well as male and female literacy and associated infrastructure. Another significant indicator of human development is the income index. Along with associated indicators such as the per capita gross district domestic product (GDDP), estimates of GDDP per worker, total, male and female work participation, share of primary, secondary and tertiary sectors in GDDP, per capita district income, change in district income have all revealed advancement in Bangalore Urban as compared to the rural neighbourhood of BMR (refer to Table 7). Subsequently, a much needed human development index was evolved by using the indicators for education, health and income.

Table 7: Human resources development indicators of BMR for 1991 and 2001

Indicators	*Bangalore Urban*		*Bangalore Rural and Ramanagar*		*BMR*	
	1991	*2001*	*1991*	*2001*	*1991*	*2001*
Population characteristics						
Rural population (%)	14	12	82	78	31	27
Urban Population (%)	86	88	18	22	69	73
Population density (persons/km^2)	2,210	2,979	288	323	776	1,052
Sex ratio (females/1000 males)	903	906	945	953	914	918
Total literacy rate (%)	76	83	50	65	62	73
Male literacy rate (%)	83	88	62	74	71	81
Female literacy rate (%)	69	77	38	55	51	65
Health characteristics						
Life expectancy at birth (years)	65	67	64	67	65	67
Crude birth rate	26	20	27	19	26	19
Crude death rate	7	6	7	7	7	6
Infant mortality rate	64	45	64	48	64	47
Fertility rate	3	1.9	4	2	4	2
No. of beds per lakh population	179	123	52	51	115	87
Population served per medical institution	26,589	37,185	18,387	15,460	22,488	26,322
Access to safe drinking water (%)	82	96	87	97	84	97
Toilet facility (%)	73	85	17	34	35	54
Economic characteristics						
Incidence of poverty	3	10	38	5	35	8
Per capita GDP (1993-94 prices, in INR)	9,816	24,774	6,427	17,144	7,133	18,670
Per worker GDP (estimate, in INR)	32,691	63,641	14,197	36,454	23,444	50,047
Work participation (%)	34	39	43	47	35	38
Work participation male (%)	53	58	56	60	54	56
Work participation female (%)	13	19	29	35	14	19
Primary share (%)	4	2	36	32	11	9
Secondary share (%)	45	38	31	30	29	23
Tertiary share (%)	51	60	33	38	60	68
Human resource indices						
GDI	0.592	0.731	0.524	0.640	0.541	0.653
HDI	0.623	0.753	0.539	0.653	0.561	0.667
Health index	0.663	0.705	0.657	0.692	0.660	0.698
Gender index	0.592	0.731	0.524	0.640	0.541	0.653
Education index	0.757	0.887	0.582	0.662	0.611	0.673
Income index	0.449	0.666	0.378	0.605	0.392	0.617

Source: Human resources Development Report, 2005; Government of Karnataka

Interestingly, among all the said indices Bangalore Urban district consistently ranks as number 1 in almost all the indices in Karnataka while Bangalore Rural and Ramanagar occupy subsequent ranks. For BMR all these indices have been derived by using weighted averages. Obviously, BMR indices are positioned between the values of Bangalore Urban on one side and Bangalore Rural and Ramanagar on the other, yet close to the urban district. Hence, in almost all aspects of infrastructure and services Bangalore Urban district has fared extremely well.

1.5. IMPACT OF SOCIO-ECONOMIC DYNAMICS

Unlike Chennai, Bangalore has not remained a very traditional city with unique cultural and religious characteristics but assumed more cosmopolitan and secular attributes. This is because of far reaching changes brought about by the combined effects of globalisation and IT development. Non-resident Indians (NRIs) and global corporates tend to look at Bangalore as an emerging global brand associated with rapid development and have shown keen interest in investment in Bangalore. As a result the NRIs share in the total investment, which was earlier only about 3%, has increased to a staggering 10% in recent years and it is likely to go up further.

Figure 7: Changing cityscape at Cantonment

The rapid growth of IT sector in the city has led to larger income disparities between households involved in IT and non-IT sector employment (Times of India, 5 September, 2006). The disparity is by and large to the tune of at least three times and in some cases would reach even up to ten times. This has resulted in a huge gap between IT and non-IT sector employees in terms of their socio-economic status and gradually reaching an alarming level. IT based employees with huge disposable income tend to look for higher quality products, brands and services to meet their life style needs. In response to that modern shopping malls, super market chains have not only emerged but occupy a large portion of the retail segment. Retail trade has emerged as a most lucrative and rapidly expanding sector and hence, acquired greater importance in terms of human resources, finance, technology, planning and management. While invasion of super markets helped high income and migrant populations, in addition to buying parity, it is posing conflicts with the traditional grocery shop culture. Higher disposable income among IT professionals has also influenced the other sectors like transport, real estate, travel, entertainment, and the hospitality industry. The sudden rise in demand for land and housing has jacked up the land value to such an extent that it has almost become beyond the reach of the people working in non-IT sectors. This has clear implications in terms of rising of revenue for the city development. This may be in addition to several ongoing programmes on eradication of urban poverty and slum development initiated by both Government of India and the Government of Karnataka.

Different land values prevailing in different parts of the city are shown in Table 8. While high land values in the central zone are owing to the economic gravity of the central business district (CBD), a hub of commercial activities is also in the east and south that form the IT belt. Land, house and rental values in the IT belt are on average much higher as compared to non-IT zones (refer to Table 9).

Table 8: Value of apartments, land and rents in Bangalore as of 2007-08

Area	Apartment values in INR /ft^2	Plot values i n INR/yard^2	Rentals in INR/month
Central	4,000-20,000	60,000-95,000	15,000-100,000
East	2,500-6,000	16,000-90,000	15,000-45,000
West	2,100-6,500	25,000-85,000	10,000-25,000
North	1,900-12,000	8,000-90,000	10,000-25,000
South	2,400-5,500	25,000-10,0000	15,000-25,000

Source: Magicbricks.com, 30th august, 2008.

Table 9: Land and rental values in IT zones of Bangalore as of 2008

Location	Built -up cost in INR/ft^2	Site cost in INR/ft^2	Rental (2BHK) INR/m	Rental (3BHK) INR/m
Banneraghatta	3,000-6,000	4,000-8,000	13,000-20,000	25,000-45,000
Sarjapura	2,500-3,600	2,500-4,000	10,000-15,000	17,000-22,000
Sarjapura	3,000-5,500	4,000 onwards	12,000-15,000	18,000-28,000
Whitefield	2,800-400	3,500-4,600	13,000-18,000	20,000-26,000
Hebbal	3,800-5,500	4,500-6,000	15,000-18,000	20,000-65,000
Electronic city	2,000-3,000	1,200-2,500	8,000-12,000	12,000-18,000
Whitefield	2,500-3,300	3,000-4,500	12,000-15,000	17,000-22,000
Yelahanka	3,300-4,000	3,500-4,200	13,000-17,000	18,000-25,000

Source: Silverline Reality, Times of India, 1 August, 2008

Multi-storeyed apartment buildings have been constructed throughout the city in order to meet housing needs of higher economic strata. In addition to mushrooming apartment buildings with unique comforts and price ranges of INR 10 to 80 lakhs, ultra modern villas of international standards are also booming in the peripheral areas in spite of exorbitant prices.

There are several ways of looking at the IT development in the city. It is true that the IT sector has contributed significantly to the state economy in terms of revenue. It has improved gender equality and now almost 30% of the sector's workforce are women and their share is likely to increase to 45% by 2010. But it is also true that with the introduction of IT, Bangalore is burning almost 72 lakh litres of fuel per day emitting large quantities of pollutants that pose serious health risks and other environmental issues.

2. PRESSURES AND UNDERLYING CAUSES

2.1. INFRASTRUCTURE

The formation of greater Bangalore without any preparedness towards infrastructure and services has put tremendous pressure on the existing infrastructure. The most affected sectors are transport and housing. It is almost impossible to imagine the transportation challenges that the city is likely to face in future with the existing means. Several infrastructure development projects have been completed, proposed or are under implementation:

- The new Bangalore International Airport (north Bangalore)
- Bangalore–Mysore Infrastructure Corridor (southwest Bangalore)
- Information Technology Corridor (southeast Bangalore)
- Bangalore Metro Rail (across Bangalore) under construction
- Large manufacturing industries (east and north)
- IT/ITES/Biotechnology industries (east and south Bangalore)
- Development of five integrated townships
- Power supply projects
- Proposed peripheral ring roads
- Proposed Urban Basic Service Delivery Projects

While these infrastructure projects provide better facilities to citizens, they also increase the pressure on environment and induce higher immigration in the name of development and employment opportunities.

2.2. IT INDUSTRY GROWTH

Bangalore has consistently emerged as a multi-functional city with specialisation in manufacturing, trade and commerce and service sectors. As a result, almost 99% of the total workforce is employed in non-primary sector with a major share in the tertiary sector (Census, 2001). However, since 1984 the main instrument for Bangalore's rapid growth has been the IT sector with the establishment of a multinational company, Texas Instruments, followed by STPI's first earth station and a group of 13 other companies. Between 1992 and 2003 the number of IT companies increased from 13 to 1,154 (9000%) while, sales in terms of software export has recorded an unparallel increase from USD 1.19 million to USD 2,628 million (22,000%). More significantly, growth in the export of software in a single year (2000-01) has recorded as high as 70%. Hence, with 1,590 million USD Bangalore has occupied the first place in software export as compared to other prominent software centres in the country like NOIDA (926), Chennai (629), Hyderabad (423) and Mumbai (343) in 2000-01. Similarly, between 1998 and 2003 the total investment by IT companies has increased from USD 840 million to USD 2.67 billion (Bangalore IT website, 2006). For smooth functioning of the IT sector it has attracted highly skilled IT professionals whose number is estimated as about 1.5 lakh. Such a rapid growth of the IT sector and associated concentration of professionals and skilled workers to meet growth targets has obviously resulted in multiplier effects to attract resources and population to the city. As a result, the city has expanded its boundaries on all sides to accommodate IT units and its professionals. Such an expansion has been more prominent in the south-eastern sector of the city (Hosur Road, Koramangala, HAL and Whitefield) which has been identified as IT corridor running from old Madras Road to New Madras Road.

2.3. SPECIAL ECONOMIC ZONES

In order to promote rapid economic growth and development Government of India has encouraged the formation of Special Economic Zones (SEZs) in the country. The main idea of SEZs is to provide land for certain economic activities and promote them by providing incentives. It is estimated that they would create multifarious employment and business opportunities in the years to come. Currently, the existing SEZs are contributing INR 1,824 crore to the state's exports.

However, the promotion of SEZs also imposed almost a similar effect as that of IT sector. While a lot has been said about the positive aspects of economic development with the introduction of SEZs, there are darker sides too as illustrated in Nandagudi village of Bangalore Rural district. Nandagudi, a small village in Hoskote taluk is a sericulture settlement since the introduction of sericulture by Tipu Sultan around 1780. The village also has a historical significance since 1530 as it has several temples and carvings of Hoysala sculptures of Vijayanagar style. The villagers have sold fertile agricultural land for a higher price and settled in nearby urban areas and have become unknown identities in an unknown place. In Bangalore about nine other non-IT SEZs are being promoted, specialising in biotechnology, textile, hardware, infrastructure, logistic services and aerospace. According to reliable estimates by 2010 Bangalore region requires 6.5 million square feet of land for the biotechnology sector alone. Following are some of the planned SEZs. Refer to Chapter 7 "INDUSTRY", section 1.2.5 for additional information on SEZs.

Proposed SEZs

- It is proposed to set up an Aerospace Park near the new airport at Devanahalli with an investment of INR 3,384 crore and in an area extending for 918 acres. The proposed project is first of its kind in the country with a nucleus of sophisticated aerospace activities. It is likely to attract top research skills and manufacturing activities. This development would obviously demand a huge volume of infrastructure and services in terms of housing, trade and retail, education, entertainment, hotels and associated services of international standard in and around the international airport;
- A biotechnology park spread over an area of 86 acres and biotechnology and IT services in an area of 103 acres are expected to come up near Electronic City in Anekal *taluk* with a huge investment and employment opportunities;
- A textile park in an area of 240 acres in Ramanagar district;
- Garments and fashion accessories manufacturing unit spread over an area of 278 acres in Ramanagar district;
- Advanced research centre with an area of 971 acres to cater to the needs of high quality research and development in Ramanagar district;
- A textile and apparel park is proposed to come up in Kanakapura Road of Bangalore South *taluk* with an area of 400 acres with 50 factory units having potential employment opportunities for about 50,000 people;
- An SEZ specialised in hardware and multi-product manufacturing is expected to come up near Hoskote in an area of 39 acres;
- A huge multi-product SEZ is likely to come up in an area of 2,810 acres at Chikkaballapur near Devanahalli.

All these non-IT SEZs have to be developed as self-contained units with adequate social and economic infrastructure and services such as power, transport, housing, hospitals, educational infrastructure, hotels, commercial complexes and recreational facilities.

Although it is doubtful that this project would be conferred the status of an SEZ, Karnataka is also set to emerge as a major wine producer. In this regard, a decision has been taken to earmark 1,000 acres of land exclusively for quality grape cultivation. Out of this an area of 500 acres has been identified in Nandi valley near Devanahalli and the remaining 500 acres in north Karnataka. The production of French quality grapes is expected to attract a huge investment and employment (18 July 2008, Times of India).

Realisation of these SEZ projects is unlikely to improve environmental conditions. The rapidly growing city will be more seriously affected in terms of air pollution, water quality, supply and sanitation shortcomings, waste management deficiencies, and degradation of greenery and water bodies. Some of the most potential issues to emerge in the absence of adequate preventive measures are:

- Degeneration of rural tracts and village settlements into slums posing serious environmental problems in terms of unhygienic conditions emerging out of poor water supply, sanitation, solid waste disposal, unhealthy housing and high population density;
- Unplanned growth with most inefficient land-use in terms of housing, industrial, commercial, transportation and cultural activities without adequate provision for open spaces;
- Air, water, noise and soil pollution due to inefficient use of both public and private transport services, inefficient management of water, wastewater, solid waste and industrial waste;
- A consequential adverse impact on human health.

In Bangalore, the three major work concentration areas are (a) Vidhana Soudha–Majestic–City Market, (b) K. R. Puram–Whitefield–HAL and (c) Hosur Road–Electronic City. Second level areas are Tumkur Road and Mysore Road. The working population is distributed throughout the city and they require transport to reach workplaces. Decentralisation of rail and road transport terminals is also essential to reduce pressure on the existing terminals as well as to promote planned growth of the city.

2.4. EMERGING STRUCTURAL SCENARIO

On the basis of present trends and planned activities some projections of socio-economic characteristics for the years 2011-2031 for BMR have been attempted. In a way the projected characteristics would provide good insight into the likely changes and thus provide a base for policy recommendations for the city administration. Some of the highlights of the projected characteristics are that the population of the region will reach 20.8 million by 2031 while 85% of the population would live in the urban area. The conservation of rural enclaves is essential for management of the urban ecosystem. With the size of BMR remaining constant the population would increase significantly which may exacerbate environmental and developmental issues. The sex ratio will remain low because of large-scale male immigration.

Table 10: Forecast of BMR's characteristics

Characteristics	*2001*	*2011*	*2021*	*2031*
Area	8,022	8,022	8,022	8,022
Population	8.41	10.88	16.00	20.8
Urban population (%)	73.3	75.0	80.0	85.0
Rural population (%)	26.7	25.0	20.0	15.0
Population density	1,048	1,346	1,994	2,592
Literacy – overall	80.9	83.0	88.0	90.0
Literacy – male	85.0	87.0	89.0	93.0
Literacy – female	72.6	75.0	78.0	80.0
Sex ratio	918	920	925	930
Workers (%)	38.4	40.0	42.0	45.0
Workers – Male (%)	56.4	59.0	62.0	65.0
Workers – Female (%)	18.6	20.0	25.0	38.0
Workers – Agric. (%)	16.0	14.0	12.0	10.0
Workers – Non-agri. (%)	84.0	86.0	88.0	90.0

Source: Census of India, 2001

Literacy levels will progress significantly and this would obviously demand educational infrastructure and employment opportunities. With proposed SEZs and other industry and service activities employment opportunities will go up significantly. As a result, work participation would reach almost 45% greater female participation. To support the process of urbanisation, non-agriculture based occupation would also be enhanced with greater involvement of workers as compared to previous decades. However, the main issue is the provision of required infrastructure and utilities in terms of housing, energy, water, transport, open spaces, recreational facilities to lead a decent urban life with pollution free environment. This obviously demands adequate policy measures to meet the development challenges in BMR.

Bangalore is unique in its location characteristics and functional specialisations. On the basis of present growth trends and projected activities, the future city will emerge in a more distinct way with identifiable structural characteristics. In particular, the city's potential as the IT and Biotechnology capital is likely to continue for some more decades before the title is claimed by other cities of India. The required infrastructure and services need to be provided by the state in consultation with the IT sector for their functioning and development. By taking the future development potential into consideration a possible scenario from 2011 to 2031 in terms of population, associated infrastructure and service requirements have been evolved on the basis of acceptable norms. Interestingly, since BMR consists of vast area which is by and large enough to meet the land demands for another few decades, the same BMR area has been maintained for the future till 2031.

The baseline used for calculation of future scenarios are (i) a population projection made on the basis of the 1991-2001 growth rate along with the components of growth of BMR; (ii) water requirements derived from the accepted norm of 135 litres per capita per day; (iii) solid waste generation estimated on the basis of 0.500 kg per person per day; and (iv) wastewater generation estimated on the basis of the existing norm that 80% of the total consumed water will come out as wastewater. The projected scenario as evolved through these norms has several implications on the environmental management of BMR. The first and the foremost task is to accommodate a population of 20.8 million in the given area of 8,022 km^2 with an average population density of 2,592 people per km^2. Other major issues are (i) efficient supply and management of drinking water to the tune of 2,460 million litres per day (MLD) and (ii) adequate technology based management of solid waste and wastewater.

Table 11: Future scenario of BMR

Variables	*2001*	*2011*	*2021*	*2031*
Population in million	8.41	10.88	16.00	20.8
Land in square kilometers	8,022	8,022	8,022	8,022
Density in people/ square kilometers	1,048	1,346	1,994	2,592
Water requirement in MLD	1,135	1,469	1,900	2,460
Solid waste generation in tons per day (TPD)	4,210	5,440	7,040	9,110
Wastewater generated in MLD	908	1,175	1,520	1,968

Considering the planning and development efforts needed, it is clear that IT and associated sectors are being encouraged in the city by Government of Karnataka. As a result by and large its associated employment is also concentrated in these specified areas along with their specific requirements. Hence, by looking at the ongoing spatial development process of IT, non-IT, SEZs and associated infrastructure, it may be argued that the future BMR will emerge with the following four distinct areas with unique socio-economic characteristics. They are:

- The traditional city consisting of some parts of old city area of Bangalore Mahanagara Palike (BMP) with major concentration of traditional lifestyles with greater importance attached to cultural and traditional values with strong determination to practice and inherit these to the next generation in order to retain the cultural and religious flavour of the city.
- The IT dominant zones consisting of the IT corridor, the quadrant of the south-eastern area extending from Electronic City and Hosur Road up to ITPL Whitefield and Hoskote. These will have a major share of migrant population with assured modern infrastructure and services along with the said socio-economic characteristics with exclusive vertical growth of high rise buildings. The most probable areas are parts of southeast of Bangalore, Bangalore South and North *taluks*, Anekal and Hoskote.
- The international airport area with infrastructure development at par with the urban infrastructure and services of a developed economy consisting of areas like Bangalore North, Devanahalli, Doddaballapur, Nelamangala and Ramanagar.
- Channapatna, Kanakapura and Magadi are expected to remain distinct areas under the influence of industrial development and allied activities along the Bangalore–Mysore corridor.

This structure may be corroborated by the proposed SEZs and associated infrastructure and service developments. The Structure Plan proposed by BMRDA with details of functional specialisation in various zones broadly conforms to the emerging structure illustrated here. Particularly the area around the airport comprising of Devanahalli, Doddaballapur and Nelamangala with its very high land value and proposed aerospace SEZ it is likely to emerge as a new urban centre with infrastructure and services of a very high quality.

Figure 8: The rural touch is not gone in many parts of Bangalore – A cow feeding in J.P. Nagar

The growth of Bangalore will put pressure on energy, water, land and other resources with an adverse impact on environment. Industrial zones would also create an environmental impact and the management of waste, both industrial and domestic waste, would be one of the key challenges. The traditional city zone on the other hand by virtue of a conservative approach would create less of an additional impact on environment. Hence, for efficient environmental management it is vital to plan emerging areas well in advance to save BMR from unplanned growth and make the city socially, culturally and environmentally liveable according to the requirements of all socio-economic groups.

