URBAN WATER RESOURCE MANAGEMENT
FOR
UDAIPUR CITY

A DISSERTATION

Submitted in partial fulfillment of the
requirements for the award of the degree
of
MASTER OF URBAN AND RURAL PLANNING

By

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JUNE, 2008

CERTIFICATE

Certified that this report titled "**Urban Water Resource Management for Udaipur City**", Which has been submitted by Mr. Anil Kumar Bairwa, in partial fulfillment of the requirements for the award of Post Graduate Degree in **Master of Urban and Rural Planning** in the Department of Architecture & Planning, Indian Institute of Technology Roorkee, is the student's own work carried out by him under my supervision and guidance. The matter embodied in this dissertation has not been submitted for the award of any other degree.

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CANDIDATE'S DECLARATION

I hereby declare that the work, which is presented in this dissertation entitled "**Urban Water Resource Management for Udaipur City**" in partial fulfillment of the requirements for the award of degree of Master of Urban and Rural Planning, submitted in the Department of Architecture and Planning, Indian Institute of Technology, Roorkee, is an authentic record of my own work carried out for a period of about one year from June 2007 to June 2008 under the supervision of **Prof. R.K. Jain and Dr. Nalini Singh**, Department of Architecture and Planning, IIT Roorkee.

The matter embodied in this dissertation has not been submitted by me for award of any other degree.

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ABSTRACT

Being one of the basic requirements of human existence it becomes highly imperative to manage the total available water, more so because it is not replaceable or replicable.

The chapter 1 first of all gives a brief overview of the available water resources in India. Then it justifies the need for the study before laying down the scope, limitations and methodology of the study to follow.

97% of the planet's surface is covered with water. So what is the use of water management after all? 2.7% if the total water on earths surface is fresh water of which 78% stays frozen in the polar caps. According to available estimates only 0.3 percent of total fresh water is usable for entire animal and human populations. Hence the need of water management.

In the chapter 2 author attempts to investigate the situations in India and Udaipur in particular, which is the study area. It is very important to make case studies before thinking off any kind of planning, designing or management solutions.

In the chapter 3 author makes case studies about Jaipur and Bhopal tries to make inferences after analyzing the water resource conditions of these cities. The cities have been selected on the basis of the similarity to the study area with respect to climate, topography and physical features. Udaipur, which is better known as the city of lakes or the Venice of the east contains four lakes. However the call of the hour is to manage the existing available resources as the conditions of most of the lakes is worsening.

The chapter 4 investigates the physical and water resource conditions of the city of Udaipur. This is highly essential before recommending any design, management or planning solutions.

After obtaining the information about the city and its water resources it is time to analyze the conditions before suggesting recommendations.

The chapter 5 analyzes the situation based upon the information gathered by various primary and secondary sources of information.

After analysis the data and the findings. The chapter 6 gives some proposal and recommendation for improving the water resource and water supply system in Udaipur city.

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ABBREVIATIONS

BCM	Billion Cubic Meters
BMC	Bhopal Municipal Corporation
BHEL	Bharat Heavy Electricals Limited
CDP	City Development Plan
CPHEEO	Central Public Health and Environmental Engineering Organization
HIG	high income group
JDA	Jaipur Development Authority
JMC	Jaipur Municipal Corporation
JNNURM	Jawahar Lal Nehru National Urban Renewable Mittion
KL	Kilo Liters
LIG	Lower Income Group
LPCD	Liters per Capita Per Day
LPS	Liters per Second
MIG	Middle Income Group
ML	Million Liters
MLD	Million Liters per Day
PHED	Public Health & Engineering Department
RUIDP	Rajasthan Urban Infrastructure Development Project
WTP	Water Treatment Plant

Chapter-1

INTRODUCTION

[Being one of the basic requirements of human existence it becomes highly imperative to manage the total available water, more so because it is not replaceable or replicable.
the following chapter first of all gives a brief overview of the available water resources in India. Then it justifies the need for the study before laying down the scope, limitations and methodology of the study to follow.]

Introduction:

Water is essential in every aspect of life and it cannot be replaced or replicated. Two third of earth surface covered by water, where as the human body consisting 75 percent water of the total body weight. Water is one of the prime elements for survival of life on earth. From the very beginning, man realized that water is essential for survival and hence most of the historic cities beginning from early civilization flourished on productive lands in the vicinity of great rivers -eg. the Tigris and Euphrates in Mesopotamia; the Nile in Egypt; the Indus in India and Huang ho in china.

It is difficult to envisage life without water and it has been also a key factor, for basic irrigation needs and for industrial development. It also plays an important role in socio-cultural and religious activities. For thousand of year, humans have consumed water as if it were an inexhaustible natural resource.

Out of the total available water on the planet earth 97 percent of it is salt water which is unsuitable for drinking and growing crops and only the remaining 3 percent of water is fresh water out of this 2.7 percent is inaccessible and effectively located up in ice caps of Antarctica and Greenland and in deep aquifers. According to available estimates only 0.3 percent of total fresh water is usable for entire animal and human populations. This 'usable' fresh water is being constantly recycled in nature and its distribution is highly uneven. Thus, it is important that this scarce resource must be valued, safeguarded and its usage monitored.

1.1 Water Resources Available in India:

Ground water as a source of water supply has been utilized in India from time immemorial, mainly for domestic needs and also partly for irrigation. The pattern of water utilization changed in recent times, nearly 90 percent being used for irrigation for purpose so much so that ground water potential is exposed more so often in terms of irrigation potential. The progressive increase of ground water potential can be seen from table. From time to time, estimates of ground water potential of India have been made by various agencies. Here the estimates of ground water potentials state wise made by central ground water board in 1995.

The total replenish able ground water in India is 431.88 BCM. Out of this 322 BCM is recoverable through recharge. The total net draft of ground water for irrigation was 115.16 BCM and for domestic and other uses the provision was for 70.93BCM. In the year 1993. Hence we have balance of 245.78 BCM for future use.

According to the latest statistics, about 15,000 habitations in the country were reported to be without any source of potable water; some 200,000 villages were partially covered by drinking water schemes; and 217,000 villages reported problems with the quality of water.

It is difficult to estimate the proportion of population that has access to clean drinking water. At the time of the First Five-Year Plan, 6% of the rural population and some 48% of the urban population had access to safe drinking water. There has been a dramatic increase in coverage, and by 1994-95, as much as 82% of the rural population was covered. According to the Centre for Science and Environment, about 70% of the country's total population has access to safe water.

Water stress is becoming acute in both urban and rural situations. Not only the quantity but also the quality of water supplied or available is being questioned. At one extreme, water is being wasted in urban areas and by industries; at the other, the rural poor lack access to safe water.