3. RECOMMENDATIONS

Bangalore is experiencing several key development issues and problems due to inefficient planning and administration in particular. As a result, the most glaring but delicate development issue that has emerged is the disparity between IT and non-IT sectors mainly in terms of income and socio-economic levels. Socio-economic indicators as well as human resources development indices reveal that the development is not uniform as BMR has a sizable rural population with well-defined rural characteristics. Hence, the main development dilemma is whether BMR should (a) promote uniform development without disparities or (b) retain rural enclaves and maintain a balance between the two. In conclusion, the emerging four distinct areas of differential socio-economic characteristics described in section 1.1 and 2.4 appear advantageous for BMR and should be maintained.

These distinct zones emerging with specific functional and socio-economic structures have been identified with a unique characterisation of socio-economic development. Hence, with these emerging structural scenarios the future city of Bangalore should look like a city with a balanced vertical and horizontal growth with well knitted socio-economic characteristics and identities with greenery all around interspersed with well planned self-contained residential neighbourhoods, infrastructure and services with minimum travel needs. To maintain the socio-economic and ecological harmony, Bangalore should be developed along with its region to achieve a symbiosis between city and region. Satellite towns should be planned as self-contained units with occasional dependence on the city for restricted specialised commercial, health and administrative services. Policy makers and urban planners should respect the location specificity and capabilities of Bangalore and promote its growth and development, if not as an ideal city then at least as a city of profound aesthetic and environmental values with a balanced urban ecosystem in terms of land use, infrastructure and citizens of all socio-economic strata. Ultimately, such a dream city with a well balanced city–region system is possible only with the combined efforts of dedicated stakeholders such as government departments, urban planners, policy makers, non-government organizations and more significantly, the citizens of Bangalore.

Chapter 12

Economic Instruments

CONTENTS

TABLES

1. STATUS

1.1. CONCEPT

A gradual shift in the development process which includes production, service systems and lifestyle has led to complex environmental issues, thus demanding altogether new approaches to environmental management. As a result, a new concept called the polluter-pays-principle (PPP) was evolved as early as in 1970s for environmental management (OECD, 1980). The basic idea of the principle is to introduce the concept that the cost of pollution should be internalised, which means the user of the resource in addition to resource use should pay for its damage, control measure as well as its security. This principle has led to the evolution of economic instruments as supportive policy instruments for environmental protection.

Economic instruments are policy measures evolved using economic concepts to abate or control environmental problems. To achieve environmental objectives, economic instruments use the market system to evolve two kinds of policy measures; administered price and administered market. In case of administered price, market prices are charged for environmental goods which otherwise would not exist (pollution tax) or the existing price is modified through policy measures such as modification of the product price by including the cost of the environmental impact. Hence, administered price either creates a new price or modifies the existing price to reflect the environmental impact. Similarly, administered market creates a market that did not exist for environmental pollution. Tradable permits are the best examples for this concept as they create market for pollution abatement through emission trading. The main aim of economic instruments is application of economic incentives or market stimuli in internalising environmental costs as well as act as a preventive measure. Hence, economic instruments influence decision-making behaviour in such a way that the chosen alternatives lead to a more desirable situation environmentally than the absence of the instrument. In other words, the basic principle is to align private costs with social costs to reduce environmental impact.

1.2. TAXONOMY OF ECONOMIC INSTRUMENTS

The broad categories of economic instruments are fiscal instruments, financial instruments, charge instruments, deposit-refund system and bonds, market creations, liability and redefining property rights (refer to Table 1). These instruments are broadly based on the economic principles like tax, user charge, incentive, markets, compensation and property rights. On further distinction, the instruments that follow polluter pays principle are fiscal instruments, charge instruments and liability. While other instruments work on general economic principles like incentives (Financial Instruments), creation of rights (Redefining Property rights) and creation of markets (Tradable emission permits; Deposit - Refund System and Bonds, refer to Table 1).

The importance of subsidy, which is also an economic instrument has been reduced considerably with the introduction of polluter-pays-principle. Of late, incentive based approaches are being seen as more effective as they provide flexibility in meeting stringent policy goals than traditional regulation. Especially in developing countries for setting right environmental damages some form of welfare measures through introduction of subsidy is essential to meet the environmental challenges (Oats, 1998). Subsidies have proved effective in pollution control in the developed world as well (OECD, 2005).

Table 1: Taxonomy of economic instruments

Category	*Examples*
Polluter-pays principle	
Fiscal instruments	▪ Pollution taxes ▪ Input taxes ▪ Import tariff
Financial instruments	▪ Financial subsidy ▪ Soft loan and grants ▪ Sectoral/revolving funds
Charge instruments	▪ Effluent charges ▪ User charges ▪ Product charges ▪ Administrative charges ▪ Financial aid for new technology ▪ Subsidies for environmental research and development expenditure ▪ Impact fees ▪ Access fees ▪ Non-compliance fees
Other economic principle	
Deposit-refund system, bonds	▪ Deposit-refund schemes for recycling ▪ Environmental performance bonds ▪ Land reclamation bonds
Market creations	▪ Tradable emission permits
Liability	▪ Liability Insurance legislation
Redefining property rights	▪ Changes in ownership ▪ Use and development rights

Source: OECD, 1987and 1989, Kuik et al (1997), Panayotou (1998), Pearce and Barbire (2000)

In fact, adequate subsidy provision is the secret for the grand success of economic instruments in OECD countries (OECD, 1994, 2005). Developing countries have better opportunities for effective use of incentive based approaches for environmental protection (Sterner, 2003).

1.3. DIRECT ECONOMIC MEASURES

1.3.1. Historical review

On India's opening up of the national economy in 1991 the country has been experiencing rapid changes in almost all sectors. In response, environmental conditions have also experienced rapid changes but by and large adverse ones. In order to conserve natural resources and promote efficient environmental management policy statements such as 'pollution abatement policy' and 'national conservation strategy' were adopted in 1992. With rapid emergence of environmental challenges a new environmental policy statement the `National Environmental Policy (NEP), 2006' was adopted. This was the revised and integrated version of two previous policy statements.

Having realised the complexities of the existing as well as emerging environmental issues both the 1992 and the NEP 2006 policy statements have promoted the use of economic instruments for environmental protection by judicious mix of incentives and legislations. Several studies were conducted to estimate the marginal cost of pollution abatement and demonstrated the potential for introduction of economic instruments in India (refer to Table 2). The table is to provide an idea of how marginal abatement costs for primary and secondary treatment of wastewater are. Refer to Chapter "**WATER SUPPLY AND SANITATION**", section 1.8 for information on water treatment of BWSSB.

Table 2: Type of pollution and marginal cost for pollution control

Study	*Industry*	*Pollutant monitored*	*Cost of abatement per unit*
James and Murthy (1999)	All type	COD	INR 0.32 per 100 grams of COD
Panday (1998)	All type	BOD	INR 2.45 per100 grams of BOD
Panday (1997)	Sugar	COD	INR 1.69 per100 grams of BOD
Goldar and Pandey (1999)	Distilleries	BOD	INR 3.50 per 100 grams of BOD
Sastry (2006)	Sewage (primary and secondary)	BOD	INR 42.22* per one unit of BOD
Sastry (2006)	Sewage (tertiary treatment)	BOD	INR 1164.90 *per one unit of BOD

** Average cost of treatment per unit of BOD*   *Source: James and Murthy ,1999; Panday ,1999; Goldar and Pandey, 1999; Sastry, 2006*

The task force on market based instruments or economic instruments by the Government of India (1997 and 2001) and the related international seminar organised by Ministry of Environment and Forests, Government of India in association with the World Bank and CII (Dasgupta and Mandal, 2001) and the government's own commitment in the policy statement on pollution abatement, 1992 and 2006 have all favoured the use of economic instruments for environmental management. In an effort to promote the use of economic instruments, the Government of India and the Government of Karnataka have introduced several direct and indirect economic measures for pollution control and environmental management.

1.3.2. Water cess

Water cess was the first direct instrument introduced by an Act of government as Water (Prevention and Control of Pollution) Cess, 1977. According to Water Cess Act, all industries that consume water for production should pay water cess. Differential rates have been fixed for different consumption purposes. For effective regulation the Cess Act has been amended twice in 1991 and in 2003 with upward revision. Some incentives are inbuilt in the Cess Act so that industries compliant with pollution norms pay less than non-compliant industries. However, the water cess does not cover the consumption from private bore wells or private supplies through lorries. As the usage from these sources other than public water supply is not considered the water cess remains overall a very low deterrent for pollution. Bringing also bore wells and private water supply under the ambit of the Act may face practical difficulties but would improve prevention and control of water pollution as well as control over-exploitation of ground water.

1.3.3. Consent fee

As per the Water and Air Acts, all pollution-prone industrial and other establishments are required to seek consent for establishment and operation of production activities and pay a consent fee for that. In other words this is an assured source of income to the State Pollution Control Boards (SPCB's) for environmental management. In Karnataka, the consent fee structure defined by Karnataka State Pollution Control Board (KSPCB) was very low in the beginning but was subsequently revised to generate more financial resources for the board. As a result, consent fees accounted for merely 36% in the total income of KSPCB in 1991-92 but increased to 80% in 2003-04. While the consent fee does not appear as a policy instrument for pollution abatement, however, by its function as finance generator it assumes the label as a direct economic instrument for environmental management

1.3.4. Public Liability Insurance Act, 1991 and Environmental Relief Fund

The Act was introduced in 1991 to provide compensation and relief to the affected people. This act is applicable to all industries which may cause accidents that could result in irreparable loss of life, property or damage the environment. The main purpose of this insurance is to provide immediate relief to life and property of affected people. The insured amount is to an extent of INR 500 million paid up capital. In case of an accident the reimbursable amount is up to INR 25,000 per person in addition to reimbursable medical expenses up to INR 12,500 per person. The eligibility of insurance is limited to INR 50 million per accident or INR 150 million per year or up to the tenure of the policy. Any excess claim is reimbursed by the Environment Relief Fund (ERF).

1.3.5. Corporate Responsibility for Environmental Protection (CREP)

CREP was introduced by the Ministry of Environment and Forest (MOEF) in 2002 to make highly polluting industries compliant with the minimum national standards (MINAS) notified under the Environment Protection Act, 1986. Units which had compliance problems are asked to prepare action plans to achieve compliance while giving a bank guarantee which would be forfeited if compliance was not achieved in the stipulated timeframe. The quantum of bank guarantee and the timeframe for compliance are to be negotiated with the SPCBs. In Bangalore Metropolitan Region (BMR) there are about 21 industries to which CREP instrument applies (refer to Chapter 7 "INDUSTRY", section 1.1.3). This instrument has been introduced on the recommendation of the task force on the market-based instruments (MBIs).

1.3.6. Guarantee money

Similar to the CREP mechanism, KSPCB has introduced a guarantee money system for installation of sewage treatment plants (STPs) and solid waste management facilities in apartments and housing projects. Guarantee money is imposed to ensure the creation of required facilities (refer to Table 3).

Table 3: Guarantee money prescribed by STP capacity, Bangalore

STP capacity	Guarantee money (in lakh INR)
Up to 100 KLD	5
101 to 300 KLD	10
301 to 500 KLD	20
501 and above	30

Source: KSPCB, 2008

1.4. INDIRECT ECONOMIC MEASURES

Table 4: Indirect incentives offered by Government of India

Incentive	Level
Investment allowance for the actual cost of new plant or machinery under section 32A of the Income Tax Act, 1961 to assist in pollution control measures.	Up to 35%
Depreciation on certain equipment for air and water pollution control as well as technology for waste minimisation, energy saving and utilisation of renewable energy	100% depreciation
Depreciation on plant and machinery and buildings for water supply projects	100% depreciation
Excise duty exemption on the use of fly ash, phospho-gypsum in 25% or more as raw material on production of low cost building materials and component	
Customs and excise duty exemption of capital goods and machinery for water supply projects	
Excise duty exemption for water pipes	
Customs duty exemption on import of equipment, machinery and capital goods required for the production of building materials such as bricks, light weight aggregates concrete elements	
Customs duty reduction on components of membrane cell technology (caustic soda industry)	From 15% to 5%
Cess on diesel/petrol to abate air pollution (2003-04 budget)	INR 0.50 per litre

Table 5: Indirect economic measures for pollution control in Karnataka

Incentive	*Level*
Subsidy on organic manure	50%
Subsidy on drip and sprinkler irrigation equipment	50% (all farmers) and 100% (SC/ST farmers)
Interest subsidy for LPG change-over for existing auto-rickshaws	INR 2,000
Subsidy on solar water pumps	Increased from 25 to 50%
Soft loans for installation of solar water heating, lighting and wind energy systems	
Subsidy on vermi-composting of farm waste	Up to 50%

Source: Discussions with KSPCB, 2008

1.5. SOLID WASTE CESS IN BBMP

Bangalore generates about 3,000 tons of solid waste per day. Its management has been a major issue for BBMP due to institutional, financial and infrastructure constraints. In order to overcome these problems, BBMP has introduced a cess on solid waste for all types of land use activities from January 1, 2006. This is in realisation of the fact that economic instruments in addition to efficient environmental management instruments are potential revenue generators for environmental management too. The solid waste cess varies by type of activity that a piece of land is put to use and in the form of plinth area. In terms of levy it is minimum for residential buildings and maximum for malls, hotels, marriage halls and nursing homes (refer to Table 6). Similarly an entry fee is being charged for many public gardens in Bangalore viz., Lal Bagh Botanical Garden (INR 10) and Banneraghatta National Park (INR 100) which may be interpreted as economic instruments for the management of respective environmental resource.

Table 6: Monthly cess for solid waste management in Bangalore

Type	*Plinth area in square feet*		
Residential	10	30	50
Commercial	50	100	200
Industrial	100	200	300
Hotels, marriage halls, nursing homes	300	500	600
Cess	***< INR 1,000***	***INR 1,001 to 3,000***	***> INR 3,000***

Source: BBMP, December 2005

2. KEY ENVIRONMENTAL IMPACT AREAS

Urban environmental management is mandatory for Urban Local Bodies under the 74th Constitutional Amendment Act, 1994. Similarly, as per the constitution a clean environment is a fundamental right of India's citizens. While a comprehensive environmental legislation exists, institutional constraints and changing industrial practices recommend modified or new policy instruments to realise environmental objectives.

Encouraging global experiences (Sastry, 2006) as well as commitments of Pollution Abatement Policy, 1992 and NEP 2006 policy statements by the government of India have prompted the formulation of economic instruments for urban environmental management for Bangalore laid out in section 3. The main sectors contributing to urban environmental problems in BMR are household, industry, trade and commerce, transport, energy, water, planning and infrastructure. The following table details key impacts of each (refer to Table 7).

Table 7: Key environmental impacts

	Activities	Consequences	Environmental impacts
Household	Consumption	Demand for goods and services	Air, water, land and noise pollution
	Waste generation	Solid and liquid waste generation	Air, water and land pollution
	Housing	Demand for land and building materials. Conversion of agricultural land to non-agricultural purposes.	Air, water, land and noise pollution due to production of building materials
	Travel	Demand for vehicle and increase in fuel consumption	Air and soil pollution and disposal of old vehicles
Industry	Minerals mining	Extensive mining	Degradation of land, water forest and biodiversity
	Water consumption	Water scarcity and excess waste water generation	Water and soil pollution
	Energy consumption	Large-scale production of hydroelectric, thermal and atomic energy	CO2, air pollution, fly ash, loss of large stretches of forest, water and soil pollution and highly radioactive atomic energy waste generation
	Labour	Involvement in production and service activities	Impact on health, loss of production
	Waste generation	Solid, liquid and gaseous waste generation	Air, water, soil and noise pollution
Trade and commerce	Services	Generation of waste	Land, water and noise pollution
Transport	Transport	Energy consumption	Air pollution,
Energy	Generation	Consumption by primary, secondary and tertiary sectors	CO2, air pollution, fly ash, loss of large stretches of forest, water and soil pollution and highly radioactive atomic energy waste generation
Water	Consumption	Depletion of water resource and wastewater generation	Resource scarcity and water pollution
Planning and infrastructure	Development of agricultural land and infrastructure development	Conversion of huge stretches of fertile agricultural land to non-agriculture purpose	Damage to health and functional aspects of the ecosystem and its balance
Forest and biodiversity	Protection of ecosystem	Indiscriminate urban and infrastructure development has led to loss of forest area and biodiversity	Problems concerning ecosystem in terms of ecological balance.

3. PROPOSED ECONOMIC INSTRUMENTS

3.1. KEY INTERVENTION AREAS

On the basis of an assessment of causes, consequences and environmental impact the following economic instruments were formulated (refer to Table 8). The proposed instruments pool common issues to achieve a comprehensive coverage.

Table 8: Summary of proposed economic instruments

	Proposed instruments	
Air	**Non-point source** • Increase in sales tax on vehicle purchase • Introduction of higher registration and renewal charges on vehicle • Restricting the entry of all vehicles into the core area of the city by imposing an entry tax • Restricting the entry of all non-city bound vehicles into the city by imposing an entry tax • Imposition of a pollution tax on non-compliers on the basis of pollution load • Discouraging the use of old and non-conforming vehicles by imposing a higher tax • Changing the fuel base of vehicles and imposing a tax on vehicles running on unclean fuels	• Restricting the vehicular ownership per household by using an appropriate tax • Buy-back policy by all automobile companies • Creation of vehicular free zones and imposing deterrent fines for non-compliance **Point sources** • Imposition of input-tax on pollution prone raw materials • Introduction of tradable permit system. • Buy back policy by all industrial companies. • Eco-siting of industrial units and imposition of high tax for non-conformity.
Water	• Replacing the existing water cess by a user charge for all water consuming industrial units • Imposition of pollution charge for all non-complying units • Imposition of treatment charge for wastewater treatment	• Encouraging effluent treatment plants (ETPs) for water pollution control • Making mandatory the reuse of treated waste water for non-potable use • Introducing dual plumbing systems
Solid waste	• Buy back policy for paper, electronic and industrial waste by respective companies • Introduction of deposit refund system for waste	• Financial incentives for recycling and reuse of waste • Penalties for littering • Strict implementation of source segregation
Land, building and infrastructure	• Deterrent charges for conversion of agricultural land to non-Agriculture with magnitude of conversion charge directly related to land fertility • Deterrent charges for non-conformity to the prescribed land use plans while locating urban activities and services	• Deterrent charges for non-conformity to environmental guidelines by individuals, private developers, government agencies while forming residential layouts, commercial complexes and infrastructure development
Forest and biodiversity	• Imposition of user charge for development and maintenance of forest and biodiversity • Deterrent charge for misuse of land meant for forest and biodiversity and wetland development	• Strict implementation towards effective utilization of forest, biodiversity and wetland fund for development and maintenance • Practicing of environment friendly mining and quarrying with adequate royalty
Energy	• Tax rebate (or subsidy) for CFLs and energy efficient fixtures • Deterrent charge on commercial hoardings, signboards etc., consuming electricity	• Continuation of the current promotion scheme for solar water heaters in buildings.
Across	• Appropriate legislation for effective use of environmental charges and taxes exclusively for environment and development programmes	• Introduction of green rating for industries, mining, transport, commercial activities and infrastructure development.

Since each environment sector is unique in terms of problems and management, a detailed tabulation has been provided in the following to reflect the future plan of action as well as institutional involvement for each of the economic instruments proposed under various environmental issues. Adequate care has been taken to take into account the problems being faced within each sector.

3.2. AIR POLLUTION

The major cause of air pollution is increase in vehicle population particularly, two-wheelers and of late cars. Without looking into the availability of required infrastructure and the conditions of roads and the availability of parking space the concerned departments are allowing the vehicular population to grow. Economic instruments proposed are capable of responding to some of these problems appropriately.

Table 9: Economic instruments for controlling non-point source air pollution

	Proposed economic instrument	Future plan of action	Agencies to be involved
1.	Increase in sales tax on vehicle purchases	A study to evolve deterrent sales tax to discourage indiscriminate vehicle purchase	Commercial Tax Department, Transport Department, KSPCB and Government of Karnataka
2.	Introduction of higher registration and renewal charges on vehicles	A policy to evolve deterrent registration/renewal charges to discourage indiscriminate vehicle purchase	Transport department, KSPCB and Government of Karnataka
3.	Restricting the entry of all vehicles into the core area of the city by imposing an entry tax	a) A study to evolve precisely the core area of the city which is also high traffic density area b) To evolve deterrent entry fee for all vehicles into the core area	BDA, BBMP and Transport Department, Police Department, KSPCB and Government of Karnataka
4.	Restricting the entry of all non-city bound vehicles into the city by imposing an entry tax	Evolving deterrent entry tax	Transport Department, BBMP, Police Department and Government of Karnataka
5.	Imposition of a pollution tax on non-complying vehicles on the basis of pollution load	A study to evolve pollution tax for pollutants on the basis of pollution load	Commercial Tax Department, KSPCB and Government of Karnataka
6.	Changing the fuel base of vehicles and imposing tax vehicles that are more pollution prone due to fuel type	A policy decision to shift to clean fuel and imposing deterrent tax on non-complying vehicles	Commercial Tax Department, Transport Department, KSPCB and Government of Karnataka
7.	Restricting vehicular ownership per household using appropriate tax	Complete enumeration of vehicle ownership by households of BMR and evolving a policy for restricting number of vehicles per household	Police Department, Transport Department, BBMP and Government of Karnataka
8.	Buy-back policy by all automobile companies	Evolving a state policy for buy-back schemes by all automobile companies to encourage recycling process	Department of Industries & Commerce, Transport Department, KSPCB and Government of Karnataka
9.	Creation of vehicular free zones and imposing deterrent fines for non-compliance	A study to identify suitable zones in BMR	BBMP, Tansport Department, Police Department, KSPCB and Government of Karnataka

Table 10: Economic instruments for controlling point source air pollution

	Proposed economic instrument	Future plan of action	Agencies to be involved
1.	Imposition of pollution tax on non-complying pollution level on the basis of pollution load	A study to evolve pollution tax structure for various pollutants	Commercial Tax Department, Industries Department, KSPCB and Government of Karnataka
2.	Imposition of input-tax on pollution prone raw materials	A study to identify pollution prone raw materials and to evolve a tax structure for various pollution prone raw materials	Commercial Tax Department, Industries Department, KSPCB and Government of Karnataka
3.	Introduction of tradable permit system	A study to identify the ambient air quality and assimilative capacity of pollution load in BMR	Industries Department, Transport Department, KSPCB and Government of Karnataka
4.	Buy back policy by all industrial companies	Evolving a state policy for buyback scheme by all industrial sectors	Industrial Department, KSPCB and Government of Karnataka
5.	Eco-siting of industrial units and imposition of higher tax for non-conformity	Evolving a policy for ecologically conducive locations of various types of industries and imposition of a tax for location of all types of industries accordingly	Industrial Department, KSPCB and Government of Karnataka

3.3. WATER MANAGEMENT

The main issues in the water sector are the efficient use and management of water resources, water pollution, cost of treatment, treatment technology and the need for water recycling and reuse. Keeping these issues in mind the following instruments are proposed which incorporate the polluter-pays-principle.

Table 11: Economic instruments for water management

	Proposed economic instrument	*Future plan of action*	*Agencies to be involved*
1.	Replacing the existing water cess by a user charge for all water consuming industries	A study to evolve user charge for all industrial units including both economic and environmental components	Water Resources Department, Industries Department, KSPCB, Government of Karnataka
2.	Imposition of pollution charge on the basis of most prominent pollutants	A study to evolve pollution tax on the basis of pollution load	BBMP, Industry department, Commercial tax department and pollution control board, Government of Karnataka
3.	Imposition of treatment charge on the basis of cost incurred for wastewater treatment.	A study to evolve pollution treatment cost for various pollution parameters	IBBMP, Industry department, pollution control board, Government of Karnataka
4.	Encouraging ETPs for pollution control	A study to identify the effectiveness of ETPs and the cost and subsidy required for pollution control	BBMP, Industry department, pollution control board, Government of Karnataka
5.	Making use of treated waste water for non potable use mandatory		BBMP, KSPCB, BWSSB, GoK
6.	Introducing dual plumbing system		BBMP, KSPCB, BWSSB, GoK

3.4. LAND AND INFRASTRUCTURE

Rapid urbanisation has been identified as the key driving force of environmental degradation. Appropriate economic instruments have been proposed to retard or slow down the urban expansion process and to promote efficient management of the environment in BMR.

Table 12: Economic instruments for land infrastructure

	Economic instruments	*Future plan of action*	*Agencies to be involved*
1.	Formulation of an ecologically conducive land use plan and its effective implementation by competent authorities	Evolve an ecologically conducive land use plan and its implementation in BMR and deterrent charges for non-compliance	BMRDA, BBMP, KSPCB and Government of Karnataka.
2.	Deterrent charges for conversion of agricultural land to non-agricultural use with magnitude of conversion charge directly related to the land fertility	A study to evolve conversion charges from agriculture to non-agriculture purpose according to the level of land fertility to prohibit indiscriminate conversion of agricultural lands	BMRDA, BBMP, KSPCB and Government of Karnataka.
3.	Deterrent charges for non-conformity to environmental guidelines by individuals, private developers, government agencies while building, layout and infrastructure development	Evolve a policy to impose deterrent fines/charges on individuals, private developers and government agencies for non-conformity to approved plans in housing, industrial and infrastructure development	BMRDA, BBMP, Industry Department, KSPCB and Government of Karnataka.
4.	Deterrent charges for non-conformity to the prescribed land use plan while locating various urban activities and services	Evolve a policy to impose deterrent fines/charges for non-conformity to approved land use plan for location of various land use activities	BMRDA, BBMP, Industry Department, KSPCB and Government of Karnataka

3.5. WASTE MANAGEMENT

Rapid urbanisation has led to most crucial issue of solid waste accumulation and its disposal. The issue is complex as it comprises different categories of waste ranging from less harmful household waste to hazardous industrial waste. Recycle and reuse of certain components require adequate incentives. An attempt has been made to formulate appropriate economic instruments to address these issues.

Table 13: Economic instruments for waste management

	Proposed economic instrument	Future plan of action	Agencies to be involved
1.	Introduction of deposit refund system for waste management	A study to identify different wastes for which deposit refund system is eligible	BBMP, electronics and machinery industries, KSPCB and Government of Karnataka
2.	Recycling and reuse and financial incentives for reuse	A policy to evolve incentives for reuse and recycling of waste materials	Industries Department, newspaper companies, BBMP, KSPCB and Government of Karnataka

3.6. FOREST AND BIODIVERSITY

The maintenance of existing natural resources in the city region has become extremely difficult due to hunger for land for development activities. There is an immediate need for conservation of environmental buffer zones formed by forest areas to help maintaining the city's ecological balance.

Table 14: Economic instruments for forest and biodiversity conservation

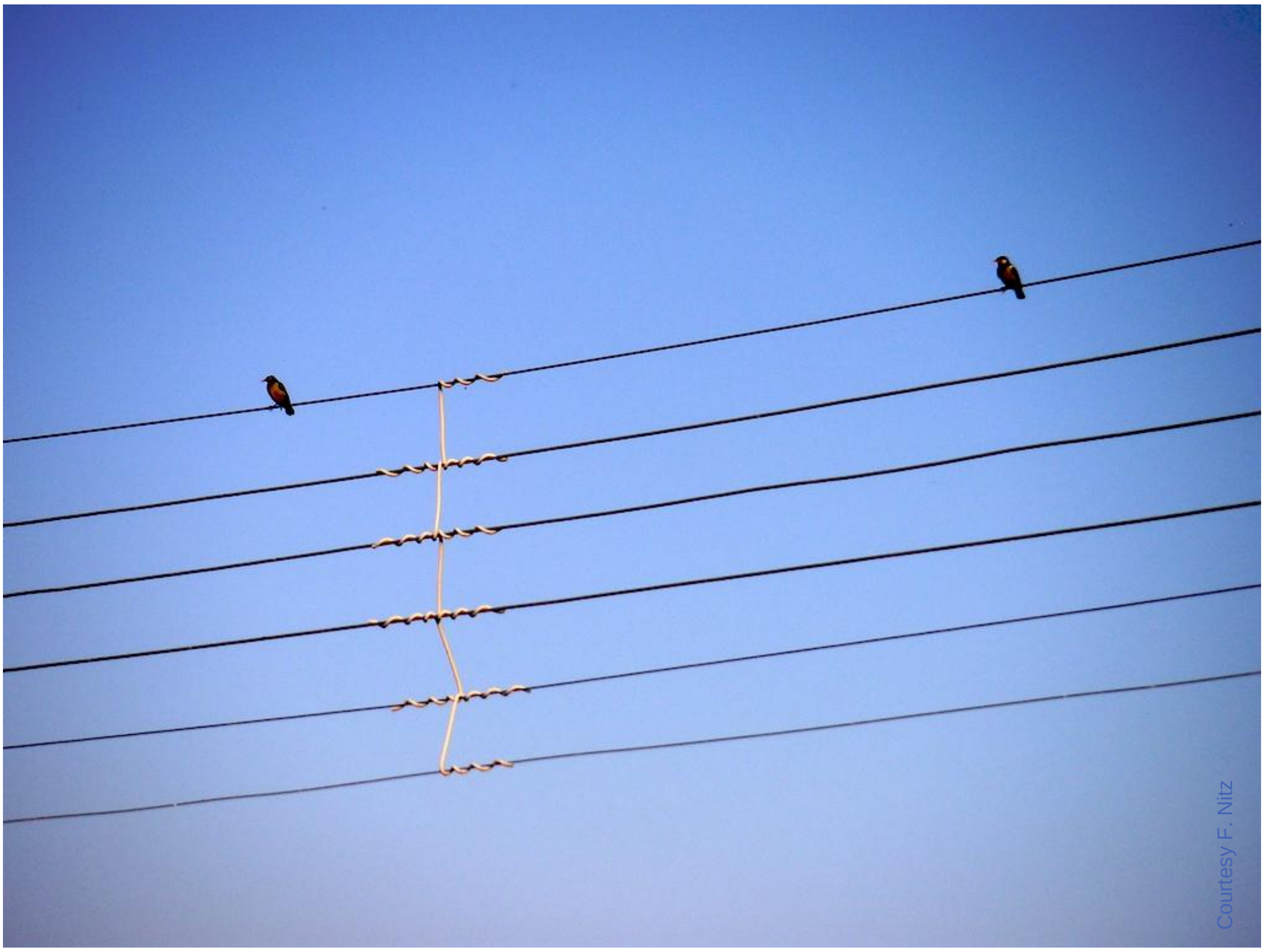
	Proposed economic instrument	Future plan of action	Agencies to be involved
1.	Reservation of large stretch of land in the BMR for forest and biodiversity development and protection	Evolve a long term land use policy to reserve large stretches of land for forest and biodiversity development and deterrent charges for encroachment	BMRDA, Forest Department, KSPCB and Government of Karnataka
2.	Imposition of user charges for development and maintenance of forest and biodiversity.	A study to evolve user charges for development and maintenance of forest and biodiversity	BMRDA, Forest Department, KSPCB and Government of Karnataka
3.	Deterrent charge for misuse of land meant for forest and biodiversity development.	A policy to impose deterrent charges for misuse of land meant for forest and biodiversity development.	BMRDA, Forest Department, KSPCB and Government of Karnataka
4.	Imposition of user charge for development and maintenance of wetlands	A study to evolve user charges for development and maintenance of wetlands and deterrent charges for encroachment	BMRDA, Forest Department, KSPCB and Government of Karnataka
5.	Introduction of forest and biodiversity fund for development and maintenance	A policy frame to evolve long term forest and biodiversity development fund	BMRDA, Forest Department, KSPCB and Government of Karnataka
6.	Imposition of environment-friendly mining and quarrying practices with adequate royalty	Evolve Eco-friendly mining policy and imposition of appropriate royalty to oversee adequacy of Eco-friendly mining	Mining Department, BMRDA, Forest Department, KSPCB and Government of Karnataka

3.7. ENERGY

Energy is one of the major resources for growth and sustenance of urban areas. Bangalore has had a historic deficit in power supply. Reduction of demand is one strategy that needs to be focused, besides augmentation of renewable resources.

Table 15: Economic instruments for energy conservation

	Proposed economic instrument	Future plan of action	Agencies to be involved
1.	Promotion of energy efficient lighting (CFLs) and fixtures by reduction in taxes or provision of subsidies	A study to identify relevant energy efficient fixtures and quantum of subsidies	Bureau for Energy Efficiency (BEE), BESCOM, Sales Tax Department and Government of Karnataka
2.	Continuation of the current promotion scheme for solar water heaters in buildings (power tariff reduction) although incentives could be more tangible		KREDL, BBMP and Government of Karnataka
3.	Deterrent charges on energy on commercial hoardings consuming electricity	A policy to discourage electricity consumption for commercial hoardings	BBMP and Government of Karnataka



Chapter 13

Environmental Management Plan

CONTENTS

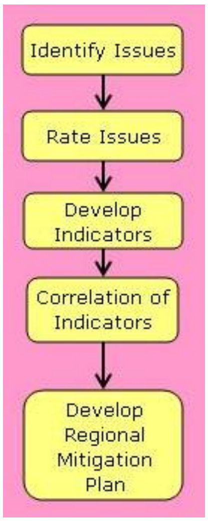
TABLES

FIGURES

1. METHODOLOGY

Chapters 1 to 12 of this report provide environmental baseline data, information on changes in environmental quality and trends and an analysis of causal factors of environmental degradation. They also identify critical issues and formulate recommendations to address the issues identified. The Environmental Management Plan presented in this chapter moulds the key recommendations of each chapter into a comprehensive actionable plan. The methodology for the development of this plan comprises of four distinct steps:

- Analysis of environmental pressures and underlying causes across different sectors;
- Rating and shortlisting of key environmental issues, consolidation and prioritisation of issues across different sectors;
- Allocation of adequate mitigation measures to address inter-sectoral issues;
- Attribution of mitigation measures to appropriate implementing agencies including departments of the government.



The core set of indicators for environmental performance describing PRESSURE, STATE and RESPONSE has been adapted for this purpose from OECD. STATE includes natural resources such as water, health, air, land, biodiversity and finance. PRESSURES include waste, energy, transport, industry and urban development. The societal RESPONSE could be from government, business and households.

The Environmental Management Plan thus consolidates recommendations for Bangalore Metropolitan Region (BMR), assesses priorities and suggests remedial actions based on the qualitative assessment of the current environmental and institutional capacity of governmental agencies. Mitigation options, be they environmental, social, financial or of management nature seek to enable Government of Karnataka to form an adequate response to environmental issues.

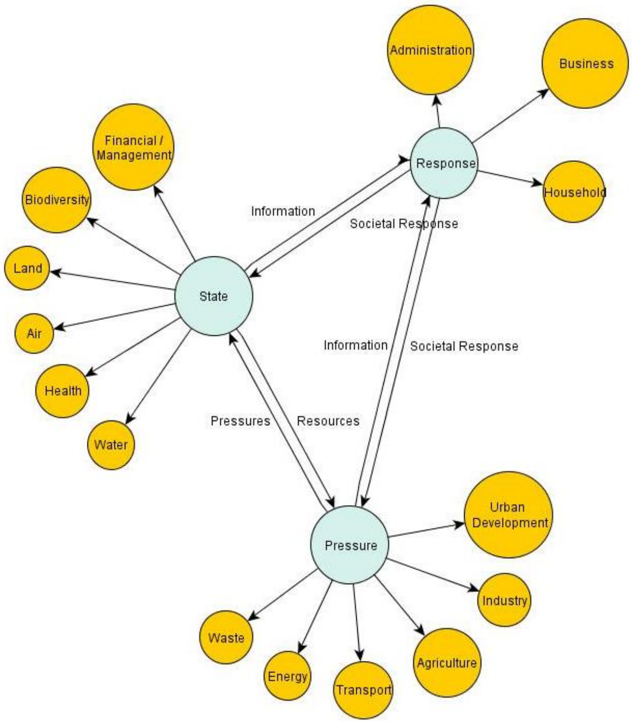


Figure 1: Core indicators for environmental performance reviews – Adapted from OECD

2. ENVIRONMENTAL ISSUES

2.1. KEY ISSUES IDENTIFIED

Rapid growth of BMR during the past two decades in conjunction with unplanned development has caused and exacerbated a range of environmental issues. Environmental issues identified in each chapter were found to have strong cross-sectoral linkages as well as some common causes and effects. Issues have been found to stem not only from unawareness amongst the general public but also from inadequacies in finance, technologies and capacities of developmental and regulatory agencies. The main problem of isolation of environment as a mere spectator of development rather than accepting it as the main resource provider has to a great extent been the main lacuna in overall development of BMR. An attempt to show cross-linkages amongst environmental issues, causes and effects is presented in Figure 2.

Key environmental issues were identified in BMR have been arranged in a matrix at Table 1 to show which of our natural resources is affected by what human activity. Colour codes indicate the severity of the impact.

Figure 2: Cross-linkages of environmental issues

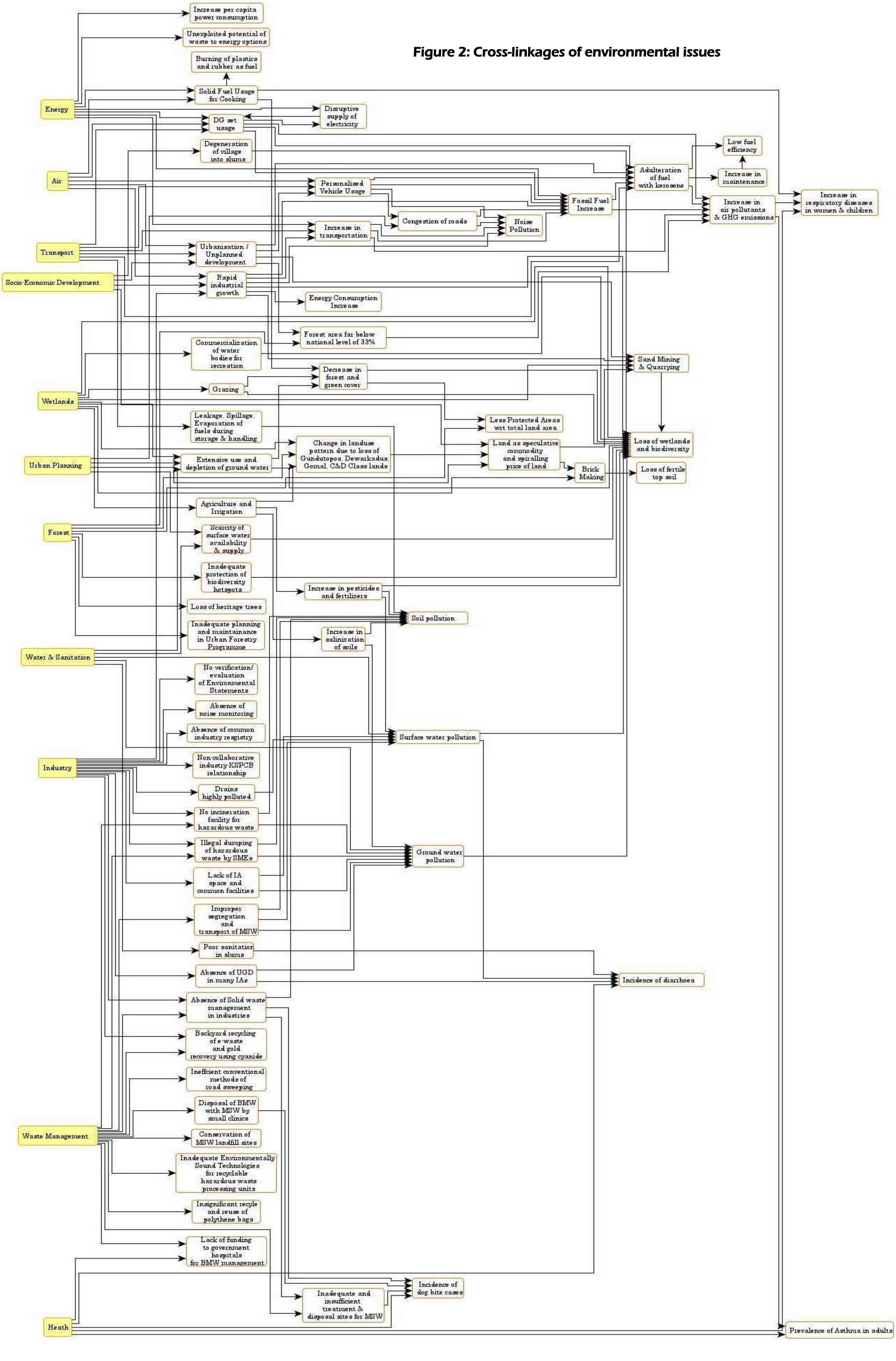


Table 1: BMR's key environmental issues

	Resources that need to be protected					
	Air quality	**Water quality**	**Forest and biodiversity**	**Land and soil**	**Water availability**	**Health**
Urban development	Loss of forests, protected areas, *Gundutopus, Devarakadus, Gomals*, C & D Class lands and heriatge trees. Inadequate implementation of Urban Forestry Programme. Inadequate protection of biodiversity hotspots			Delay in approval of Interim Master Plan and preparation of Master Plans	Depletion of ground water table beyond recharge	Water borne diseases
	Increasing per capita energy consumption	Encroachment of wetlands and other green areas		Land as speculative commodity and the spiraling prices of land.	Execptionally high levels of unaccounted-for water (UFW)	Lack of funding to government hospitals
		Sewage pollution due to inadequate treatment facility	Sand mining in water bodies and quarrying.		Destruction of vegetation and over-grazing in catchment areas	Diarrhea among under 5 year olds
		Overexploitation and commercialisation of lakes for recreation				
Transport	No control over rising emssions of SPM, RSPM					Congestion increases commuers' exposure time to air pollution
	Absence of noise monitoring					Asthma in adults
	Use of adulterated fuel					Acute respiratory infection among under 5 year olds
Energy	Increased energy demand and high dependance of fossil fuels					
	Use of solid fuels for cooking and lighting at rural/periurban areas					
Industy	Limited over rising emssions of SPM, RSPM	Surface water pollution encouraged by lack of common treatment facilities		Lack of industrial area space and common facilities	Depletion of ground water table beyond recharge	Water borne diseases
	Increasing reliance on DG sets and captive power generation	Absence of UGD in a large share of industrial areas		Absence of industrial SW management		Asthma in adults
	Non-collaborative industry-KSPCB relationship			Illegal dumping of hazardous waste		Acute respiratory infection among under 5 year olds
	Absence of a common industry registry. Absence of a consent management information system for establishments registered by KSPCB			Brick making in tank beds		
Waste	Uncontrolled burning of waste	Improper segregation of MSW and transport to the disposal site		Inadequate treatment and disposal of MSW		Backyard recycling of e-waste recycling impairs workers' health
	Unexploited potential of waste to energy options			Absence of adequate incineration facility at the TSDF		Asthma in adults
				Insignificant recycling and reuse of polythene bags		Acute respiratory infection among under 5 year olds
				Very small clinics, disposing BMW along with MSW		
				Lack of conservation of MSW landfill sites		
Agriculture					Intense agriculture and irrigation in BMR	

Impact 4) Massive | 3) Substantial | 2) Significant | 1) Tangible

Though all issues identified require attention the significance of impacts varies. The severity of issues was assessed by evaluating its impact against 9 environmental, 7 social and 3 financial parameters. The environmental parameters look at impacts on resources such as air, water, soil, biodiversity and land use. Social parameters consider, among other things, impacts on livelihoods, health, labour, displacement, child labour and conflict potential. Financial impacts consider healthcare and living costs of citizens and communities. It has been noticed that social and financial issues at the individual level have the tendency to lead to environmental issues due to cumulative effects at the regional level. The rating thus provides a prioritisation for addressing issues through mitigative measures proposed in section 4.