It should be remembered that water is not an unlimited source; it also needs to be recharge. Over exploitation of ground water, and increasing population both has put tremendous pressure on it made it necessary to recharge through better water management practices and recharge of it through rainwater harvesting and other measures.

The projected demand of water in different sector for different year is given in the table 1.1.

Table 1.1 India's Water Demand in Different Sector (BCM)

S.NO.	USE	1990 AD	2000 AD (Proj.)	2025 AD (Proj.)	2050 AD (Proj.)
1.	Irrigation	460	630	770	800
2.	Drinking and Domestic	25	33	52	60
3.	Industry	15	30	120	130
4.	Energy	19	27	71	120
5.	Other	33	30	37	40
	Total	552	750	1050	1150

Source: Journal of Water Works Association

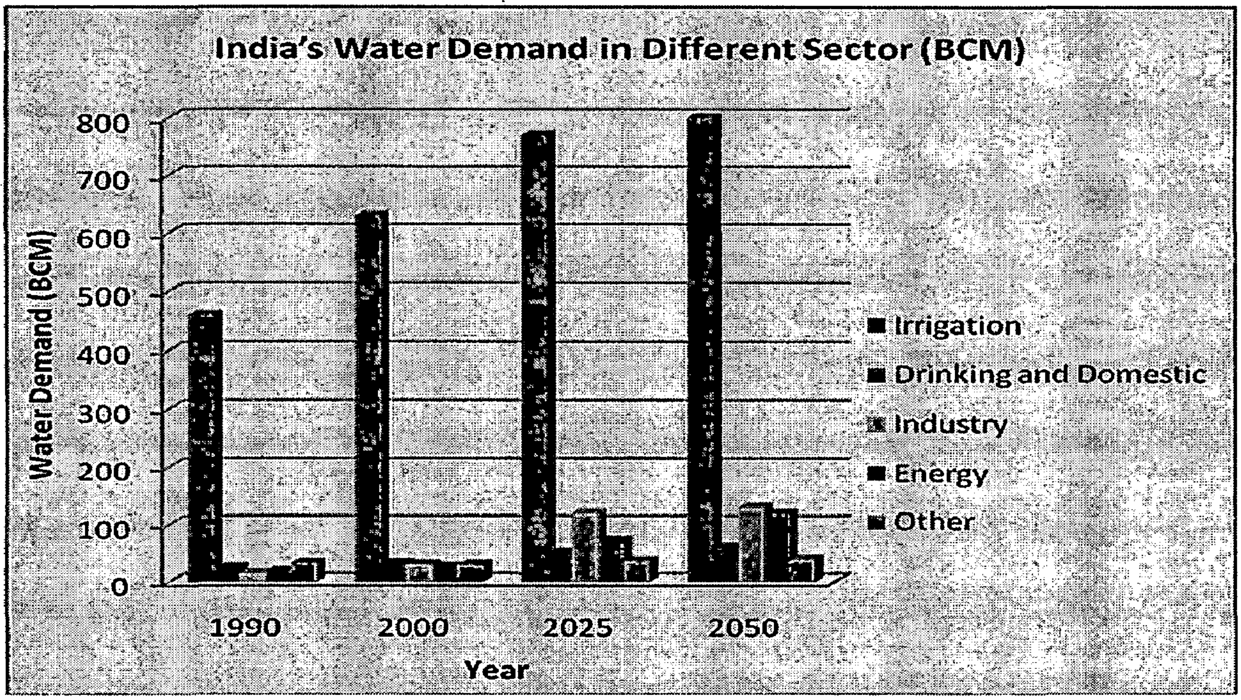

Figure 1.1: India's water demand in different sector (BCM)

Source: Journal of Water Works Association

Per capita availability of replenish able water for different year is given in table 1.2.

Table 1.2 Per Capita Water Availability in India

Year	Water Availability (in CUM.)
1947	6000
1955	5277
1997	1970
1999	1947
2017(Proj.)	1600
2025(Proj.)	1350

Source: Journal of Water Works Association

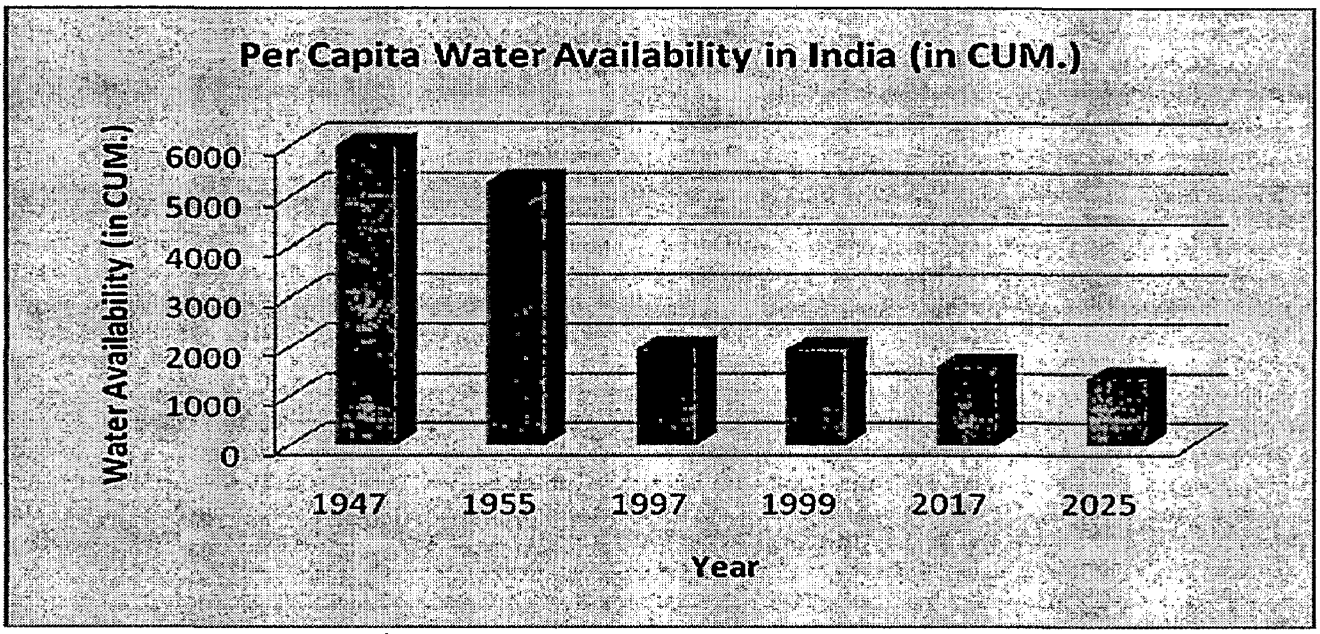

Figure 1.2: Per Capita Water Availability in India

Source: Journal of Water Works Association

It is obvious from the above table 1.2 that per capita water availability is decreasing rapidly due to increase in population and decrease in ground water. Water supply mainly dependent on groundwater source, this dependency on ground water should be reduced the various rainwater harvesting practices should be adopted both for recharge of ground water and for domestic & other uses.