2.2. ROOT CAUSE ANALYSIS

This section provides an analysis of root causes of environmental issues identified. The analysis brought to light that there are five main causes namely, change in land-use pattern, unplanned development, deforestation and loss of biodiversity, waste management, and urbanisation. Details are provided in the following table.

Table 2: Root causes of environemntal issues

Change in land use patterns	*Unplanned development*	*Deforestation and loss of biodiversity*	*Waste management*	*Urbanisation*
Root causes of environemntal issues				
➲ Changes in BMR's land-use pattern has been very substantial in the past two decades. Conversion of agricultural lands for residential layouts and complexes have been witnessed in periurban areas. ➲ Changes in the types of crops grown, especially the transition from food crops to commercial crops or high yielding varieties that require more pesticides and fertilisers and water, etc., have been observed. ➲ Over abstraction of groundwater for irrigation had led to salinisation of agricultural soil. Large scale urbansation, intense sand mining in water bodies and agricultural lands have been witnessed. Increase in stone quarrying has led to many hill tops being destroyed. ➲ Siphoning off of highly biodiversity intense *gundutopus, devarakadus, gomals* and C&D class lands for commercial purposes, school buildings or religious places has brought about disruption in ecosystems. With the forest land being far below the necessary 33% this land use change is quite devastating for the biodiversity of the region.	➲ Rapid unprecedented growth in the IT sector in the past two decades has seen unplanned development in Bangalore and BMR as a whole. Rapid industrial growth has resulted in many issues such as mass scale migration of educated people and subsequent migration of low skill workers to support the educated migrated. The result has been exponential growth in infrastructure, industries and rise in land prices. ➲ The government's response was inadequatewith delays in approval of Master Plans, lack of legal reforms in the housing sector especially for the poor, lack of policies and their implementation on land-use pattern and land-use change, inadequate planning and maintenance of infrastructure, etc. ➲ Issues such as encroachment of wetlands and *gomal* lands, increase in personal transport, insufficient water and sewerage systems, over-extraction of groundwater and absence of UGD leading to contamination of ground water.	➲ Siphoning off of highly biodiversity intense – *gundutopus, devarakadus, gomals* and C&D class lands for commercial purposes, school buildings or religious places has brought about disruption in ecosystems. With the forest land being far below the necessary 33% this land use change is quite devastating for biodiversity of the region. ➲ Added to this is the extraction of wood for cooking and intense grazing in the whole of BMR. ➲ Bangalore and its surroundings known for its unique lake system in the past have now lost most of its lakes through neglect, contamination, encroachment, destruction of catchment areas.	➲ Though waste management has one of the most comprehensive legislations in the country, its implementation in BMR has not been up to the mark. Inadequacy on the part of regulatory agencies towards monitoring compliances and also on the part of various stakeholders like industries, offices, residential complexes and individual towards legal compliance have led to mismanagement of the waste sector. While municipal solid waste collection is reported in many wards of BBMP, it is a total failure in rural and semi urban (municipalities) areas and also in industrial areas. Issues like mixing of non-biodegradable with biodegradable waste, unscientific burning of mixed waste, mixing of biomedical waste and/or hazardous waste with MSW, inadequate and inappropriate treatment and disposal of all types of waste (MSW, hazardous waste, biomedical, plastic, e-waste), and illegal dumping of waste, lack of necessary infrastructure are prominent in the BMR. Lack of recycling facilities, lack of initiatives/ inclination for recycling, inadequate finances, inadequate storage facilities, lack of environmentally sound technologies for recycling or conversion of waste to energy initiatives are some of the reasons which aggravate the waste issue	➲ Rapid urbanisation of BMR gave rise to many primary and secondary environmental issues. While over-exploitation of groundwater is a primary environmental issue; subsequent depletion of groundwater table, contamination of groundwater due to leaching of arsenic from base rock are secondary issues. ➲ Brick making leads to loss of fertile top soil (primary issue), baking leads to air pollution (secondary issue). ➲ Urbanisation has given rise to many water and sewerage issues like inadequatcy of the sewerage system, contamination of groundwater with sewage, increase in pesticides, fertilisers and detergents into surface water bodies, etc. ➲ The energy consumption for transport, households and industries is rising. While pollution due to energy generation is a primary issue, secondary issues include increase in air pollutants due to congestion, adulteration of fuel, noise pollution and increase in fuel consumption. ➲ The greatest impact of urbanisation is the loss of biodiversity of the region. Also, urbanisation has resulted in more man-animal conflicts such as dog bites or wild animals entering agricultural lands.

Change in land use patterns	Unplanned development	Deforestation and loss of biodiversity	Waste management	Urbanisation
Related environmental issues required to be addressed				
▪ Sand Mining ▪ Change in land-use due to loss of *gundutopus, devarakadus, gomals*, C & D class lands. ▪ Quarrying ▪ Agriculture and irrigation	▪ Rapid industrial growth ▪ Encroachment of wetlands and *gomal* lands ▪ Inadequate planning and management of Urban Forestry Programmes ▪ Personalised mode of transport ▪ Delay in approval of IMP and preparation of MPs ▪ Degeneration of villages into slums ▪ Lack of industrial area space and common facilities ▪ Absence of legal reforms for land reservation in housing schemes for BPL/EWS ▪ Absence of a common industry registry ▪ Absence of a consent management information system for establishments registered by KSPCB ▪ Non-collaborative industry-KSPCB relationship ▪ Use of adulterated fuel ▪ Land as speculative commodity and the spiralling prices of land ▪ Absence of UGD in large share of industrial areas	▪ Use of solid fuels for cooking and lighting at rural/periurban areas ▪ Loss of heritage tree ▪ Scarcity of surface water supply ▪ Loss of protected areas with respect to total land area ▪ Decline of green space ▪ Deforestation ▪ Protection of identified biodiversity hotspots ▪ Grazing ▪ Commercial exploitation of lake for recreation	▪ Absence of industrial SW management ▪ Inadequate and insufficient treatment and disposal sites for MSW ▪ Unexploited potential of waste to energy options ▪ Backyard recycling of e-waste and gold recovery using cyanide ▪ Improper segregation and transport of MSW up to the disposal site ▪ Absence of adequate incineration facility at the TSDF ▪ Lack of funding to government hospitals ▪ Illegal dumping of hazardous waste by small and medium industries ▪ Insignificant recycling and reuse of polythene bags ▪ Conservation of MSW landfill sites ▪ Disposal of BMW along with MSW by very small clinics	▪ Over-exploitation and depletion of the groundwater table ▪ Groundwater extraction ▪ Absence of noise monitoring ▪ Brick making ▪ Adverse human health impacts ▪ Pollution of surface water and drains with untreated sewage and effluents ▪ Pollution of rivers, tanks, *nalas* and valleys ▪ High share of fossil fuel as a source of energy ▪ Increasing energy demand for transport ▪ Congestion of roads causing air and noise pollution ▪ Increased per capita power consumption ▪ Increasing captive power generation system ▪ Prevalence of asthma in adults ▪ Incidence of acute respiratory infections among under 5 year olds ▪ Incidence of diarrhoea among under 5 year olds ▪ Incidence of dog bite cases ▪ Neglect of emissions from public transport vehicles
Limitations of institutional capacity				
▪ Lack of awareness amongst forest officials and the general public towards conservation ▪ Lack of carrying capacity studies for quarrying and sand mining ▪ Lack of co-ordination between concerned departments (Mines and Geology Department and Department of Forest, Ecology, Environment) on quarrying and sand mining leases given in a specific year and the actual extent of quarrying/mining actually carried out. ▪ Lack of any regulation on abstraction of sand from agricultural lands ▪ Lack of coordinated and scientific denotification of agricultural lands for residential layouts and complexes for commercial purposes	▪ Lack of awareness amongst forest officials and the general public towards environment ▪ Lack of carrying capacity studies for groundwater extraction ▪ Lack of coordination between concerned departments, organisations, companies (industry – pollution control board – builders – concerned departments) ▪ Lack of compliance by industry and monitoring by regulatory agencies ▪ Lack of coordinated and scientific denotification of lands for residential layouts and complexes for commercial purposes ▪ Lack of inventory of pollutants and waste generation with regulatory agencies ▪ Lack of promotion / initiatives towards cleaner pro-	▪ Lack of awareness amongst forest officials and the general public towards conservation ▪ Lack of demarcation of catchment areas of water bodies and absence of a watershed development approach especially in urban areas ▪ Lack of in-depth inventory of biodiversity in the region ▪ Lack of coordination between agencies towards restoration/conservation of biodiversity ▪ Introduction of exotic species, hybrid varieties without the knowledge of its intrusion into the current ecosystem	▪ Lack of inherent initiative on the part of individuals to segregate waste ▪ Lack of respects towards the *pourakarmikas* tending to waste ▪ Lack of in-depth studies relating to recycling of high value waste (especially those containing precious metals) ▪ Lack of coordinated efforts by concerned authorities towards management of waste	▪ None specified

Change in land use patterns	Unplanned development	Deforestation and loss of biodiversity	Waste management	Urbanisation
	duction from the regulatory bodies and industries ▪ Lack of preliminary data on ambient air quality, water quality, noise, soils, waste for the whole BMR ▪ Lack of coordinated efforts towards sustainable development ▪ Lack of emission inventory for primary PM2.5 and gaseous pollutants ▪ Inadequacy of air monitoring data (spatial coverage, frequency, period)			

3. ENVIRONMENTAL GOVERNANCE

While the key responsibility of environmental management amongst various governmental agencies rests with the Department of Forest, Ecology and Environment and the agencies and boards established under it, there are nevertheless many other departments, corporations and agencies which can influence environmental conservation. Figure 3 shows the relationships between the stakeholders concerned within the legislative framework.

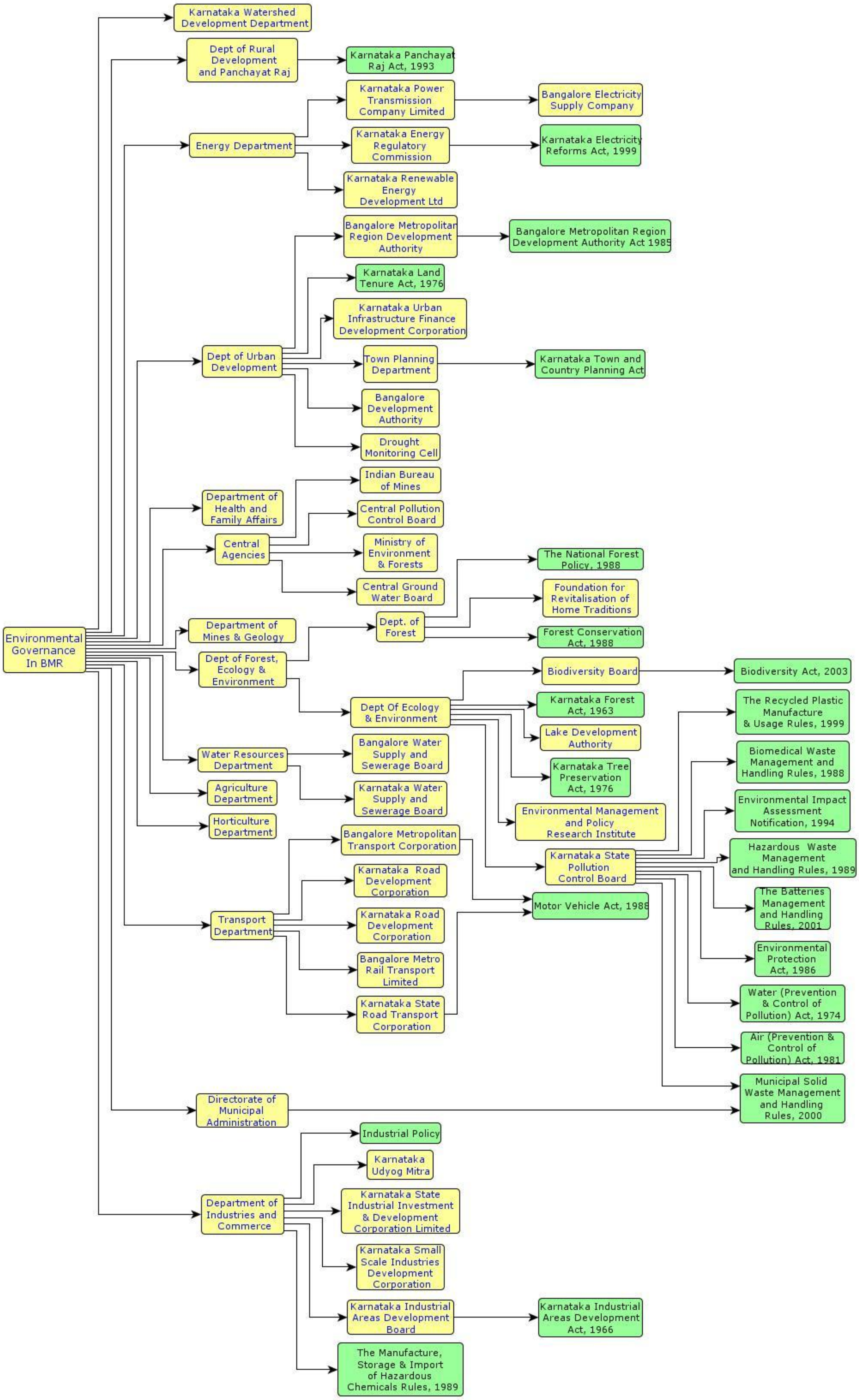


Figure 3: Environmental governance framework

4. MITIGATION PLAN

4.1. REQUIRED ACTIONS

For each environmental issue identified an adequate response capable of mitigating the issue has been formulated in the table below. The implementation of mitigation actions require monitoring so as to understand whether the actions initiated actually have the desired effect or whether adjustments need to be made. Monitoring requires indicators whose reading permits an understanding of the current state of the issue looked at. For each issue indicators were selected that offer the following:

- Dependable,
- Easy to monitor,
- Directly relevant to the objectives of stakeholders,
- Provide an effective link of cause and effect and
- Can assist in monitoring cost.

Separate indicators were defined for inputs, outputs and impact and these were correlated among sectors and compared with environmental indicators commonly used across the globe.

Table 3: Mitigation matrix

Legend

Impact of environmental issue: 4) Massive | 3) Substantial | 2) Significant | 1) Tangible

Nature of intervention: Policy, finance & pricing | Management & enforcement | Implementation and promotion | Monitoring & surveillance | Capacity building | Further research

Issues	Indicators	Action required	Mitigating agency
1. Forest			
Loss of forests, protected areas, *gundutopus*, *devarakadus*, *gomals*, C & D class lands and heriatge trees	Village records (*jama bandi*) are maintained by *Shanbhogs* (village officers)	Creating awareness amongst stakeholders on the importance of such lands	Revenue Department
		Survey of areas and listing of vegetation therein of C&D class lands, *gomals*, *gundutopus and devarakadus* by Revenue Department once in two years. Preparation of Biodiversity Registers as per the Bio-diversity Act	Karnataka Forest Department, BMREC (proposed)
		Revenue waste lands like C&D class lands and *gomal* lands to be taken back from the Revenue Department for management by the Forest Department	
Inadequate protection of biodiversity hotspots	Deforestation and encroachment records in Forest Department's Annual Report	Afforestation with local species to be taken up in degraded forest areas	
		Involvement of citizens and students in the greening of surroundings	
		Enhancement of budgetary allocation for afforestation and conservation	
		Prevention of deforestation and lease of forests for any purpose including mining, quarrying, roads and dams. Recovery of encroached forest areas and imposing penalties on encroachers	
Inadequate implementation of Urban Forestry Programme	Number of saplings raised per year and number of saplings planted	Selection of appropriate species for planting in accordance with local conditions. Preferences for local species	Karnataka Forest Department, BBMP, Biodiversity Board
	Number of plants planted location wise	Tree Warden Scheme to be revived. Village *Panchayats*, school children and NGOs to be involved	
	Survival percentage of trees after 3 years	Adequate budgetary allocation for raising and planting saplings	
		Adequate staff for planting and supervision in Urban Forestry Programme	
2. Urban Planning			
Lack of coordination between government agencies	Planning and actions are carried out through consultation of stakeholder agencies	An Environment Cell under BMRDA should be created to include environmental perspectives in the planning process and coordinate with other agencies, the action on environmental issues (refer to section 4.2 below)	BMRDA
Delay in approval of Interim Master Plan and preparation of Master Plans	Time required to prepare a Master Plan	To make the District Planning Committees (DPC) more effective and accountable by increasing the capacity of staff	Government of Karnataka, DMA, BMRDA, BDA, DTP, BBMP
	Time required to approve a Master Plan		
Lack of funding to government hospitals	Increase in number of government hospitals	Training of decision makers presiding over funding to enable informed decisions	Department of Health, individual hospitals
		Developing a charging mechanism from users and also timely budgeting of annual allocation of funds for health care and environment	

Issues	Indicators	Action required	Mitigating agency
Legend		Impact of environmental issue: 4) Massive; 3) Substantial; 2) Significant; 1) Tangible	
	Nature of intervention:	Policy, finance & pricing; Management & enforcement; Implementation and promotion; Monitoring & surveillance; Capacity building	Further research
3. Groundwater			
Depletion of ground water table beyond recharge	Density of bore wells	The Groundwater Act stipulating the extent and area where extraction of water is permitted. The enforcement of rainwater harvesting is to be legislated by Government of Karnataka and implemented by ULB's, BMRDA, Mines and Geology Department. In rural areas community participation in watershed management needs to be ensured.	ULB's, BMRDA, Mines and Geology Department
	Increase in level of hardness and pollutants	Use of economic instruments to conserve groundwater and supply surface water	BWSSB, BBMP, Mines and Geology Department
	Increase of waterborne diseases or arsenic poisoning	Recharge of groundwater through rainwater harvesting. Recycling of treated waste water for non-domestic purposes or for recharging groundwater	
Water borne diseases	Levels of coliform organisms in drinking water	Prevention of fecal contamination through compulsory use of latrines	BWSSB, Health department, BBMP
	Increase in the number of diarrhoeal diseases among under 5 year olds	Improve maternal knowledge on home management of diarrhea and recognition of danger signs. Promote exclusive breast feeding and proper weaning. Promote adequate hand washing practices.	
	Increase in the number of malnutrition cases among children under 5 years old. Increase in hospital admissions due to diarrhoeal.	Ensure standard case management practices. Infant immunisation especially Measles and Vit A prophylaxis. Increase availability and accessibility of oral rehydration salts	
Absence of UGD in a large share of industrial areas	Number of industries discharging sewage untreated or into soak pits	UGD connection with decentralised STPs for all current and future industrial areas (refer to Chapter 7 "Industry", section 4.2)	KIADB and KSSIDC
	Coverage of UGD in industrial areas		
	Cases of gastro-enteritis		
4. Surface water			
Encroachment of wetlands and other green areas	Extent of water body	Create awareness amongst general public on the necessity of water bodies and natural drainage	BBMP, BMRDA, KSPCB, Police
	Inventorisation of illegal structures on the foreshore of water body as well as in the catchment areas and drainage paths	Stop all construction activities in and around water bodies to keep the natural drainage intact	
	Inventory of construction activities in the vicinity of water bodies, annual yield of fish		
Sewage pollution due to inadequate treatment facility	Quality of sewage and effluent entering the stream	Establishment of a long-term drain water quality monitoring and action programme (refer to Chapter 7 "Industry", section 4.2). KSPCB is sought to look into the problem of contaminated drains on a regular basis rather than the complaint-and-check method adopted currently.	KSPCB
	Level of nitrates, phosphates, LABS, total coliform and detergents in drain water		
	Cases of gastro-enteritis		
	Extent of under ground drainage coverage	Proper drainage and sewage treatment. Encourage decentralised treatment systems (DTS) in non-sewered areas	BWSSB
	Ground and surface water pollution	Economic use of waste water for productive uses	
		Significant systematic improvement in wastewater treatment infrastructure along with increased reuse of treated wastewater for non-domestic purposes or for recharging ground water	
Surface water pollution encouraged by lack of common treatment facilities	Extent of UGD coverage, number of CETPs installed, number of ETPs installed, number of industrial connections into storm water drains	Improve sewage and waste water treatment, policy to encourage reuse of treated water	BWSSB, LDA, BBMP and KSPCB
		Imposition of fines on water polluting industries	

Issues	Indicators	Action required	Mitigating agency
Legend		**Impact of environmental issue:** 4) Massive; 3) Substantial; 2) Significant; 1) Tangible	
	Nature of intervention:	Policy, finance & pricing; Management & enforcement; Implementation and promotion; Monitoring & surveillance; Capacity building; Further research	
(continued from above)	Incidence of water borne diseases and flooding of low lying areas en route	Conservation of lakes and water bodies	
		Annual maintenance of storm water drains and *raja kaluves*. Encroachment and development should not be allowed along the flow and valley zones. Recovery of already encroached lands along with heavy fines. Afforestation of land adjacent to *raja kaluves* should be taken up to protect the valley zones and drainage.	Government of Karnataka, BMRDA, BBMP, ULBs, BDA, District Planning Committee, Metropolitan Planning Committee
		Relocation of slums in low lying areas to other environmentally suitable areas with better infrastructure	
		Separate allocation for protection of valley zones should be made in the budgets of ULBs and UDAs and an escrow account maintained for the protection	
5. Land			
Land as speculative commodity and the spiralling prices of land	Land prices in the region	Relocations of slums should be done with the involvement of people concerned, ideally in public-private partnership.	BMRDA, KSCB, ULBs and Government of Karnataka
	Extent of encroachment of land and springing of overnight slums	Amendment of the existing law regarding land acquisition for all types of housing (for low income and those developed by BDA) based on existing land rates	
Intense agriculture and irrigation in BMR	Number of bore wells	A study on alternative sourcing options for water should be taken up, particularly for the agricultural east of BMR	All the ULBs, BMREC (proposed), Mines and Geology Department
	Average yield of bore well	Promote and create awareness on conservation of water in day to day life	
	Monitoring of ground water table	Strict enforcement of rainwater harvesting at the time of construction and operation of buildings. Zoning of industries depending upon the availability and demand for water	
	Extent of application of pesticides and fertilisers	Promotion of organic farming, Promotion of local varieties	Agriculture Department, Horticulture, UAS
	Concentration of nitrates in both surface and ground water bodies	Awareness on organic farming and the ill effects of pesticides and fertilisers	
	Extent of eutrophication of water bodies	Revise the high subsidies on urea in order to lessen the incentives for its use	
Sand mining in water bodies and quarrying	Permits given every year for sand mining and dredging	Increase in monitoring by regulatory agencies	Mines and Geology Department, KSPCB
	Number of sand lorries entering the city		
Brick making in tank beds	Number of brick kilns in vicinity of water bodies	Creation of awareness on the importance of silt	KSPCB, BBMP
		KSPCB in conjunction with BBMP carries out on a routine monitoring schedule. Strict regulatory action on brick makers using silt from tank bed.	
Over-grazing in the catchment area of water bodies	Livestock census	Awareness on the importance of stall feeding and community stall feeding facilities	Animal husbandry Department
	Extent of stall feeding sheds in the vicinity of water bodies, number of hybrid variety livestock	Guidance through the Animal Husbandry Department	
Overexploitation and commercialisation of lakes for recreation	Number of lakes given for commercial exploitation	Stringent monitoring of lakes	KSPCB
		Creating awareness amongst stakeholders on the importance of water bodies and their ecosystem	LDA, DEE
	State of each lake	Reclaim lakes as a corporate-social responsibility and not as a commercial venture	
	Level of nitrates, phosphates, LABS, total coliform and detergents in drain water	Restrictions on washing/laundry units near any water body to encourage the use of common wastewater treatment	KSPCB, Garment Industries Association
		Installation of CETPs in washing and laundry industry in view of the fact that the STPs of BWSSB do not remove phosphates brought in by detergents	

Issues	Indicators		Action required	Mitigating agency
Legend			*Impact of environmental issue:* 4) Massive; 3) Substantial; 2) Significant; 1) Tangible	
	Nature of intervention:		Policy, finance & pricing; Management & enforcement; Implementation and promotion; Monitoring & surveillance; Capacity building; Further research	
6. Air				
Congestion increases commuters' exposure time to air pollution	Increase of vehicle volume; Increase in public transport services	Management & enforcement	The synchronisation of different modes of public transport needs to be improved and linked to a park-and-ride concept so that commuters from the outskirts find public transport reliable and comfortable. A parking fee policy should be enacted for all parking places except for residential roads. Toll *nakas* to take user fees for certain roads	BMRDA, DTP
		Management & enforcement	Certain parts of the city area (CBD wards, Brigade Road, Commercial Street) should be made traffic free like in many European cities. Vehicle use could be restricted to delivery based on specific permits or certain timings.	
	Levels of air pollutants and noise levels; Average speed of vehicles	Implementation and promotion	Better infrastructure is required for pedestrians: Unobstructed continuity of footpaths (many of which are blocked by BESCOM), installation of skywalks or underpasses equipped with functional lifts. Traffic signals for pedestrians should replace zebra crossings which are not respected and hence do not provide the intended safety for pedestrians.	
		Management & enforcement	A Traffic Cell should be created in BMRDA for formulation and regular revision of a comprehensive traffic plan for the BMR in coordination with BMTC and other agencies involved in infrastructure development.	
Asthma in adults	Increase in the levels of SPM, RSPM,SO_2, NO_2, Clorine gas	Implementation and promotion	Creation of green belts	KSPCB, BBMP, Transport Department
		Capacity building	Increase in the awareness of companies employing occupational high risk groups about personal protective equipment (PPE)	
	Increase in the number of asthma cases	Monitoring & surveillance	Strengthening the surveillance and monitoring of out-door air pollution. Screening and appropriate clinical case management of detected cases	
Acute respiratory infections among under 5 year olds	Increase in the levels of SPM, RSPM,SO_2, NO_2,Cl gas	Capacity building	Creating awareness in low income groups about the merits of ventilation, efficient stove designs, chimneys, use of cleaner fuels and the cost involved.	To be defined
Limited over rising emssions of SPM, RSPM	Increase in the number of upper and lower respiratory infections among under 5 year olds	Monitoring & surveillance	Strengthening the surveillance and monitoring of in-door air pollution	Health Department
Use of solid fuels for cooking and lighting at rural/peri-urban areas	Use of firewood	Implementation and promotion	Promoting gaseous fuels and improved cook stoves to reduce exposure to indoor air pollution	MoPNG, MNRE
	Increase in air pollutants	Capacity building	Creation of awareness on the adverse health impact of indoor air pollution to bring about behavioural change	
	Increase in acute respiratory infections among children and chronic obstructive pulmonary disease among adults	Policy, finance & pricing	Target oriented subsidy to promote LPG among poor. Micro-credit facility to increase the purchasing power of rural women to buy improved cook stoves/LPG connection	
Absence of noise monitoring	Noise profile of industrial, commercial, residential and sensitive areas	Capacity building	Awareness campaign to inform about noise impact, limits and remedial actions	KSPCB
		Monitoring & surveillance	Establishment of a regular noise-monitoring programme that focuses on roads, commercial, residential and sensitive areas	KSPCB
	Incidence of noise related symptoms in workers	Monitoring & surveillance	Establishment of regular monitoring of industrial noise with focus on both ambience and workers (refer to Chapter 7 "Industry", section 4.2)	Department of Factories and Boilers, KSPCB
Use of adulterated fuel	Availability of low quality fuel	Monitoring & surveillance	Regular monitoring of air and environmental quality. Initiate stringent quality control measures	KSPCB, Food and Civil Supplies and Weights & Measures Department
	High levels of pollution	Capacity building	Create drivers' awareness on air pollution, adulterated fuel and health impacts	
	Increase in respiratory health hazards, Increase in vehicle engine repair times	Management & enforcement	KSPCB carries out regular compliance monitoring and identifies the culprit while the Food and Civil Supplies and Weights & Measures Department takes action against the supplier.	
		Monitoring & surveillance	Discourage the syndicate involved in the trade through stricter vigilance by regulatory authorities	

Issues	Indicators	Action required	Mitigating agency
Legend		*Impact of environmental issue:* 4) Massive; 3) Substantial; 2) Significant; 1) Tangible	
	Nature of intervention:	Policy, finance & pricing; Management & enforcement; Implementation and promotion; Monitoring & surveillance; Capacity building; Further research	
7. Industry			
Lack of industrial area space and common facilities	Quantity of effluent treated	Faster establishment of new industrial areas with sector focus and CETPs (refer to Chapter 7 "Industry", section 4.2)	KIADB, KSSIDC
	Number of operating common facilities	Granting of land based on sector specific focus of industrial areas. Introduction of sector specific siting guidelines for industries (refer to Chapter 7 "Industry", section 4.2). Guidelines should be developed depending upon the density of industries, water availability and land use and to be proposed to Government of Karnataka.	KSPCB, CPCB in consultation with BMRDA, BBMP, ULB's and Department of Industries and Commerce
Absence of industrial solid waste management	Growth of industrial solid waste dumps Incidence of waste burning	Establishment of a SW management system in industrial areas through private operators under the supervision of KIADB or KSSIDC. Rehabilitation of dumpsites (refer to Chapter 7 "Industry", section 4.2).	KIADB, KSSIDC, private operators
	Ambient air quality in and around industrial areas	Vigilance on illegal waste dumping	
Illegal dumping of hazardous waste	Availability of storage space	Inventorisation and classification of hazardous waste (chemical and physical properties). Collection centres for hazardous waste in industrial areas. Stringent action on defaulters and transporters by regulators. Decontamination of sites	KSPCB, KIADB, BMREC (proposed), RTO, Police
	Contamination of lake waters, vacant lands and highways	Awareness programmes for industries and transporters	
		Decontamination costs to be recovered from industries. Penal amount collected to be used for maintaining watchdogs and awareness programmes. Constitution of steering group to oversee action	
Backyard recycling of e-waste recycling impairs workers' health	Industry growth especially software industries	Authorise recyclers with certified proven recovery systems	KSPCB, CPCB, E-waste Association (EWA)
		Awareness creation of backyard recyclers to bring them into the organised sector in order to improve the working conditions and reduce adverse health impacts	
		E-waste generators to pay for disposal costs or vice versa	
		Inventorisation of e-waste. Regulation of e-waste collection mechanisms	
Non-collaborative industry-KSPCB relationship	Share of industries seeking advisory services of KSPCB	Promotion of pollution control measures with focus on sectoral and individual needs (refer to Chapter 7 "Industry", section 4.2)	KSPCB, industry associations
		Gradual establishment of trust between industries and KSPCB (refer to Chapter 7 "Industry", section 4.2)	
		KSPCB portfolio expansion and image overhaul to assist industries to manage pollution (refer to Chapter 7 "Industry", section 4.2)	
Absence of a common industry registry. Absence of a consent management information system	Coverage of the industry registry	Establishment of single window registry. The establishment as well as compulsion for registration should be enacted. Access of departments to centralised industry MIS (refer to Chapter 7 "Industry", section 4.2)	Department of Industries and Commerce
	Availability of spatial macro and micro level data on resource consumption and pollution loads of establishments registered under the Water and Air Act.	Establishment, commissioning and operation of a state-wide electronic consent management information system (MIS) as web-hosted central repository with multi-point interface for access by all Regional Offices by KSPCB (refer to Chapter 7 "Industry", section 4.2).	KSPCB
8. Waste			
Inadequate treatment and disposal of MSW	Population and business growth Increasing MSW quantum Epidemic outbreaks	Identify NGO and self-help groups to provide necessary assistance in implementation, awareness and training of general public on topics such as waste segregation, disposal and littering. Make segregation mandatory, impose penalty for littering and dumping debris.	BBMP, municipal authorities, DFEE, Department of Urban Planning, BMREC (proposed)
Absence of adequate incineration facility at proposed TSDF	Amounts of incinerable hazardous waste stored	Installation of a state of art incinerator at the TSDF, upgrading existing small incinerators and explore nearby cement units	KSPCB, operator and industries associations
		TSDF operator to work out the costs and commitment for installation. Generator of waste shall pay to operator on waste volumes	
		Evolve a mechanism of charging formula through regulator and operator	

Issues	Indicators	Action required	Mitigating agency
Legend		Impact of environmental issue: 4) Massive; 3) Substantial; 2) Significant; 1) Tangible	
	Nature of intervention:	Policy, finance & pricing; Management & enforcement; Implementation and promotion; Monitoring & surveillance; Capacity building; Further research	
Improper segregation of MSW and transport to the disposal site	Number of collection centres for sorted garbage	Mobilise multi-chambered collection and transport vehicles. Create collection centers and install compactors. Transfer only organic and non-recyclables	BBMP, municipal authorities, BMREC (proposed), Private transporters
		Impart training to garbage collection and transporting staff. Create awareness in house holds and recyclers in each ward.	
	Number of authorised recyclers	The sale of recyclables and reduction in transport expenditure to be used for new waste segregation equipment. Possibility of an additional grant under JNURM scheme is to be explored. Enhance property tax collection	
		A special cell to be created by NGOs and experts with the participation of volunteers to assist BBMP in the necessary social interventions and to finalise schemes in each ward	
Insignificant recycling and reuse of polythene bags	Inventory of thin plastic bag manufacturing units	Mix with bitumen for road laying, recycle in plastic industry and attempt conversion of plastics to diesel	KSPCB, BBMP, MSW operators
		Training to rag pickers and garbage collectors and road contractors	
		Pay rates for bitumen or equivalent to rag pickers for plastics. Provide funding to a plastics to diesel pilot plant under PPP model	
		A cell to be constituted at BBMP with support from NGOs and technology suppliers for providing the necessary linkage between the pickers and industry for implementation of schemes	
Biomedical waste is not yet systematically managed	Biomedical waste is collected within stipulated timeframe	Ensure prompt payments so that biomedical waste is brought to disposal facilities without delay	Individual hospitals
		Each hospital to earmark a nodal person for routine management of BMW	
Unexploited potential of waste to energy options	Increase in solid waste generation	Identification and adaptation technologies that permit efficient and economic conversion of waste to energy	Municipal Corporations, KSPCB, MoEF, MNRE
	Improper disposal of solid waste, increasing pollution problems, health impact	Awareness on waste management, segregation at the source, 3Rs (reduce, reuse and recycle)	
		Exploring Clean Development Mechanism benefits for waste to energy options	
	Increase in malaria, dengue	Strict vigilance of violation of waste management rules and regulations	
Lack of conservation of MSW landfill sites	Extent of segregation of municipal solid waste	Promote garbage to energy through mass combustion. Incinerated ash to be land filled at TSDF. Pilot plant for plastic-to-diesel technology. Integration of MSW sites	BBMP, DEEF, KSPCB, CPCB, BMREC (proposed)
		Awareness programmes for segregation of metals, glass and other hazardous wastes at source. Road sweepings to be disposed off separately. Construction license should be conditional to safe management of construction and debris waste	
	Rate of application of MSW in landfills. Extent of available compost at MSW sites	Waste to Energy to be promoted through PPP model. Co-financing plastics-to-diesel technology	
		BBMP to create expert groups for technology transfer that render assistance to private promoters for project implementation	
Very small clinics dispose BMW along with MSW	Inventorisation of quantum of BMW generation in small clinics	Withdrawal of license by BBMP and KSPCB. Operator of Common Biomedical Waste Handling Facility (CBMWHF) to expand the membership network	KSPCB, BBMP, CBMWHF operators, BMREC (proposed)
		Training to doctors and garbage collectors	
	Records of health issues amongst garbage handlers and rag pickers	Polluters to pay for the service extended to them. Common collection centres to be promoted	
		Routine surveillance checks to be carried out by KSPCB and BBMP. Operators to assist in providing database	

Legend						
Impact of environmental issue:	4) Massive	3) Substantial	2) Significant	1) Tangible		
Nature of intervention:	Policy, finance & pricing	Management & enforcement	Implementation and promotion	Monitoring & surveillance	Capacity building	Further research

Issues	Indicators	Action required	Mitigating agency
9. Energy			
Increasing per capita energy consumption	Increase in DG sets	Monitoring and enforcement of emission norms	KSPCB, Electrical Inspectorate
		Compulsory registration of DG sets so as to have reliable special data available based on which pollution loads can be determined	
	Increase in consumption of petroleum products Increase in air pollutants (NO_X) and noise emission Increase in number of metered households	Create awareness to minimise power demand and promote energy efficiency and power demand management	
		Increase tax on diesel and diesel generators which cannot meet emission standards. Pollution levy on smaller DG sets that are not regulated by KSPCB, for instance those of trade establishments and households	
Increased energy demand and high dependence on fossil fuels	Increase in annual fuel consumption	Continued exploitation of renewable energy sources so that they account for a growing share in the energy mix	MoPNG, MNRE
	Increase in respiratory illness Increase in average temperature of BMR	Promotion of energy efficient technologies under CDM; High taxes on less efficient/high polluting sources of energy	
		Reduce subsidies on fossil fuels	
	Increase in number of vehicles	Strengthening air quality monitoring network, setting and tightening air quality and fuel standards	KSPCB, CPCB, MoEF, MoPNG, KSRTC, BMTC, municipal authorities, Department of Town Planning and Urban Development, BMRDA
	Increase in congestion; Increase in air pollutant concentrations	Create awareness to bring behavioural changes to use public transport, vehicle maintenance, promote car pooling	
		Road use pricing (toll fee, congestion fee, high parking fee in congested area). Set incentives for car pooling. Increase diesel taxes for their usage in private cars	
	Increase in respiratory morbidity	Integrated land use and transport planning	
Increasing reliance on DG sets and captive power generation	Increase in use of DG sets	Monitoring and enforcement of emission norms	KSPCB, Tax authorities
	Increase in diesel consumption, air (NO_X) and noise emission	Create awareness to minimise power demand and promote energy efficiency and power demand management	
		Compulsory registration of DG sets so as to have reliable special data available based on which pollution loads can be determined	

4.2. INSTITUTIONAL ARRANGEMENTS

Bangalore Metropolitan Region Development Authority (BMRDA) is endowed with the mandate to prepare the Structure Plan and to revise it on a regular basis to reflect emerging needs in close consultation with stakeholders. Aspects of environmental management which need to form an integral part of regional development have, however, not been put under the ambit of BMRDA. The agency thus does not currently coordinate with stakeholders in respect of environmental needs. It is hence, proposed that BMRDA establishes an Environment Cell called BMR Environment Cell (or BMREC for short) that would help BMRDA to integrate cross-sectoral environmental issues into the planning process and coordinate with other government departments on actions required for better environmental management. BMREC could be formed with a legal amendment of the Bangalore Metropolitan Region Act. BMREC would provide technical support to BMRDA inside and to other government departments on environmental issues and their mitigation. Its mandate would include:

- Coordination with other agencies such as BDA, BCC, BWSSB, KIADB and KSPCB on environmental aspects concerning regional development;
- Providing background data to address environmental issues of BMR;
- Providing expertise in incorporating environmental safeguards into the Structure Plan developed by BMRDA;

Figure 4 presents the proposed structure and integration of BMREC while Table 4 presents the proposed terms of reference.