1.2.1 Surface Water Resource:

India is a land of rivers. There are 14 major, 44 medium and 55 minor river basins in the country. Major rivers have a catchment area of 20,000 square kilometers or above, medium between 2,000 and 20,000 square kilometers and minor systems have a catchment area of 2,000 square kilometers or less. But, in some dry areas of Rajasthan, every inch of land contributes water through runoff to these rivers.

The major river basins constitute about 83-84% of the total drainage area. This, along with the medium river basins, accounts for 91% of the country's total drainage. Though only the last 4,000 kilometers of the Brahmaputra pass through Indian Territory, the river carries 31% of all the water carried by Indian rivers. By contrast, the Ganges carries about 30%. In all, a total of 1,645 cubic kilometers of water flows through our river system every year.

1.2 Need for Water Resource Management:

Population growth and the expansion of economic activities lead to increasing demand of water for various uses like domestic, industrial, irrigation, hydro-power, thermal-power, recreation etc. the crisis about water resources development and management arises because most of water on earth is not available for use and secondly it is characterized by its highly uneven spatial distribution. There is need to conserve and manage to water resources because of

a) Limited renewable water resource
b) High population growth and demand
c) Lack of integrated water resource planning & management
d) Increasing cost of water supply expansion
e) Deteriorating water quality

1.3 Aim of the Study:

To plan for management of water resource & water supply system in Udaipur city.

1.5 Objectives:

The following set of objectives has been framed:

1. To study & analyze the prevailing water sources of Udaipur in the light of its supply and demand.
2. To assess the water consumption pattern in the city.
3. To assess the potential of water resources available in the form of lakes and ground water reservoir in and around Udaipur.
4. To project the demand and supply of water resource in the city for 2022 A.D...
5. To evolve a set of policy guidelines for water supply.

1.6 Scope:

The scope of the study includes assessment of the potential of water resources available in the form of lakes and ground water reservoir in around the Udaipur for drinking purpose and for all other uses of the city. While the main purpose will be to deal with urban household primarily, the project attempts to cover other sectors of urban water consumption as well.

1.7 Limitations:

Due to the limitation on time and resources for undertaking necessary studies, the bulk of the studies will be confined within the urban control area of Udaipur & field survey will be limited to cover only the key planning aspects and bulk of the data & maps will be from secondary official sources.

1.8 Methodology of the Study:

1. Extensive literature study to understand the management of water resource, case studies on management of water resource and water supply system with in the city.
2. Collection of primary data from primary household survey & observations Collection of secondary data from government agencies, form publications and institutions of census statics, data about availability of water resource with in the city.

3. Analysis of data through statistical methods and presentation of the analyzed data and report through various computer softwares.
4. Formulation of plan basis and preparation of proposal for management of water resource of Udaipur city.

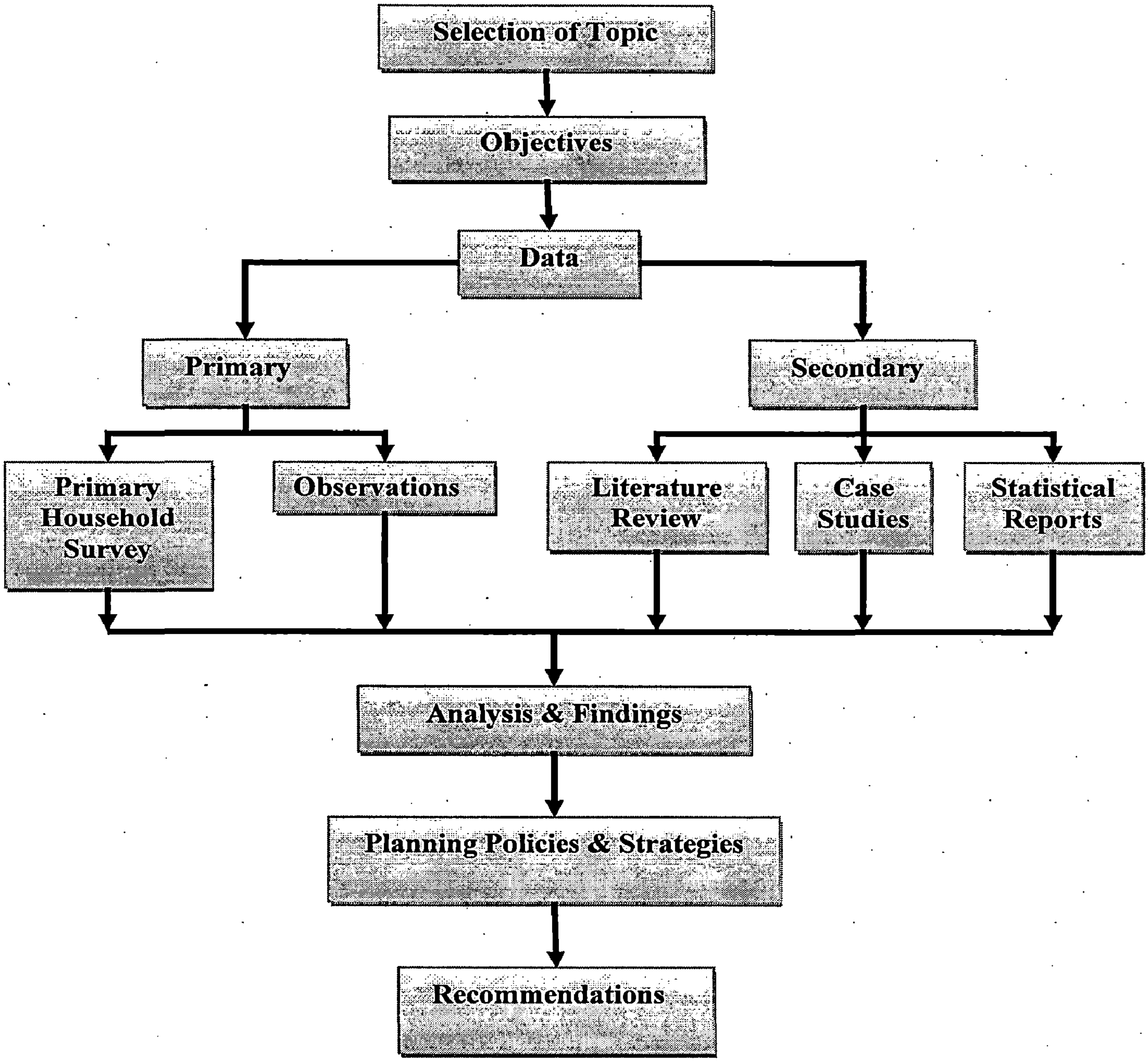

Figure 1.3: Methodology

Chapter-2

LITERATURE STUDY

[97% of the planet's surface is covered with water. So what is the use of water management after all?
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In the following chapter the author attempts to investigate the situations in India and Udaipur in particular, which is the study area.]

2.1 The State of Water Availability in the World

2.1.1 Existing Scenario

Oceans cover about three fourth of earth's surface. According to the UN estimates, the total amount of water on earth is about 161,000,000 ML (million liters). However the fresh water constitutes a very small proportion of this enormous quantity. About 2.7 percent of the total water available on the earth is fresh water of which about 75.2 percent lies frozen in Polar Regions and another 22.6 percent is present as ground water. The remaining is available in lakes, rivers, atmosphere, moisture, soil and vegetation. What is effectively available for consumption and other uses is a small proportion of the quantity available in rivers, lakes, and ground water.

The state of water supply in the world, specially in the developing countries presents a grim scenario. As per 2000 figure about 2 of every 10 people in the developing world were without access to safe drinking water; 5 out of 10 live without adequate sanitation; and 9 out of 10 live without their wastewater treated in any way.

According to an UN-Habitat Report, water and sanitation services are too often the cause of failing communities. Full pressure "24X7" water supply remains a dream in many cities. Because a quarter to half (and more) of urban water supply remains unaccounted for, many cities are turned into leaking buckets. The limited number of network access points are widely shared, which dramatically increases waiting times and often simply overwhelms the system.

2.1.2 Water Stress in World

Water stress is being experienced all over the world. That is because the existing sources of water that could be accessed cost-effectively have already been developed or are in the process of development and the water that has been harnessed has already been fully allocated and in many cases over-allocated Additional supplies of drinking water can be obtained only by reallocating water that is currently used by other sectors, especially agriculture The following statements clearly show the extent of water stress the world over.

- 2 billion people have no access to clean drinking and 2.9 billion have no access to sanitation.
- By 2015, 40% of world's population, or about 3 billion people will live in countries where it is difficult or impossible to get enough water to satisfy basic needs.
- In developing countries 90% of wastewater is discharged without treatment.
- 80% of all illness and death in developing world due to contaminated water.
- 6000 children die every day from diseases associated with unsafe water and sanitation and hygiene.
- 1.1 billion People lack access to save drinking water (1\6th of population) and 2.4 billion lack safe sanitation (40% of pop.)
- 6000 children die every day from diseases associated with unsafe water and sanitation and hygiene.
- More than 2.2 million die each year from disease associated with poor water and sanitation.
- Unsafe water and sanitation leads to 80% of all the diseases in the developing world.
- In developing countries 90% of waste water is discharged without treatment.
- Over pumping groundwater caused decline of water levels by tens of meters in many regions, forcing people to use low quality water for drinking.
- Loss water through leakage, illegal hook-ups and waste is about 50% of water for drinking and 60% of water for irrigation in developing countries.

2.2. Water supply Scenario in India

2.2.1. Water Resources

As per the latest assessment (1993), out of the total precipitation, including snowfall, of around 460,000 ML in the country, the availability from surface water and replenishable ground water is put at 1869X106 ML. Because of topographical and other constraints, about 60% of this i.e. 79,350 ML from surface water and 49,680 ML from ground water can be put to beneficial use.

2.2.2. *Geographic and Climatic Variations –Precipitation*

A major feature of the Indian climate, which has a direct bearing on water dynamics, is the alternation of wind direction twice a year, resulting in four distinct seasons. Rainfall in India is dependent largely on the Southwest and northeast monsoons, on shallow cyclonic depressions and disturbances and on violent local storms. Most of the rainfall takes place under the influence of southwest monsoon between June to September except in Tamil Nadu and some other Southern States where it occurs under the influence of northeast monsoon during October and November.

The rainfall shows great variations, unequal seasonal distribution, still more unequal geographical distribution and frequent departures from the normal. As much as 21 percent of the area of the countries receives less than 750 millimeters (mm) of rain annually while 15 percent receives rainfall in excess of 1500 mm. It extends to 2500 mm along almost the entire west coast and over most of Assam and sub-Himalayan West Bengal. The large areas of peninsular India have rainfall less than 600 mm. Annual rainfall of less than 500 mm is experienced in western Rajasthan and adjoining parts of Gujarat, Haryana and Punjab. Rainfall is equally low in the interior of the Deccan plateau east of the Sahyadris. A third area of low precipitation is around Leh in Kashmir. Rest of the country receives moderate rainfall. Snowfall is restricted to the Himalayan region.

With an average annual rainfall of 1,170 mm, India is one of the wettest countries in the world but this in itself does not solve the water problems of the country. At one extreme are areas like Cherrapunji, in the northeast, which is drenched each year with 11,000 mm of rainfall and at the other extreme are places like Jaisalmer, in the west which receives barely 100 mm of rain. Though the average rainfall is adequate, nearly three-quarters of the rain Pours down in less than 120 days, from June to September.

2.2.2.1. River System

India is a land of rivers. There are 14 major, 44 medium and 55 minor river basins in the country. Major rivers have a catchment area of 20,000 square kilometers or above medium between 2,000 and 20,000 square kilometers and minor systems have catchment area of 2,000 square kilometers or less. But, in some dry areas of Rajasthan every inch of land contributes water through runoff to these rivers.

The major river basins constitute about 83-84% of the total drainage area. This, along with the medium river basins, accounts for 91% of the country's total drainage. Though only the last 4000 kilometers of the Brahmaputra pass through Indian territory, the river carries 31% of all the water carried by Indian rivers. By contrast, the Ganges carries about 30%. In all, a total of 1,645 cubic kilometers of water flows through our river system every year.

The main Himalayan river systems are the Indus and the Ganga-Brahmaputra-Meghna (Barak) system. The Ganga rising from the snow capped Himalayan mountains, flows through the great indo-gangetic plains. The Brahmaputra rises in Tibet where it is known as the Tsangpo and runs a long distance until it crosses over into India in Arunachal Pradesh under the name of Siang or Dihang. The Ganges and the Brahmaputra join nside Bangladesh and continue to flow under the name Padma forming the Sunderban delta.