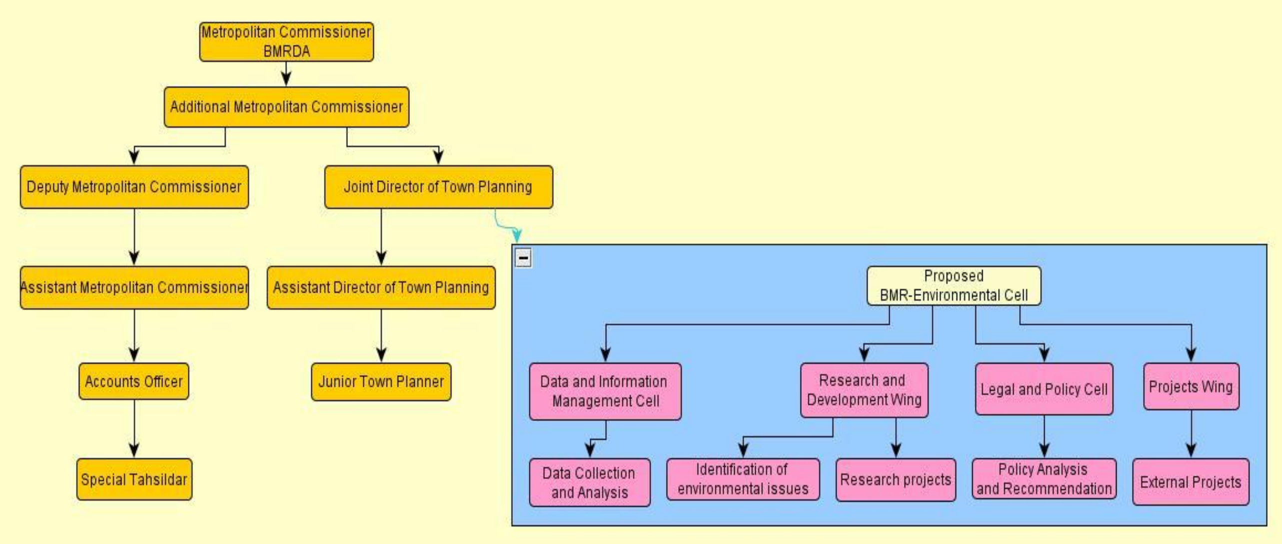


Figure 4: Structure and integration of the proposed Environment Cell

Table 4: Proposed terms of reference for BMREC

1) Coordination	2) Monitoring of environmental parameters to address gaps
➲ BMREC will systematically integrate environmental perspectives into the planning process of BMR's development in consultation with other stakeholders. ➲ BMREC will assume a coordinating role that succeeds in bringing all relevant agencies together so as to address cross-sectoral environmental issues jointly. ➲ BMREC will review the mitigation plan proposed by this report and will assist in the development of terms of reference for addressing specific environmental issues in consultation with the stakeholders concerned.	➲ BMREC will develop a more comprehensive understanding of ecological and other environmental systems using methodological approaches to address cumulative impacts. ➲ BMREC will help in reducing institutional barriers to integrate the consideration of biophysical and social/economic sciences, along with risk assessment and environmental impact assessments. BMREC could evolve to be an agency for natural resource management in BMR completing the efforts of other government agencies from a planning perspective.
3) Collection of secondary data to help in information management on ecological and environmental systems	**4) Budgeting sustainable ecosystem management**
➲ A major obstacle for this report has been the lack of adequate data for the whole of BMR and the lack of access to some data because of institutional barriers. Also, the analysis was impeded because certain data sets could not be aggregated and compared because of differences in scales, map projections, boundaries and geographical divisions. BMREC will develop a centralised environmental data depositary to store trend data for environmental variables from various sources.	➲ Budgetary allocations for environmental management and preventive actions at the planning and implementation stages have been meagre or absent. BMREC's role as an internal agency of BMRDA would be to estimate financial resources required and seek allocations to enable implementation of the same.
5) Training of governmental personnel involved in implementing environmental mitigation measures	**6) Provision of institutional guidance**
➲ There is a lack of institutional capacity for environmental management across most of the concerned departments. The limitation of the capacity of officials to analyse complex environmental data and the lack of ability to identify risks and plan for eventualities have led to or exacerbated most of the present environmental issues. BMREC will establish a Continual Improvement Programme and provide training on various environmental aspects and also provide technical and capacity building assistance to research and monitoring facilities related to environmental management of BMR.	➲ BMREC will provide guidance to concerned departments in the following areas: ▪ Generation of primary and secondary environmental data; ▪ Technical expertise in carrying out environmental auditing, energy auditing, carbon footprinting, environmental impact assessments, etc., ▪ Providing inputs towards environmental stewardship, sustainability, reporting and participation of local governance in planning and implementation.

REFERRED MATERIAL

CHAPTER 1: FOREST AND BIODIVERSITY

- 2003 ▪ Working Plan for the Bangalore Rural Forest Division
- 2003 ▪ Working Plan for the Bangalore Urban Forest Division
- Daniel J.C.; BNHS Bombay, 1983 ▪ The Book of Indian Reptiles
- Field Club of Bangalore, 1994 ▪ Annotated checklist of the 'Birds of Bangalore – Birdwatchers'
- Neginhal, S.G.; 2002 ▪ A Handbook on City Trees and Urban Planting (Urban Forestry)
- Neginhal, S.G.; 2004 ▪ Distribution of Birds in Karnataka (MyForest Vol. 40(2) No 2 – 2004)
- Neginhal, S.G.; 2004 ▪ Forest Trees of South India
- Neginhal, S.G.; 2006 ▪ Golden Trees, Greenspaces and Urban Forestry
- Neginhal, S.G.; Bangalore Urban Art Commission, Bangalore, 1994 ▪ Your Bangalore – The Trees
- Prater S.H.; BNHS, 1980 ▪ The Book of Indian Animals
- Richard Grimmett, Carol Inskipp, Tim Inskipp; Oxford University Press, 2007 ▪ Oxford Pocket Guide to the Birds of the Indian Subcontinent
- Saldanha Cecil; Oxford and IBH. Publishing Co., 1984 ▪ Flora of Karnataka Vol. I.
- Saldanha Cecil; Oxford and IBH. Publishing Co., 1996 ▪ Flora of Karnataka Vol. II.
- Salim Ali, S. Dillon Ripley; BNHS, Oxford University Press ▪ Handbook of Birds of India and Pakistan
- Salim Ali; BNHS, 2002 ▪ The Book of Indian Birds – 13th Edition
- WWF Bangalore, 1999 ▪ The Fauna of Bangalore

CHAPTER 2: WETLANDS

- Ashok Verma; Ministry of Environment and Forests, Government of India, New Delhi, 2007 ▪ Conservation and Management of Lakes in Proceedings of the 12th World Lake Conference, Jaipur – India; 28th October – 2nd November 2007
- Ataaz, Rahmath, Moolenath, Yogananda; Ministry of Environment and Forests, Government of India, New Delhi, 2007 ▪ Biodiversity of Water Snakes and their Conservation in Palace Lake, Bangalore in Proceedings of the 12th World Lake Conference, Jaipur – India; 28th October – 2nd November 2007
- Balasubrahmanyam S.K.; Center for Ecological Sciences; Indian Institute of Science, Bangalore, 2002 ▪ Thoughts on the Upgradation and Maintenance of Water Bodies in Urban Settings in Proceedings of Symposium on Restoration of Lakes and Wetlands
- Bengeri, K.V.; Environment Association of Bangalore, 1996 ▪ Toxicity of Industrial Effluents to Fish Life in Proceedings of Seminar on Environmental Related Issues of Bangalore
- Bruhat Bangalore Mahanagara Palike, 2007 ▪ A STEM Report on A Detailed Feasibility Study Report for Rejuvenation of Lakes in Bruhat Bangalore Mahanagara Palike
- Chakrapani B.K., Ravichandra Reddy S; Center for Ecological Sciences; Indian Institute of Science, Bangalore, 2000 ▪ Status of Benthic and Littoral Fauna of Wetland Habitat in the Bangalore Urban Region with Associative Ecological Management Strategies suggested in Proceedings of Symposium on Restoration of Lakes and Wetlands, 27–29th November 2000
- Chakrapani B.K.; Center for Ecological Sciences; Indian Institute of Science, Bangalore, 2000 ▪ Long-term Ecological Observations with respect to Plankton, Fish and Avian Fauna of the Madiwala Wetland Habitat, Bangalore Urban Region, Karnataka in Proceedings of Symposium on Restoration of Lakes and Wetlands, 27 – 29th November 2000

- Chakrapani B.K.; Ph. D thesis submitted to Bangalore University, 1989 ▪ Ecology and Dynamics of Planktons in Lentic Habitat
- Chanakya H.N., Karthick B., Ramachandra T.V.; 2006 ▪ Nitrogen and Carbon Flows through Bellandur Lake – Role of Bellandur Lake as a Natural Wetland treating Bangalore Wastewater in Symposium on Environment Education & Ecosystem Conservation, 28–30th December 2006
- Directorate of Economics and Statistics, 2006 ▪ Agriculture and Land Utilization; Karnataka at a Glance
- Directorate of Economics and Statistics, Government of Karnataka, 2007 ▪ Rainfall; Statistical Abstracts of Karnataka 2001–02 and 2004–05
- Directorate of Economics and Statistics, Government of Karnataka, 2007 ▪ Forest; Statistical Abstracts of Karnataka 2001–02 and 2004–05
- Directorate of Economics and Statistics, Government of Karnataka, 2007 ▪ Agriculture; Statistical abstracts of Karnataka 2001–02 and 2004–05
- Directorate of Economics and Statistics, Government of Karnataka, 2007 ▪ Fisheries; Statistical abstracts of Karnataka 2001–02 and 2004–05
- Directorate of Economics and Statistics, Government of Karnataka, 2007 ▪ Irrigation; Statistical abstracts of Karnataka 2001–02 and 2004–05
- Goud B., Ph.D. Thesis in Engineering submitted to Bangalore University, 2000 ▪ Studies on Groundwater Qualities Around Nagarbhavi villages with special reference to Fluoride and other Cations
- Gowda S.C. Kari; Environment Association of Bangalore, 1996 ▪ Comprehensive Development Plan (Revised) – A Tool for Planned Growth of Metropolitan Bangalore in Proceedings of Seminar on Environmental Related Issues of Bangalore
- International Lake Environment Foundation, Kusatsu, Japan, 2005 ▪ Integrated Lake Basin Management – An Introduction
- Jafari N.; Ministry of Environment and Forests, Government of India, New Delhi, 2007 ▪ Ecological Role of Aquatic Plants in Freshwater Lakes in Proceedings of the 12th World Lake Conference, Jaipur – India, 28th October – 2nd November 2007
- Jagannatha, Venkataramaiah; Center for Ecological Sciences; Indian Institute of Science, Bangalore, 2000 ▪ Environmental Sound Technologies (ESTs) For Conservation And Management Of Lakes – A Case Study of Mysore Region in Proceedings of Symposium on Restoration of Lakes and Wetlands, 27–29th November 2000
- Jayaram C.; Environment Association of Bangalore, 1996 ▪ Management of Lake and Surface Water Bodies in Bangalore in Proceedings of Seminar on environmental related issues of Bangalore
- Karmakar, Ashmita; Ministry of Environment and Forests, Government of India, New Delhi, 2007 ▪ Conservation and Restoration Adi Ganga Through Practices in Proceedings of the 12th World Lake Conference, Jaipur, India, 28th October – 2nd November 2007
- Karnataka State Pollution Control Board, 2001 ▪ Water Quality Monitoring of Lakes in and around Bangalore City
- Krishna M.B., Chakrapani B.K., Jayaram C; Department of Forests, Ecology and Environment, Government of Karnataka, 1995 ▪ National Lake Conservation Plan – A Proposal for Bangalore (A First Phase)
- Krishna M.B., Chakrapani B.K., Sreenivasa T.S.; Environment Association of Bangalore, 1996 ▪ The Birds of Bangalore's Wetlands in Proceedings of Seminar on environmental related issues of Bangalore
- Kumar P.J., Dilip; Center for Ecological Sciences; Indian Institute of Science, Bangalore, 2000 ▪ Restoration of Tanks – The Need for Ecological Sensitivity in Proceedings of Symposium on Restoration of Lakes and Wetlands, 27–29th November 2000
- Lake Development Authority, 2004 ▪ A Concept Paper on Proposal for Revival of Urban Lakes in Karnataka
- Lakshman Rao N., Issar T.P., Parthasarathy M.A., Patil S.M., Vijaya Devi, Giri Gowda P. and Shenoy P.D.; Shivashankar Engineering Co. Pvt. Ltd., Bangalore, 1986 ▪ Report on the High Power Committee of the Government of Karnataka on 'Beautification of Bangalore'
- Madhyastha M.N., Rekha P.D., Shashikumar K.C.; Center for Ecological Sciences; Indian Institute of Science, Bangalore, 2000 ▪ Wetlands – Functions, Threats and Management in Proceedings of Symposium on Restoration of Lakes and Wetlands, 27–29th November 2000
- Mathew M., Mohanraj R., Azeez P.A.., Pattabhi S.; Bulletin Environment, Contamination and Toxicology, 2003 ▪ Speciation of Heavy Metals in Bed Sediments of Wetlands in Urban Coimbatore, India

- Meenamba T., Prabha S. and Vidhya S.S.; Center for Ecological Sciences; Indian Institute of Science, Bangalore, 2000 ▪ Reclamation of Lakes in Proceedings of Symposium on Restoration of Lakes and Wetlands, 27–29th November 2000
- Ministry of Environment and Forests, Government of India, New Delhi, 1999 ▪ National policy and Macro Level Actions Strategy on Biodiversity
- Nandini N.; M. Phil. dissertation in Environmental Science submitted to Bangalore University, Bangalore, 1995 ▪ Pollution Indicator Bacteria in Intestinal Tract of Fish
- Nandini N.; Ph. D Thesis in Environmental Science submitted to Bangalore University, Bangalore, 2003 ▪ Antibiotic Resistant Bacteria in Drinking Water of Bangalore North Taluk
- Narayan Aracelis, Rosales Judith, Sanchez Luzmilla; Ministry of Environment and Forests, Government of India, New Delhi, 2007 ▪ Metals Pollution in Sediments at the Lower Orinoco River in Proceedings of the 12th World Lake Conference, Jaipur, India, 28th October–2nd November 2007
- Nataraju C., Nyamathi, Shivakumar J., Ranganna G.; Center for Ecological Sciences; Indian Institute of Science, Bangalore, 2002 ▪ Groundwater Recharge in an urbanizing area – A Case Study for Bangalore Urban and Rural Districts, Karnataka State, India in Proceedings of Symposium on Conservation, Restoration and Management of Aquatic Ecosystems, 9-13th December 2002
- Pal Rama, Tewari Saumyata, Saraswat Shewat, Rai J.P.N.; Ministry of Environment and Forests, Government of India, New Delhi, 2007 ▪ Biosorption of Lead containing Industrial Effluent employing spent Yeast: A Pollution Control Technology for Lake Conservation in Proceedings of the 12th World Lake Conference, Jaipur, India, 28th October – 2nd November 2007
- Patel Sejal, Dharaiya Nitish; Ministry of Environment and Forests, Government of India, New Delhi, 2007 ▪ March Bird Community Index of Biotic Integrity: A Key to Study an Ecological Condition of Wetlands in Proceedings of the 12th World Lake Conference, Jaipur, India, 28th October – 2nd November 2007
- Prakash K.L., Nandini N., Somashekar R.K.; Journal of Ecology, Environment and Conservation, Vol. 10 (2), 2004 ▪ Fluoride Contamination in Ground Water of Anekal Taluk of Bangalore Urban District, India
- Rajnikanth R., Ramachandra T.V.; Center for Ecological Sciences; Indian Institute of Science, Bangalore, 2000 ▪ Status and Socio-Economic aspects of Wetlands in Proceedings of Symposium on Restoration of Lakes and Wetlands, 27–29th November 2000
- Ramachandra T.V., Kiran R., Ahalya N., Deepa R.S.; Center for Ecological Studies; Indian Institute of Science, Bangalore, 2002 ▪ Status of Wetlands in Bangalore, Technical Report 86
- Ramachandra T.V., Murthy C. Rajasekara; Center for Ecological Sciences; Indian Institute of Science, Bangalore, 2000 ▪ Restoration and Management Strategies for Wetlands in Proceedings of Symposium on Restoration of Lakes and Wetlands, 27–29th November 2000
- Ramesh K; Environment Association of Bangalore, 1996 ▪ Bangalore Water Supply System in Proceedings of Seminar on Environmental Related Issues of Bangalore
- Ranjani V.G, Ramachandra T.V.; Center for Ecological Sciences; Indian Institute of Science, Bangalore, 2000 ▪ Bathymetric Analysis and the characterization of the Hebbal Lake to Explore Restoration and Management Options in Proceedings of Symposium on Restoration of Lakes and Wetlands, 27–29th November 2000
- Ranjeev Benjamin, B.K. Chakrapani, Kar Devashish, A.V. Nagarathna and T.V. Ramachandra; Electronic Green Journal; Issue No. 6, 1996 ▪ Fish Mortality in Bangalore Lakes, India
- Rao H.V.N.; Environment Association of Bangalore, 1996 ▪ Population Dynamics of Bangalore, in Proceedings of Seminar on Environmental Related Issues of Bangalore
- Rathore K.C., Pattusamy V.; Center for Ecological Sciences; Indian Institute of Science, Bangalore, 2000 ▪ Status of Ulsoor Lake Water Quality between 1996 and 1997 in Proceedings of Symposium on Restoration of Lakes and Wetlands, 27–29th November 2000
- Ravichandra Reddy S., Niranjanaradhya; Center for Ecological Sciences; Indian Institute of Science, Bangalore, 2000 ▪ Changes in CPN Levels and their Influence on the Primary Production in the Sankey Tank, Bangalore in Proceedings of Symposium on Restoration of Lakes and Wetlands, 27–29th November 2000
- Ravichandra S., Shakuntala Katre; Center for Ecological Sciences; Indian Institute of Science, Bangalore, 2000 ▪ A Review of Comparative Limnology of Freshwater Impoundments of Bangalore in Proceedings of Symposium on Restoration of Lakes and Wetlands, 27–29th November 2000
- Ravishankar D.N.; Environment Association of Bangalore,1996 ▪ Operation and Maintenance Problems in Distribution of Water and Disposal of Waste Water in Bangalore City in Proceedings of Seminar on Environmental Related Issues of Bangalore

- Roselene Helen; Selvam Paneer; Ministry of Environment and Forests, Government of India, New Delhi, 2007 ▪ Physicochemical Analysis and Role of Phytiplanktons in the Bellandur Lake in Proceedings of the 12th World Lake Conference, Jaipur, India, 28th October – 2nd November 2007
- Sathishkumar R, Ramachandra T.V; Center for Ecological Sciences; Indian Institute of Science, Bangalore, 2000 ▪ Improved Solid Waste Management in the Catchment Area in Proceedings of Symposium on Restoration of Lakes and Wetlands, 27–29th November 2000
- Shetty V.G.; Environment Association of Bangalore, 1996 ▪ Solid Waste Management in Bangalore City in Proceedings of Seminar on Environmental Related Issues of Bangalore
- Society for Advancement of Aquaculture, 2002 ▪ Freshwater and Marine Fishes of Karnataka
- Sridhar, Chakrapani B.K., Chakravarthy A.K.; Center for Ecological Sciences; Indian Institute of Science, Bangalore, 2000 ▪ An Overview of Conservation Strategies and Suggestions for Restoration of Wetlands of Karnataka in Proceedings of Symposium on Restoration of Lakes and Wetlands, 27–29th November 2000
- Sudha P. and Ravindranath N.H.; 2000 ▪ A Study of Bangalore Urban Forest, Landscape and Urban Planning
- Sudhira H.S., Ramachandra T.V., Balasubrahmanya M.H.; 2007 City Profile – Bangalore; Cities, Vol. 24 No. 5
- Sukumaran K.; Center for Ecological Sciences; Indian Institute of Science, Bangalore, 2002 ▪ Environmental aspects of Lake Water and its Quality Management in Proceedings of Symposium on Restoration of Lakes and Wetlands
- Vardanyan L., Schmieder K., Sayadyan H., Heege T., Heblinski, Agyemang T.; Ministry of Environment and Forests, Government of India, New Delhi, 2007 ▪ Heavy Metal accumulation by certain Aquatic Macrophytes from Lake Sevan (Armenia) in Proceedings of the 12th World Lake Conference, Jaipur, India, 28th October – 2nd November 2007
- Wendy S. Ayres, Awa Busia, Ariel Dinar, Rafik Hirji, Stephen E Lintner, Alex E McCalla, Robert Robelus; World Bank Technical Paper No. 358; World Bank Publications, 1996 ▪ Integrated Lake and Reservoir Management - World Bank Approach and Experience