The Indus, which is one of the great rivers of the world, rises near Mansarovar in Tibet, flows through India and thereafter through Pakistan and finally falls in the Arabian Sea near Karachi. Its major tributaries the Jhelum, Chenab, Ravi Beas and Sutlej originate in India and after flowing through the Punjab plains join the Indus.

The important river systems in the Deccan are the Narmada and the Tapi, which flow westwards into Arabian Sea. The east-flowing rivers of the Deccan, the Brahmani, the Mahanadi, the Godavari, the Krishna, the Pennar and the

Cauvery fall into Bay of Bengal. There are numerous coastal rivers, which are comparatively small. While only a handful of such rivers drain into the sea from the east coast, there are as many as 600 such rivers on the west coast.

2.2.2.2. Groundwater

Based on large volume of hydro-geological and related data generated by Central Ground Water Board and State Ground Water Organizations and the existing knowledge of ground water regime, replenishable ground water resources in the country have been estimated as 432X106 ML.

In the alluvium plains of the Indo-Gangetic valley, ground water depths measure upto 450 meter. The coastal aquifers also have similar depth range of ground water availability. Inland river basins in the country have recorded shallower depth within the range of 100 - 150 m.

Static Ground Water resource also sometimes known as "fossil' water, considered as ground water available in the aquifer zones below the zone of water level fluctuation, available in the country has been assessed as 10,812X106 ML, on the basis of the depth of availability of ground water and the productivity of deeper aquifers. However as Per the National Water Policy, development of ground water resources is to be limited to utilization of replenish able component of naturally occurring ground water available in sub-surface domain.

Ground water is widely dispersed. It is an important source of water for drinking and irrigation. Ground water contributes 51 percent of the irrigation potential created in the country through more than 4 million dug wells, 5 million shallow tube wells and some ninety thousand public tube wells.

2.2.3. Crisis Situation

2.2.3.1. Water Stress

Water as a resource is under relentless pressure. Due to population growth, economic development, rapid urbanization, large-scale industrialization and environmental concerns water stress has emerged as a real threat.

The scarcity of water for human and ecosystem uses and the deteriorating water quality leads to "water stress" and intense socio-political pressures. Many areas in the country are already under severe water stress. Any addition to the intensity of water stress in the existing water scarcity areas, or addition of new areas to water stressed list, will only further push the problem in to the realm of a crisis situation.

If per capita water availability is any indication, water stress is only just beginning to show. The annual per capita availability of renewable freshwater in the country has fallen from around 5.177 ML in 1955 to 2.209 ML in 1991. Given the projected increase in population by the year 2025, the per capita availability is likely to drop to 1 .341 ML. If the availability falls below 1 ML, the situation is labeled as e water scarce zone.

Water scarcity occurs when the supply of water is unable to meet demand. Water resources and water use vary considerably across the country. A widely used measure of a nation's economic status is its gross national product per head of population. A similar index of the level of development of a nation's water resource and the stress places on them by the demand for water is the water used as a percentage of the available water resource.

Table 2.1 population & Per Capita Water Availability in India

Year	Population (in million)	Per Capita Water Availability (in cubic meters)
1951	361 M	5177
1955	395M	4732
1991	846M	2209
2001	1027M	1820
2025	1394 M (projected)	1341
2050	1640 M (projected)	1140

Source: www.freshwaterindia.org

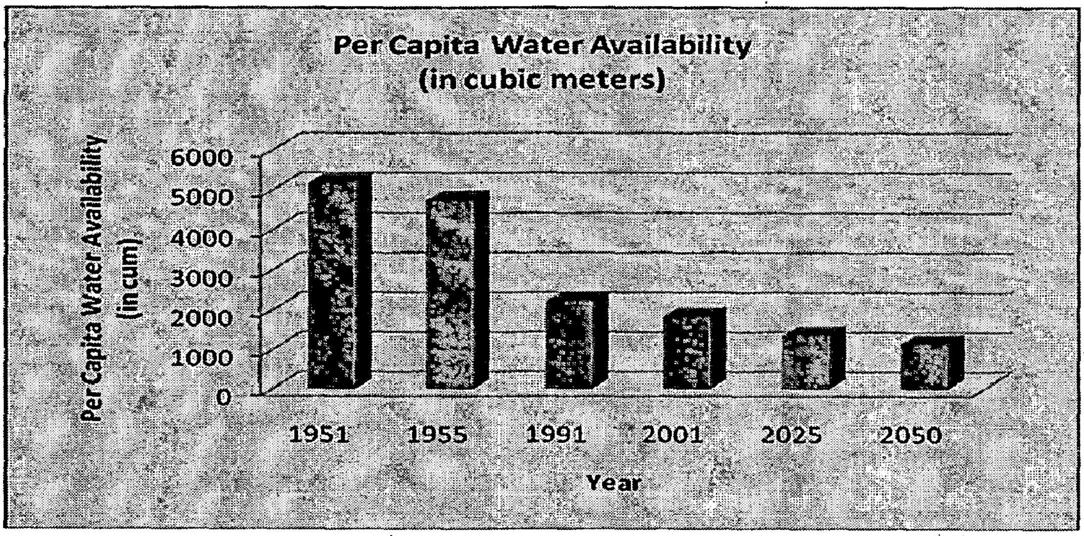

Figure 2.1 per Capita Water Availability

Source: www.freshwaterindia.org

2.2.3.2. Water Pollution

A serious degradation in the quality of groundwater and river water has occurred due to excessive and indiscriminate use of pesticides and chemical fertilizers in agriculture, as well as salinity resulting from overexploitation of groundwater. The deterioration of water quality is compounded by lack of proper effluent treatment for domestic wastewater and industrial wastes.

Streams and rivers are now being used as convenient places to dump wastes. When the world's population was small and industry and agriculture were primitive, this posed no problems. But conditions have changes as cities swell and industry and agriculture demands increase. Today water pollution comes from many different sources, often in large volumes. Some of it is in the forms of untreated sewage, industrial discharges, leakage from oil storage tanks, mine drainage and leaching from mine waste, and drainage from the residues of agricultural fertilizers and pesticides. Water pollution varies in severity from one region to the other depending on the density of urban development, agricultural and industrial practices and the presence or absence of systems for collecting and treating waste waters.

In most of the cities in the country untreated sewage finds its way into the nearest watercourse. Sewage requires to be adequately treated, so that the wastewater discharges from the treatment works reaches standards, which ensure a minimal impact on the receiving waters. Such systems allow the reuse of water in a number of river basins. Pollution can get locked away in river sediments and dumps of mine waste, which continue to haunt future generations. The release of heavy metals such as lead, mercury, silver and chromium which are highly toxic to aquatic life is one of such inherited problems. Some heavy metals are stored by fish and then passed on to humans through its consumption.

2.2.3.3. Losses

Much of the water abstracted from surface and groundwater sources for human activities is used very inefficiently. Losses also occur in the public water supply distribution systems particularly, where the water mains are old and are not well maintained. Leakage of 50 per cent or more of the water is not uncommon and there are losses due to illegal connections as well. There are also losses from the sewers, which carry away the wastewater, which can cause serious pollution problems.

Unfortunately, much of the water abstracted from surface and groundwater sources for human activities is used very inefficiently. In irrigation, for example, more than 60 per cent of the water seeps from the channels of the distribution systems and is lost by evaporation. To make matters worse, seepage causes water logging and salinization in irrigated lands, resulting in significant reductions in crop yield. Many industrial processes use water inefficiently and fail to make savings through techniques such as recycling.

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2.2.4. Management of Water

In India, from the 19th century onward the paradigm of managing water has followed two interconnected routes.

a) The state took upon itself the role of sole provider of water. It was the colonial state that centralized control over water resources.

b) The post-independent state inherited this role, and continued with it. Among other things, this led to communities and households being no longer the primary agents of water provision and management.

c) The earlier use of rainwater and floodwater declined. In its place, there came a growing reliance on surface water (primarily rivers) and groundwater.

Today, the effects of this way of managing water are clearly visible:

a) The level of extraction from rivers in most of India's river basins have degraded and the rivers are polluted.

b) Large dams are the major source of water storage, and canals are the major distributory route. The former have caused large-scale community displacement and ecological disorder. The latter, large-scale degradation of land via soil salivation.

c) Groundwater resources have been exploited.

Thus water availability, both in terms of quality and quantity, has declined to such an extent that many parts of India, rural and urban, today face a drought-like situation. And when drought actually sets in, as it did in Gujarat and other parts of the country in the year 2000, scarcity takes on a frightening visage.

2.2.5. Urban Water Scenario in India

Even though the rate of urbanization in India is among the lowest in the world, the nation has more than 250 million city-dwellers. Experts predict that this number will rise even further, and by 2020, about 50 per cent of India's population will be living in cities. This is going to put further pressure on the already strained centralized water supply systems of urban areas.

The urban water supply and sanitation sector in the country is suffering from inadequate levels of service, an increasing demand-supply gap, poor sanitary conditions and deteriorating financial and technical performance. According to Central Public Health Engineering Organization (CPHEEO) estimates, as on 31 March 2000, 88 per cent of urban population has access to a potable water supply. But this supply is highly erratic and unreliable. Transmission and distribution networks are old and poorly maintained, and generally of a poor quality. Consequently physical losses are typically high, ranging from 25 to over 50 per cent. Low pressures and intermittent supplies allow back siphoning, which results in contamination of water in the distribution network. Water is typically available for only 2-8 hours a day in most Indian cities. The situation is even worse in summer when water is available only for a few minutes, sometimes not at all.

According to a World Bank study, of the 27 Asian cities with populations of over 1,000,000, Chennai and Delhi are ranked as the worst performing metropolitan cities in terms of hours of water availability per day, while Mumbai is ranked as second worst performer and Calcutta fourth worst.

In most cities, centralized water supply systems depend on surface water sources like rivers and lakes. Chennai, for instance, has to bring in water from a distance of 200 km whereas Bangalore gets its water from the Cauvery river, which is 95 km away. Where surface water sources fail to meet the rising demand, groundwater reserves are being tapped, often to unsustainable levels.

Source: www.rainwaterharvesting.org

2.2.6. Water Resource Availability in Rajasthan

The State of Rajasthan is the second largest state in the country covering an area of 34.271 Million hectares, which is more than 10% of the total geographical area of the country. About 5% of the total population of the country resides in the State and it has more than 15.7 million hectares of land suitable for agriculture. The State of Rajasthan is one of the driest states of the country and the total surface water resources in the State are only about 1% of the total surface water resources of the country. The rivers of the state are rainfed and identified by 14 major basins divided into 59 sub-basins. The surface water resources in the state are mainly confined to south and south-eastern part of the State. There is a large area in Western part of the State, which does not have any defined drainage basin. Thus the water resources in the state are not only scarce but have highly uneven distribution both in time and space.

The ground water also plays an important role specially in agriculture and drinking water supply. The situation of ground water exploitation is also not satisfactory as in areas where surface irrigation is provided there is a tendency of not using ground water for agriculture, which creates problem of water table rise and even water, logging. On the contrary, in large areas of the State ground water is being over exploited and the water table in some areas is going down even at the rate of 3 metre per year.

Source: www.rainwaterharvesting.org

2.3. Planning for Water Supply

2.3.1. Demand for Water

In today's estimated demand for water, some 605,000 billion liters a year, agriculture takes more than 80 percent, mostly for irrigation. To meet the demand for water, humankind has been supplementing and reinforcing the hydrological cycle by constructing wells and boreholes, reservoirs, aqueducts, water supply systems, irrigation schemes, drainage systems and similar facilities. Government and public bodies spend large sums of money to develop and maintain these facilities. Excessive use of rivers, are causing downstream problems, of water quality and ecological stress.

Demand for water is rising and is estimated to have risen six to seven times from 1900 to 2001, more than the rate of population growth. It is rise, whish seems likely to accelerate in to the future, because the population is expected to reach 1.3 billion by the year 2025 and 1.6 billion by 2050. A tentative study indicates that total annual requirement of freshwater for various sectors in country will be about $1093X10^6$ MLby 2025 AD. This requirement by 2025 AD will be almost at par with exploitable water resource including both surface and ground water. Thereafter additional supply will be necessary of else scarcity conditions would prevail in majority of our river basins.