CHAPTER 3: WATER SUPPLY AND SANITATION

- AusAID (Australia-India Development Cooperation), 2002 ▪ "The Bangalore Water Supply and Environmental Sanitation Master plan Project" (BWSESMP)
- Bangalore Water Supply and Sewerage Board ▪ Annual Performance Reports (Different years)
- Bangalore Water Supply and Sewerage Board ▪ Handbook of Statistics (Different years)
- Central Public Health & Environmental Engineering Organization, Ministry of Urban Development, Government of India at http://cpheeo.nic.in
- Department of Mines and Geology, December 1999 ▪ Groundwater Resource Status of Karnataka
- Karnataka State Pollution Control Board, 2002 ▪ Water Quality Monitoring of Lakes in and around Bangalore City
- Latha N.; ISEC, Bangalore, 2003 ▪ An unpublished project report on "Water Pollution and its impact on Health and Environment: A Case Study of Vrishabhavati in Bangalore City
- Ministry of Urban Development and Asian Development Bank, 2007 ▪ Benchmarking and Data Book of Water Utilities in India
- Raghuram M.; The Hindu, 6th November 2007 ▪ Watershed Development only hope for TG Halli
- Saleth R Maria and Sastry G. S.; 2004 ▪ Water Supply and Sanitation Sector of Karnataka, India: Status, Performance and Change in Water Policy, Vol. 6 Pp 161–183
- Sastry G. S.; The Icfai Journal of Urban Policy, Vol II No.1, 2007 ▪ "Issues of Urban Water Management: A Study of Unaccounted-for Water in Bangalore"
- Sudhira et al; Elsevier journal "Cities" Vol. 24, No. 5, 2007 ▪ City profile of Bangalore
- United Nations Human settlements programme (UN-HABITAT), Earthscan Publications Ltd. London, 2003 ▪ Water and Sanitation in the World's Cities: Local Actions for Global Goals
- Vishwanath S.; IITD, New Delhi, Rain Water Harvesting Conference, 2001 ▪ Domestic Rainwater Harvesting Some applications in Bangalore, India

- World Bank, 2006 ▪ Urban Water Sector in South Asia "Benchmarking Performance"
- World Bank, 2006 ▪ Water and Sanitation Programme Connecting the Slums "A Utility's Pro-Poor Approach in Bangalore"
- World Bank, New Delhi, 2006 ▪ India Water Supply and Sanitation: Bridging the Gap between Infrastructure and Service
- World Health Organization and United Nations Children's Fund, 2000 ▪ Global Water Supply and Sanitation Assessment Report

CHAPTER 4: AIR

- Bangalore Metro Rail Corporation Limited and Ramky Enviro Engineers Limited, Bangalore 2006 ▪ Baseline Environmental Monitoring Report
- Bangalore Metro Rail Corporation Limited, Bangalore, 2006 ▪ Baseline Environmental Monitoring Report
- Bangalore Metropolitan Region Development Authority and Wilbur Smith Associates, 2007 ▪ Comprehensive Traffic & Transportation Plan for Bangalore
- Department of Forest, Ecology and Environment, Government of Karnataka, 2003 ▪ Environmental Status Report for Bangalore, 2003
- Directorate of Statistics and Economics, Government of Karnataka ▪ Karnataka at a Glance 2001–02 to 2004–05 and 2006–07
- Environment Pollution (Prevention & Control) Authority, Bangalore, September 2007 ▪ Review meeting on Implementation of Air Quality Improvement Action Plan for Bangalore City
- Environmental Management and Policy Research Institute, Bangalore, 2007 ▪ Report on law and regulations for setting up a hazardous waste treatment facility
- Environmental Management and Policy Research Institute, Bangalore, 2008 ▪ Environmental Database for Peenya Industrial Area, Complementary Project Report
- Karnataka State Pollution Control Board, Bangalore, 2008 ▪ Ambient air quality monitoring at http://kspcb.kar.nic.in/ambient_air_quality.htm as on 25 January 2008
- Karnataka State Pollution Control Board, Bangalore, 2008 ▪ Consent applications of major industries submitted
- Parivesh; Central Pollution Control Board, 2001 ▪ Air Pollution and Human Health
- Puttanna Honaganahalli and Raju K.V.; Institute for Social and Economic Change, Bangalore ▪ Air Quality Management in Bangalore, India: Policies and Issues
- TERI and Department of Environment of Government of National Capital Territory, Delhi, 2001 ▪ State of Environment Report for Delhi 2001

CHAPTER 5: HEALTH

- Ashraf S.M., Yunus M.; Biomed. Environ. Science 1997 Dec; 10 (4),1997 ▪ Waterborne diseases of bacterial origin in relation to quality of water in a suburb of Uttar Pradesh
- Central Pollution Control Board at www.cpcbnvis.nic.in/newsletter/air pollution-sep 2001/sept 2001 air.html
- Central Pollution Control Board at www.cpcbnvis.nic.in/newsletter/air pollution-sep 2001/sept 2001 air.html
- Chaithra T M, Bharathi K, Manjunatha S.N.; Journal of the Indian Society of hospital waste management, Vol 4, issue 1, 2005 ▪ "Hospital waste management practices at Victoria and Vanivilas Hospitals of Bangalore City"
- Chethan B Bhatt et al.; Journal of the Indian Society of hospital waste management, Vol 5, issue 1, 2006 ▪ "Evaluation of in house systems of health care waste management in intervened health care settings of the Malleshwaram pilot project"
- Dr. T.S. Sidhu; Center for Science and Environment, New Delhi, mimeo, 1998, ▪ Need for research on health hazards due to noise pollution in metropolitan India at the National Conference of Health & Environment

- HAWA–GTZ, 2007 ▪ Malkan Mussarath et al., Study on E-Waste Recycling Processes leading to Occupational Health Hazards in Bangalore
- Hosmac India Pvt. Ltd., Bangalore, 2008 ▪ Report on hospitals in four Indian metropolitan cities
- Institute of Health Management Research, Bangalore, April 2008 ▪ Social Assessment Study for Karnataka Health Systems Development Project at www.ihmr.org/about_pc_project1_1.html
- Jyothi J.; MD thesis ▪ Study of Morbidity due to water borne infections and bacteriological quality of water
- Kacker, Prof. S.K.; Center for Science and Environment, New Delhi, mimeo, 1998 ▪ Overview of the Health Effects of Noise Pollution with special reference to India, at the National Conference of Health & Environment
- Kempegowda Institute of Medical Sciences, Bangalore, January 2009 ▪ Performance audit of animal birth control programme in Bangalore City, A report by Department of Community Medicine at www.kimscommunitymedicine.org
- Kumar, R. et al; 1997 ▪ Typhoid fever – Contemporary Issues as related to the disease in India, Round table Conference Series No. 2, Water borne Diseases: The continuing Challenge
- Lahiri et al.; Indian Journal of Medical Research, Vol. 112, 2000 ▪ Air pollution in Calcutta elicits adverse pulmonary reaction in children
- Laura Spinney; New Science Publications, London; 1997 ▪ Pump down the Volume, New Scientist, Vol.155, No. 2091
- M.S. Ramaiah Medical College, Bangalore in association with GTZ – ASEM Indo-German Environment programme and Health Care Waste Management Cell, 2007 ▪ National level colloquium on effluent and other waste management in health care settings, 3–5th May 2007
- Malkan Mussarath, et al.; 2007 ▪ Study on E-Waste Recycling Processes leading to Occupational Health Hazards in Bangalore
- Paramesh H.; CSE Conference, New Delhi 2006 ▪ Overview and Assessment of the Key Databases, Health and Air for Health Studies
- Parkin et al.; American Water Works Association 1992 ▪ Epidemiological Studies on Arsenic
- Parmesh; Indian Journal of Pediatrics, Vol. 73, 2006 ▪ Special Supplement
- Prof. S.K. Kacker; Center for Science and Environment, New Delhi, mimeo, 1998 ▪ Overview of the Health effects of Noise Pollution with Special reference to India at the National Conference of Health & Environment
- Pruthvish S. et al; Health Care Waste Management Cell, M.S. Ramaiah Medical College, 1997 ▪ Health care waste management – An exploration
- Rajasekaran P., P.R. Dutt, K.A. Pisharoti; Indian journal of Medical Research, 1997 ▪ Impact of water supply on the incidence of diarrhea and shigellosis among children in rural communities in Madurai
- Ramakrishna Goud et al.; Journal of the Indian Society of Hospital Waste Management, Vol. 1, issue 1, 2002 ▪ "Attitudes towards safe management of health care waste – An exploration"
- Ramakrishna Goud, Gopinath D.; Dissertation, submitted to Rajiv Gandhi University of Health Sciences Karnataka, in partial fulfilment of University regulations for the award of degree of Doctor of Medicine, 2001 ▪ Determinants of safe management of health care waste
- Regional Occupational Health Centre (Southern) and Indian Council of Medical Research, Bangalore ▪ National Environmental Health Profile and Comparative Health Risk Assessment of Bangalore City
- Regional Office of Health and Family Welfare, Kendriya Sadan, Bangalore ▪ Data on Vector Borne Diseases
- Rekha Kashyap et al.; National Institute of Health, ICMR, Ahmedabad ▪ National Environmental Health Profile and Comparative Health Risk Assessment
- ROHC ▪ National Environmental Health Profile and Comparative Health Risk Assessment for Bangalore City for the period 2003–04
- Shally Awasthi, et al.; North India Ind. Pediatrics, Vol. 41, 2004 ▪ Prevalence and risk factors of Asthma and wheeze in school going children in Lucknow
- Shamsunder S D, Chethan B Bhat, Gopinath D.; Journal of the Indian Society of hospital waste management, Vol 5, issue 1, 2006 ▪ Knowledge, Attitude and Practices of universal precautions and occupational safety among nursing professionals in tertiary centres in Bangalore

- Shibani Bandopadhyay, K. Banerjee, K.K. Khanna, R.S. Sharma, T. Verghese; Journal of communicable diseases, September 1992 ▪ Drinking water quality and diarrhoea in Delhi
- Shivakumar S.; ▪ Sustainable management of health care waste
- WHO, 2003 ▪ Emerging Issues in Water and Infectious Disease
- World Health Organisation and UNICEF, 2006 ▪ Joint Monitoring Programme for Water Supply and Sanitation and updated coverage estimates for improved sanitation
- World Health Organisation, August 2008 ▪ Emerging issues in Water and Infectious Disease www.who.int/water_sanitation_health/emerging/emerging.pdf
- World Health Organisation, October 2005 ▪ Burden of disease and cost-effectiveness estimate available from http://www.who.int/water_sanitation_health/monitoring/globalassess/en/print.html
- World Health Organization at www.who.int/water_sanitation _health/medicalwaste/020to030.pdf
- World Health Organization Regional Office for Europe at www.euro.who.int/HEN/syntheses/short/20060911_1

CHAPTER 6: TRANSPORT

- None

CHAPTER 7: INDUSTRY

- Bangalore Metropolitan Region Development Authority, 2006 ▪ Internal communication on metropolitan growth, form and sustainability: A case study of Bangalore Metropolitan Region
- Central Pollution Control Board, 2005 ▪ Performance Status of Common Effluent Treatment Plants in India
- CIRJE, University of Tokyo and Institute for Social and Economic Change, 2008 ▪ Globalization and Urban Growth: Evidence for Bangalore
- Department of Factories and Boilers, GoK, 2008 ▪ Internal communication on factories and boilers in Bangalore Urban and Rural
- Department of Industries and Commerce, GoK, 2006 ▪ New Industrial Policy 2006-2011
- Department of Industries and Commerce, GoK, 2009 ▪ Karnataka Industrial Policy 2009-2014
- Department of Industries and Commerce, GoK, June 2008 ▪ Special Economic Zones at www.karnatakaindustry.gov.in/SEZonweb.php?PHPSESSID=24a148f8234fe695d0f612be6d7b257b
- Department of Information Technology, Biotechnology and Science & Technology, GoK ▪ Passport to Karnataka
- Department of Statistics and Economics, GoK ▪ Districts at a Glance: Bangalore Urban,1997/98 – 2006/07
- Department of Statistics and Economics, GoK ▪ Districts at a Glance: Bangalore Rural, 1997/98 – 2006/07
- Development Commissioner Small Scale Industries, New Delhi, and Directorate of Industries and Commerce, Bangalore, 2005 ▪ Third all India census of registered and unregistered small scale industries in Karnataka
- District Industries Centre, 2007 ▪ Internal communication on SSIs in Karnataka, district and sector wise, 1996–2007
- District Industries Centre, 2008 ▪ Internal communication on SSIs in Bangalore Urban and Rural, sector-wise, 1969–2008
- Eicher Goodearth Limited, 2007 ▪ City Map Bangalore
- Electrical Inspectorate, Government of Karnataka, 2007 ▪ Internal communication on DG sets registered in Karnataka
- Environmental Management and Policy Research Institute, Bangalore 2005 ▪ Cyber waste in Karnataka: Status, Problems and Management Options
- Hazardous Waste Management Project Karnataka, 2004 ▪ Inventorisation of Hazardous Waste in Karnataka

- Hazardous Waste Management Project, Bangalore, 2004 ▪ Preliminary Survey of Hazardous Waste Illegal Dump Sites in Karnataka
- Intergovernmental Panel on Climate Change (IPCC), Geneva, 2007: Climate Change 2007: Synthesis Report ▪ Contribution of Working Groups I, II and III to the Fourth Assessment Report
- Karnataka Industrial Areas Development Board, 2008 ▪ Internal communication on allotments made until December 2007
- Karnataka Industrial Areas Development Board, 2008 ▪ Internal communication on land acquisitions until January 2008
- Karnataka Small-Scale Industries Development Corporation, 2007 ▪ Administration Information Report
- Karnataka State Pollution Control Board, 2007 ▪ Internal communication on 17 highly polluting industries in Karnataka
- Karnataka State Pollution Control Board, 2008 ▪ Internal communication on F-registers of Regional Offices Bangalore City 1, 2 and 3; East 1 and 2, South 1 and 2, North 1 and 2, West, and Peenya
- Karnataka State Pollution Control Board, July 2008 ▪ Consent management at http://kspcb.kar.nic.in/consent_management.htm
- LiveMint.com, February 2008 ▪ Services sector growth continues to accelerate, Manas Chakravarty at www.livemint.com/2008/02/09001455/Services-sector-growth-continu.html
- Ozone Cell, June 2008 ▪ Ozone depleting substance country database at www.ozonecell.com/search_odsdb.jsp
- Textiles Committee and German Technical Cooperation, 2006 ▪ Internal memo on inventory of textile industries in Bangalore Urban

CHAPTER 8: WASTE

- None

CHAPTER 9: ENERGY

- 1996–2007 ▪ A decade of the Karnataka Renewable Energy Development Limited
- Apricus Solar Company at www.apricus.com/html/insolation_levels_asiap.htm
- Bangalore Electricity Supply Company at www.bescom.org
- Bangalore Electricity Supply Company at www.bescom.org/en/news/belp.asp
- Bangalore Electricity Supply Company at www.bescom.org/statistics
- Bangalore Metro Rail Corporation Limited at www.bmrc.co.in/benefits.html
- Bruhat Bangalore Mahanagara Palike at www.bbmp.org
- Bureau of Energy Efficiency at www.bee-india.nic.in/sidelinks/ECBC.html
- Department of Forest, Ecology and Environment, GoK ▪ Review of implementation of Air Quality Improvement Action Plan for Bangalore city by Environment Pollution Authority
- Directorate of Economics and Statistics ▪ Karnataka at a glance 2006-2007
- Indian Oil Corporation Limited, Bangalore ▪ Data on Liquid fuel consumption
- Karnataka Electricity Regulation Commission at www.kerc.org
- Karnataka Power Corporation Limited at www.karnatakapower.com/bidadi.htm
- REVA Electric Car Company at www.revaindia.com/savings.php
- TERI and Office of the Principal Scientific Adviser, Government of India ▪ National Energy Map for India: Technology Vision 2030
- United Nations Framework Convention on Climate Change at cdm.unfccc.int/UserManagement/FileStorage/FEQN7QFO8XVUINSM711MZIV28E2CRO
- Vishweswaraiah Vidhyut Nigama Limited at http://vvnl.org.in/yelahanka.htm

- Wikipedia at http://en.wikipedia.org/wiki/Electricity_in_India

CHAPTER 10: URBAN PLANNING

- April 4, 2008 ▪ Times of India Newspaper
- Bangalore Development Authority ▪ Annual Reports
- Bangalore Metropolitan Region Development Authority ▪ Structure Plan
- Bangalore Metropolitan Region Development Authority ▪ Thippagondanahalli catchment area
- Census of India, 2001 ▪ District Population Booklet (Series 30), Karnataka
- Census of India, 2001 ▪ Tables on household amenities and assets
- Eswara Prasad, J. and J. Krishna Kishore; FCA, IRS ▪ Towards an Urban Revolution by Justice
- June 2002 ▪ High Power committee for Redressal of Regional Imbalances report
- Karnataka Housing Board ▪ Annual Reports
- Karnataka Slum Clearance Board ▪ Annual Reports
- Master Plan, Bangalore – 2015
- National Commission on Urbanisation Report

CHAPTER 11: SOCIO-ECONOMIC DEVELOPMENT

- Government of Karnataka (Undated) ▪ Directorate of Information Technology, Bangalore
- Government of Karnataka, 2007 ▪ Gazette Notification, Urban Development Secretariat, Bangalore
- Government of Mysore, 1968 ▪ The Outline Development Plan for the Bangalore Metropolitan Region
- Rao V.L.S. Prakasa and V.K. Tewari; 1979 ▪ The structure of an Indian Metropolis, A Study of Bangalore, Allied publications
- Sastry G. S.; Academic Publication, New Delhi, 2007(a) ▪ Karnataka Development Report
- Sastry G. S.; Sailabala Debi and V. B. Annigeri; New Delhi: Serial Publications, 2006 ▪ Urbanization in an IT Prominent State of India: Patterns, Issues and Policy in the book Sustainable Development and the Indian Economy: Issues and Challenges; (eds.)
- Sastry G. S.; The ICFAI Journal of Urban Policy, 2(1), 2007(b) ▪ Issues of Urban Water Management: A Study of Un-accounted for Water in Bangalore
- The World Bank, Washington DC, 1992 ▪ The World Development Report
- Times of India, 4th November 2006 ▪ Expanding New Horizons, Bangalore Edition
- Times of India, 5th November 2006 ▪ Formation of Grater Bangalore, Bangalore Edition

CHAPTER 12: ECONOMIC INSTRUMENTS

- Dasgupta, Purnamita and Subrata Mandal; 13–15th June 2001 ▪ Rapporteur's Report, International Seminar on Economic Instruments. New Delhi
- Gouldar B and R Pandey; National Institute of Public Finance and Policy, New Delhi, 1999 ▪ Fiscal Instruments for Pollution Abatement: A Case Study of Distilleries in India
- James A. J. and M. N. Murthy; Oxford University Press, 1999 ▪ Water Pollution Abatement: A Taxes and Standard Approach for Indian Industry in M. N. Murthy and A. J. James and Smita Misra (eds) Economics of Industrial Pollution Abatement: Theory and Empirical Evidence from the Indian Experience, Delhi
- Kadekodi K. Gopal; Institute for Social and Economic Change, Bangalore, 2004 ▪ Design of Socio-Economic and Legal Instruments: State of Environment Report for Karnataka, Bangalore
- Karnataka State Pollution Control Board ▪ Annual Reports: 1993–94, 1998–99 and 2003–04, Bangalore
- Karnataka State Pollution Control Board, 2002 ▪ Notification regarding the consent validity, Bangalore