Table 2.2: Growing Demand for Water in India

Use	Demand for water(10^6MLD)		
	2000	2010	2025
Domestic	30	56	73
Irrigation	501	688	910
Industry	20	12	23
Energy	20	5	15
Other	34	52	72
Total	605	813	1093

Source: www.freshwaterindia.org

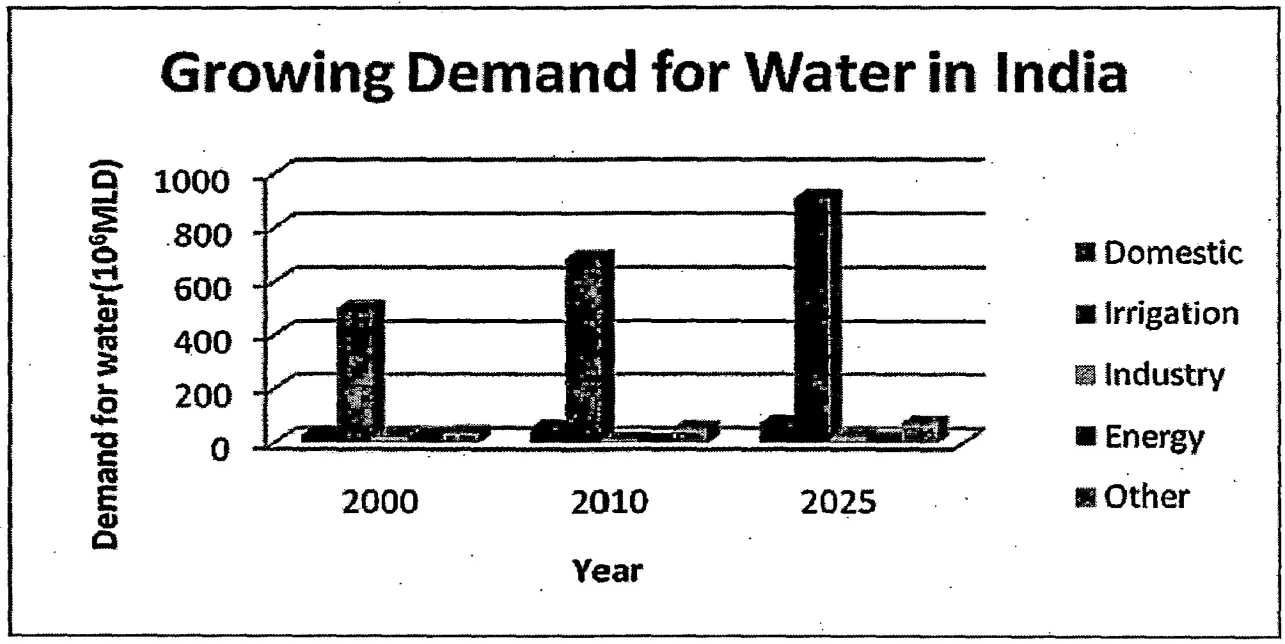


Figure 2.2: Growing Demand for Water in India

Source: www.freshwaterindia.org

2.4 Standards of Urban Services – By S. K. GARG

As per the report of the National Commission of Urbanization (NCU). At the new growth centers of the future. The existing urban settlement's which make a substantial contribution to national wealth, or cities and towns which are stagnating, one common strain is the total inadequacy of water supply, drainage, sewerage and housing. Under Article 47 of the Constitution, it is the duty of the state to improve the standards of living of the people and in particular, to improve the public health standards. (Water, sewerage and housing are three critical elements for life, without which there can be neither health for comfort."

According to NCU, "new norms have to be devised, with a per capita daily supply of between 80 to 100 liter's as an absolutely minimum level, and between 110 to 120 liter's on a slightly more desirable level. This is possible only if a minimum per capita daily supply of 170 liter's for domestic use is ensured on an equitable basis.

NCU'S recommendation, "use of sewage and sullage "after treatment, must be encrusted. It could be used for irrigation after full treatment, for other not – domestic uses. Recycling of waste water, even up to tertiary level, is at least less costly than drawing and treating raw water. "The by products of treatment- gas, measure and treated liquid should be sold commercially. This will make the treatment system self sufficient."

"The extension of sewerage system to cover all urban areas is clearly beyond our means. There are cheaper technologies of cheaper human waste available. The commission recommends setting up of a technology mission to look waste water recycling and human waste disposal, with a view to evolving affordable alternatives which can provide universal sanitation coverage in the near future.

The standards for water supply can be qualitative and quantative. The quantative standards are variable from place to place. India the average water consumption is kept as following table no. 2.3

Table 2.3 Average Domestic Water Consumption in Indian City

Use	Consumption in lpcd
Drinking	5
Cooking	5
Bathing	55
Washing of clothes	20
Washing of utensils	10
Washing and cleaning of house	10
Flushing of latrines	30
Total	135 lpcd

Source: water supply engineering by S.K. Garg.

But for an average Indian town, as per the Indian standards recommendations, the per capita demand may be taken as below table 2.4.

Table – 2.4 City Level per Capita Demand of Water (LPCD)

(i) Domestic use	135 LPCD
(ii) Industrial use	50 LPCD
(iii) Commercial use	20 LPCD
(iv) Civil or public use	10 LPCD
(v) Wastes thefts etc.	55 LPCD
Total	270 LPCD

Source: water supply engineering by S.K. Garg.

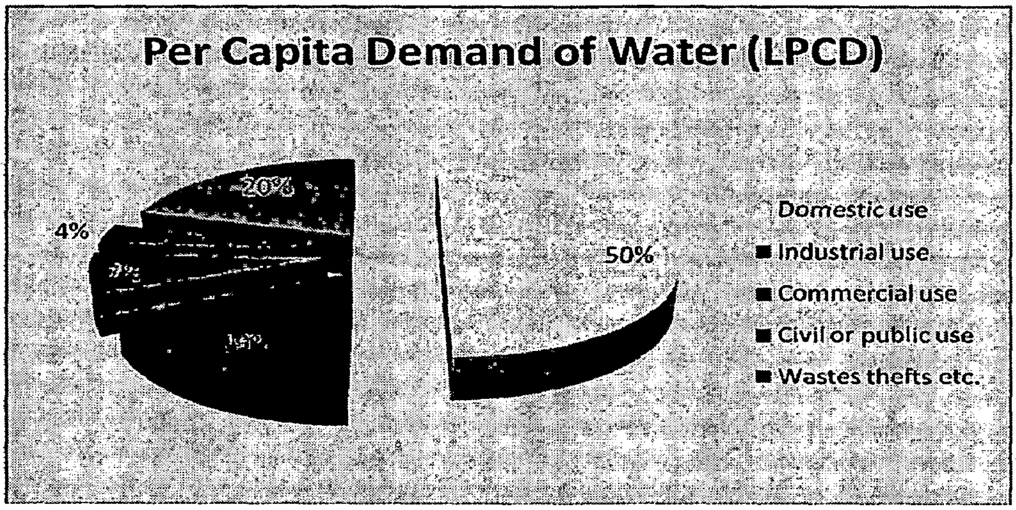


Figure 2.3 per capita demand of water (lpcd)

Source: water supply engineering by S.K. Garg.