- Karnataka State Pollution Control Board, 2003 ▪ Notification regarding the financial incentive for medium and small red category industries who have acquired ISO14001 certificate, Bangalore
- Kuik O. J., M. V. Nadkarni, F. H. Oosterhuies, G. S. Sastry and A. E. Akkerman; Sage India, New Delhi, 1997 ▪ Pollution Control in the South and North: A Comparative Assessment of Environmental Policy Approaches in India and The Netherlands
- Ministry of Environment and Forests, Government of India, New Delhi, 1997 ▪ Report of the Task Force to Evaluate Market Based Instruments for Industrial Pollution Abatement
- Ministry of Environment and Forests, Government of India, New Delhi, 2005 ▪ Carport Responsibility for Environmental Protection
- Ministry of Environment and Forests, Government of India, New Delhi, 2006 ▪ National Environmental Policy 2006
- Oats W. E.; Harmonization or National Standards, Empirical, 25:1-13, 1998 ▪ Environmental Policy in the European Community
- OECD, Paris, 1980 ▪ Pollution Charges in Practice
- OECD, Paris, 1987 ▪ Survey of Economics Instruments
- OECD, Paris, 1989 ▪ Economic Instruments for Environmental Protection
- OECD, Paris, 1994 ▪ Managing the Environment: The Role of Economic Instruments
- OECD, Paris, 2001 ▪ Environmentally Related Taxes in OECD Countries: Issues and Strategies
- OECD, Paris, 2005 ▪ Environmentally Related Taxes in OECD Countries
- Panayotou T.; Earth Scan, London, 1998 ▪ Economic Instruments of Change, Motivating and Financing Sustainable Development
- Pandey Rita; National Institute of Public Finance and Policy, New Delhi, 1997 ▪ Designing of Pigovian Tax for Pollution Abatement in Sugar Industry
- Pandey Rita; National Institute of Public Finance and Policy, New Delhi, 1998 ▪ Pollution Tax for Industrial Water Pollution Control
- Pearce D. and E. B. Barbire; Earth Scan, London, 2000 ▪ Blueprint for Sustainable Economy
- Sastry G. S.; Institute for Social and Economic Change, Bangalore, 2006 ▪ Role of Policy Instruments in Pollution Abatement: A Comparative Study of India and France, CEENR
- Sterner Thomas; Washington DC: Resource for Future, 2003 ▪ Policy Instruments for Environmental and Natural Resource Management.
- Ministry of Environment and Forests, Government of Bangladesh at www.MoEF.gov.bd

CHAPTER 13: ENVIRONMENTAL MANAGEMENT PLAN

- World Bank, 2006 ▪ Little Green Data Book

ACRONYMS

A

ABIDE	Agenda for Bangalore Infrastructure Development
AD	Anno Domini
ADB	Asian Development Bank
AIIMS	All India Institute of Medical Sciences
ALDS	Auto LPG Dispensing Stations
ALRI	Acute Lower Respiratory Tract Infection
AMP	Action management plan
APZ	Area Planning Zone
ARI	Acute respiratory infections
ARV	Anti retroviral vaccine
ARWSP	Accelerated Rural Water Supply Programme
ASP	Aeriated sewage plant
ATREE	Ashoka Trust for Research in Ecology and the Environment
AusAID	Australian Agency for International Development

B

BATF	Bangalore Agenda Task Force
BBMP	Bruhat Bangalore Mahanagara Palike
BDA	Bangalore Development Authority
BEC	Bangalore Environmental Commission
BEL	Bharat Electronics Limited
BELP	BESCOM Efficient Lighting Programme
BESCOM	Bangalore Electricity Supply Company
BHEL	Bharat Heavy Electricals Limited
BIAPA	Bangalore International Airport Planning Authority
BIS	Bureau of Indian Standards
BMA	Bangalore Metropolitan Area
BMA	Bangalore Municipal Authority
BMAZ	Bangalore Metropolitan Area Zone
BMC	Bangalore Municipal Corporation
BMIC	Bangalore-Mysore Infrastructure Corridor
BMICAPA	Bangalore Mysore Infrastructure Corridor Area Planning Authority
BMP	Bangalore Mahanagara Palike
BMR	Bangalore Metropolitan Region
BMRC	Bangalore Metropolitan Region Council
BMRCL	Bangalore Metro Rail Corporation Limited
BMRDA	Bangalore Metropolitan Region Development Authority
BMTC	Bangalore Metropolitan Transport Corporation
BMW	Biomedical waste
BOD	Biochemical oxygen demand
BOT	Build, operate and transfer
BPCL	Bharat Petroleum Corporation Limited
BPL	Below poverty level
BPO	Business process outsourcing
BRC	Bangalore Rural Circle
BRTS	Bus Rapid Transit System
BSUP	Basic services for the urban poor
BT	Biotechnology
BTS	Bangalore Transport System
BTX	Benzene, toulene and xylene
BUA	Bangalore urban agglomeration
BUC	Bangalore University Campus
BWSESMP	Bangalore Water Supply and Environmental Sanitation Masterplan Project
BWSSB	Bangalore Water Supply and Sewerage Board

C

CAAQMS	Continuous Ambient Air Quality Monitoring Stations
CAD	Catchment area development
CBD	Central business district
CBMWHF	Common biomedical waste handling facility
CBR	Crude birth rate
CDC	Center for Disease Control and Prevention
CDM	Clean Development Mechanism
CDP	Comprehensive Development Programme
CDR	Crude death rate
CETP	Common effluent treatment plant
CFE	Consent for establishment
CFO	Consent for operation
CII	Confederation of Indian Industry
CITB	City Improvement Trust Board
CMASP	Complete Mixed Activated Sludge Process
CMC	City Municipal Council
CNG	Compressed natural gas
CNS	Central nervous system
CO	Carbon monoxide
COD	Chemical oxygen demand
COPD	Chronic obstructive pulmonary disease

CPC	Cleaner Production Centre
CPCB	Central Pollution Control Board
CPEEHO	Central Public Health and Environmental Organization
CPR	Common Property Resources
CREP	Corporate Responsibility for Environmental Protection
CRR	Core Ring Road
CTC	Carbon tetrachloride
CTTP	Comprehensive Traffic & Transportation Plan
CWDT	Cauvery Water Dispute Tribunal
CWSS	Cauvery Water Supply Schemes

D

DALY	Disability-adjusted life years
dB (A)	Decibel, a-weighted
D-BOT	Design, Build, Operate, Transfer
DEEF	Department of Ecology, Environment and Forest
DEWAT	Decentralized Wastewater Treatment System
DG	Diesel generator
DGHS	Directorate General of Health Services
DIC	District Industries Centre
DLF	Directly landfillable waste
DMA	Directorate of Municipal Administration
DMG	Director of Mines and Geology
DO	Dissolved oxygen
DPF	Diesel particulate filter

E

ED	Epidemic diseases
EIA	Environmental Impact Assessment
EMPRI	Environmental Management and Policy Research Institute
ENT	Ear nose throat
EPA	Environmental Protection Act
EPCA	Environmental Pollution Control Agency
ERF	Environment Relief Fund
ESMAP	Energy Sector Management Assistance Program
ESR	Environmental status report
ETC	Emission testing center
ETM	Electronic Ticketing Machine
ETP	Effluent treatment plant
EUDC	Extra urban driving cycle
EW	Expressway
EWA	E waste agency
EWS	Economically weaker section

F

FDI	Foreign direct investment
FR	Fertility rate
FRLHT	Foundation for Revitalization of Local Health Traditions
FY	Financial Year

G

GAIL	Gas Authority of India Limited
GBDC	Greater Bangalore Development Council
GDDP	Gross district domestic product
GDI	Gross domestic income
GDP	Gross domestic product
GE	Gastro enteritis
GHG	Greenhouse gas
GIS	Geographic Information System
GKVK	Gandhi Krishi Vignana Kendra
GO	Government Order
GoI	Government of India
GoK	Government of Karnataka
GPS	Global Positioning System
GS	Gross supply
GTZ	German Technical Cooperation
GW	Ground water

H

HAL	Hindustan Aeronautics Limited
HAP	Heavy air pollution
HAWA	Hazardous Waste Management Project of KSPCB and GTZ
HC	Hydro carbon
HCFC	Hydrochlorofluorocarbons
HCWM	Health Care Waste Management
HDI	Human development index
HDPE	High-density polyethylene
HGV	Heavy goods vehicle
HIV	Human immunodeficiency virus
HPCL	Hindustan Petroleum Corporation Limited
HSD	High speed diesel
HTV	Heavy transport vehicle
HUDCO	Housing and Urban Development Corporation
HVS	Highvolume sampler
HW	Hazardous waste

I

I & M	Inspection & maintenance
ICD	International Classification of Diseases
IEC	Implementation, education, communication
IGNOU	Indira Gandhi National Open University
IISc	Indian Institute of Science
IMR	Infant mortality rate

INAAQS	Indian National Ambient Air Quality Standards
INEP	Indo-Norwegian Environment Program
INR	Indian rupees
IOCL	Indian Oil Corporation Limited
IPCC	Intergovernmental Panel on Climate Change
IPT	Intermediate Public Transport
IQ	Intelligence quotient
IRR	Intermediate Ring Road
IS	Indian standards
ISEC	Institute for Social and Economic Change
ISI	Indian Standards Institute
ISO	International Organization for Standardization
ISRO	Indian Space Research Organization
IT	Information technology
ITES	Information technology enabled services
ITPL	International Technological Park
ITS	Intelligent Transportation Systems
IVRS	Interactive Voice Response System
IWDP	Integrated Wastelands Development Programme
IZ	Interstitial Zone

J

JBIC	Japan Bank for International Cooperation
JNNURM	Jawaharlal Nehru National Urban Renewal Mission

K

KASSIA	Karnataka Small Scale Industries Association
KBB	Karnataka Biodiversity Board
KCDC	Karnataka Compost Development Center
KCTU	Karnataka Council for Technological Upgradation
KFD	Karnataka Forest Department
KFDC	Karnataka Forest Development Corporation
KHB	Karnataka Housing Board
KIADB	Karnataka Industrial Areas Development Board
KIMS	Kempegowda Institute of Medical Sciences
KMC	Karnataka Municipal Corporation
KRDCL	Karnataka Road Development Corporation Limited
KREDL	Karnataka Renewable Energy Development Limited
KRS	Krishna Raja Sagar
KSCB	Karnataka Slum Clearance Board
KSPCB	Karnataka State Pollution Control Board
KSRSAC	Karnataka State Remote Sensing Application Center
KSRTC	Karnataka State Road Transport Corporation
KSSIDC	Karnataka Small-Scale Industries Development Corporation
KT & CP	Karnataka Town & Country Planning
KUIDFC	Karnataka Urban Infrastructure Development & Finance Corporation
KUIDP	Karnataka Urban Infrastructure Development Project
KVIB	Khadi and Village Industries Board
KWMP	Karnataka Waste Management Project

L

LABS	Linear alkylbenzene sulfonate
LAP	Light air pollution
LDA	Lake Development Authority
LEQ	Energy-equivalent sound level
LIG	Low income group
LMV	Light motor vehicle
LOS	Level of service
LPA	Local planning area
LPCD	Liters per capita per day
LPG	Liquid petroleum gas
LST	Land surface temperature

M

MAP	Management action plan
MAP	Moderate air pollution
MBR	Membrane bioreactor
MCh	Methyl chloroform
MCS	Mega City Scheme
MDG	Millennium Development Goal
MDI	Metered dose inhaler
MDR	Major district road
MINAS	Minimum national standards
MIS	Management information system
ML	Million liter
MMSME	Ministry of Micro, Small and Medium Enterprises
MNC	Multi-national company
MoEF	Ministry of Environment and Forest
MOH	Medical Officers of Health
MOP	Meeting of parties
MoU	Memorandum of understanding
MoUD	Ministry of Urban Development
MPN	Most probable number
MSL	Mean sea level
MSME	Micro, small and medium enterprises
MSRMC	MS Ramaiah Medical College
MSW	Municipal solid waste
MVR	Mechanical vapour recompression

N

NAAQ	National Ambient Air Quality
NAMP	National Air Quality Monitoring Programme
NBAY	Nirmal Bharath Abhiyan Yojana
NDVI	Normalised Difference in Vegetation Index
NEP	National Environmental Policy
NFHS	National Family Health Survey in Karnataka
NGO	Non-Governmental Organization
NH	National Highway
NHAI	National Highways Authority of India
NICD	National Institute of Communicable Diseases
NICE	National Institute for Clinical Excellence
NJY	Nirmal Joythi Yojana
NLCP	National Lake Conservation Plan
NLSIU	National Law School of India University
NO_2	Nitrogen di oxide
NO_X	Oxides of nitrogen
NPR	Northern Peripheral Road
NRCA	National River Conservation Authority
NRCLPI	National Referral Centre for Lead Poisoning Prevention in India
NRI	Non resident Indian
NRW	Non-revenue water
NS	Net supply
NSDP	National Slum Development Programme
NTI	National Tuberculosis Institute
NTU	Nephelometric Turbidity Units

O

O & M	Operation and maintenance
OBG	Obstetrics and gynecology
ODP	Outline Development Plan
ODP	Ozone depleting potential
ODR	Other district road
ODS	Ozone depleting substances
OECD	Organisation for Economic Co-operation and Development
ORR	Outer Ring Road
ORS	Oral rehydration solution

P

PBR	People's Biodiversity Register
PCTR	Per capita trip rate
PCU	Passenger car unit
PDA	Personal digital assistant
PDS	Public distribution system
PHPDT	Peak Hour Peak Direction Traffic
PIA	Peenya Industries Association
PICUP	Peenya Infrastructure Corridor Upgradation Project
PM	Particulate matter
ppb	parts per billion
PPE	Personal protective equipment
ppm	Parts per million
PPP	Public-private partnership
PRR	Peripheral Ring Road
PSU	Public sector unit
PUC	Pollution under control
PVC	Poly vinyl chloride
PWD	Public Works Department

R

R & D	Research and Development
RAC	Refrigeration and air-conditioning
RCC	Reinforced cement concrete
RDS	Respirable dust sampler
RFID	Radio-frequency identification
RGCC	Registrar General and Census Commissioner
RGRHCL	Rajiv Gandhi Rural Housing Corporation Limited
RIHFW	Regional Institute of Health and Family Welfare
RO	Reverse osmosis
ROB	Road over bridges
ROHC	Regional Occupational Health Center
RPA	Rapid Participatory Assessment
RPM	Respirable particulate matter
RSPM	Respirable suspended particulate matter
RTO	Regional Transport Office
RUB	Road under-bridges
RWH	Rainwater harvesting

S

SAP	Severe air pollution
SDF	Self declaration forms
SEARO	South East Asian Region
SEC	Socio-economic category
SEZ	Special economic zones
SGRRL	Srinivasa Gayatri Resource Recovery Limited
SH	State Highway
SIDA	Swedish International Development Co-operation Agency
SJMC	St. Johns Medical College
SKO	Superior kerosene oil
SME	Small and medium sized enterprises
SO_2	Sulphur dioxide
SO_X	Oxides of Sulphur
SPM	Suspended particulate matter
SPR	Southern Peripheral Road
SPV	Special purpose vehicles
SSI	Small scale industry

STEM	Centre for Symbiosis of Technology, Environment and Management
STP	Sewage treatment plant
STPI	Software Technology Parks of India
STRR	Satellite Town Ring Road
SUC	Single unit complexes
SW	Solid waste
SWM	Solid waste management
SWOT	Strength, weakness, opportunities and threats

T

TBS	Tarun Bharat Singh
TCPO	Town and Country Planning Organisation
TDS	Total dissolved solids
TFBL	Terra Firma Biotechnologies Limited
TG	Thippagondanahalli
TGR	Tippagondanahalli reservoir
TMC	Thousand million cubic
TMC	Town Municipal Council
TO	Total organics
TSDF	Treatment, storage and disposal facility
TTMC	Traffic and Transit Management Centers
TTP	Tertiary treatment plant
TWA	Time weighted average

U

UAS	University of Agricultural Sciences
UASB	Upflow anaerobic sludge blanket
UC	Under construction
UDA	Urban Development Authority
UDC	Urban Driving Cycle
UDWSP	Urban Drinking Water and Sanitation Policy
UFW	Unaccounted-for water
UGD	Underground drainage
ULB	Urban local bodies
UNICEF	United Nations Children's Fund
UNIDO	United Nations Industrial Development Organization
URTI	Upper respiratory tract infection
USA	United States of America
USD	United States Dollar
UT	Union Territory
UV	Ultraviolet

V

VAMBAY	Valmiki Ambedkar Malin Basti Awas Yojana
VAT	Value added tax
VOC	Volatile organic compounds
VR	Village roads
VVNL	Visvesvaraya Vidyuth Nigama Limited

W

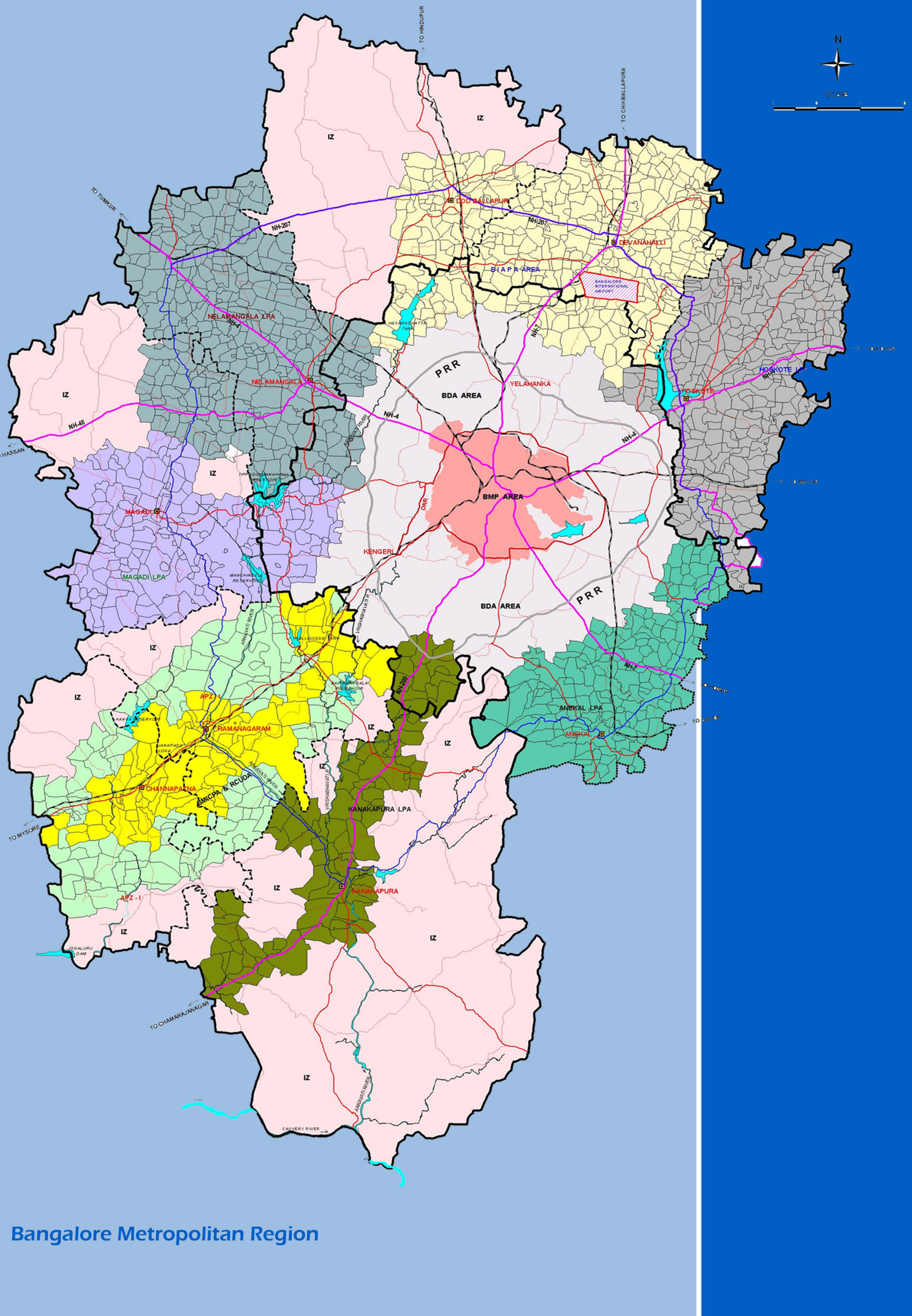
WHO	World Health Organization
WMTC	World Maritime Technology Congress

Y

YTC	Yet to commence

Z

ZR	Zoning regulation



Bangalore Metropolitan Region