Table – 2.5 Water Demand as per Population Size

Population of the town/city	Per capita demand (LPCD)
Less than 20,000	110
20,000 – 50,000	110 – 150
50,000 – 2 lakhs	150 – 180
2lakhs – 5 lakhs	180 – 210
5 lakhs – 10 lakhs	210 – 240
More than 10 lakhs	240 – 270

Sources: water supply engineering by S.K. Garg.

It is apparent from above table that as per the Indian Standards Udaipur city should have a supply of 180 – 210 LPCD.

Table – 2.6 Water Quality Standards for Public Water Supply

S.No.	Characteristics	Acceptable	Cause for rejection
1.	Turbidity (Units in J.T.U Scale)	2.5	10
2.	Colour(Units In Platinum Cobalt Scale)	5.0	25
3.	Taste and odour	unobjectionable	unobjectionable
4.	PH	7.0 to 8.5	6.5 to 9.3
5.	Total dissolved solids(mg/l)	500	1500
6.	Total Hardness(as CaCo3) (mg/l)	200	600
7.	*Chlorides (as cl (mg/l))	200	400
8.	*Sulphates (as SO4)	200	400
9.	**Fluorides (as F (mg/l))	1.0	1.5
10.	*Nitrates(NO3)	45	45
11.	Iron (as fat (mg/l))	0.1	45
12.	Manganese (as Mn) (mg/l)	0.05	1.0
13.	*Copper (as Cu) (mg/l)	0.05	0.5
14.	*Zinc (as Zn) (mg/l)	0.001	1.5
15.	Pherolic compounds (as Phenol (mg/l))	0.01	1.50
16.	Anionic	0.2	0.002
17.	Arsenic (as As) (mg/l)	0.05	1.0
18.	*Cadmium (as Cd) (mg/l)	0.01	0.005
19.	*Chromium (as Hexavalentcr) (mg/l)	0.05	0.01
20.	*Cyanides (as CN)	0.05	0.05
21.	*Lead (as pb) (mg/l)	0.1	0.05
22.	*Lead (as Pb) (mg/l)	0.01	0.1
23.	*mercury total (as Hg) (mg/l)	0.001	0.01
24.	*polynuclear aromatic hydrocarbons (PAH) (mg/l) 0.2	0.2	0.001
25.	Coliform count in water entering distribution system	Shall be nil in any sample of 100ml	0.2

*These characteristics cannot be corrected by conventional water treatment method.

2.4.1 Treatment Plants

Similarly the land requirement for sewage treatment plants also varies according to the population and the method adopted for it. The table shows that we can use an oxidation ditch for a population up to 100,000 the water stabilization pond can be used. The land that can farmed by the final disposal is also given in the table 2.7

Table – 2.7 Land Requirements for Water Treatment Plants (Unit Hectare)

design	Plan sedimentation & slow sand filters (Ha.)	Chemical treatment &rapid sand filters (Ha.)	Pumping Station at head works
10,000	0.80	0.40	0.20
50,000	1.75	0.60	0.25
100,000	N.A.	1.00	0.40
500,000	N.A.	3.50	0.70
1,000,000	N.A.	7.00	1.00

Table – 2.8 Land Requirements for Sewerage Treatment Plants (in Hectares)

Design population	Water stables oxidation pond	Averted lagoon	Oxygen ditches	Conventional waste treatment
10,000	6 – 7	1 – 1.5	0.5 – 1	1.00 – 1.25
50,000	12 – 15	2 – 3	N.A.	1.5 – 2.00
100,000	25 – 15	5 – 6	N.A.	2.5 – 3.00
500,000	N.A.	N.A.	N.A.	8.00 – 10.00
1,000,000	N.A.	N.A.	N.A.	16.00 – 20.00

Sources: Norms and standards for urban W/S and sewerage services by TCPO and ministry of works and housing, Government of India.

Besides the NCU recommendation, the government of India has various policies measures bearing on the subjects of urban services. The major progreammes as given below:

a) The minimum needs programme (MNP)
b) Integrated development of small and medium towns(IDSMT)
c) National Master Plan for Development of Water Supply and Sanitation

MNP emphasizes on raising social consumption level of the poor and the human resources development. The provision of free or subsidized services through public agencies expected to improve the consumption level of those living below poverty line and thereby improving the productive efficiency of both rural and hard workers.

2.5 Lakes Rejuvenation in Urban Areas: A Case of Ahmadabad

By-Harpreet Singh Brar

In this technical paper the author discusses the efforts done by Ahmedabad Urban Development Authority (AUDA) under the 'Vastrapur Lake Development Project', as a case study regarding the water bodies status in the city of Ahmedabad. Narrating the multifunctional role of water bodies the author points out that the continuous neglect of lakes over the period has resulted into their decline. The author presented the prevalent problems in the area, the efforts done by the authority and the current situation.

Vastrapur, part of south Ahmedabad has grown very fast in last decade. Huge development has mushroomed in this part of the city. The construction of high-rise apartments, numerous shopping malls have eaten away all the open spaces. The worst hit due to the uncontrolled expansion and construction was the Vastrapur Lake (earlier was a gram talav). Encroachment from all sides by slum dwellers blocked the natural drainage and stopped the storm water to enter the lake. Lake itself was slowly converted into the garbage-dumping yard. With the coming up of concrete everywhere, left no open space for ground water recharge. Water percolation became negligible in comparison to the huge withdrawal because of the increase in the population. During summers the area faces severe water stress. But last year's continuous 8 hours of good downpour left the Vastrapur flooded. Streets turned into small rivers and low areas as stagnant pool of water. The promises made by the authorities of diverting the rainwater to the lake, left the residents in disarray.

To rebuild these old lakes, identified by AUDA, was definitely a challenging job. Though the site of Vastrapur Lake was identified as a part of lake development project, but because of lack of any proper plan it was encroached by hutments (nearly 243 in number) along the Talav. The development work although started way back in 1999, but the removal of hutments was the major hurdle. So AUDA decided to split the work into two components:

i. Development project outside the area, and

ii. Development of the lake area itself.

The related development project outside the area included:

- Provision of sewer line in surrounding area.
- Laying of drainage lines to bring surrounding rainwater in lake.

- Removal of slums under the slum improvement scheme.
- Developing new linkages between AMC to lake area.

Development project within the lake area.

- Increasing the storage capacity of the lake.
- Consolidation of Lake Sign, architectural shape, land reclamation, etc.
- Development of public place, amusement park and public garden.

Conclusions

Planning ironically treats urban spaces and resources as percentage, and its citizens merely being numbers. Its now a time for urban planners, architects and engineers to expand their views from mere statistics, and need to make urban areas aesthetically and environmentally sound. Cities are to be planned and designed in such a manner that residents should spend their time in enjoying instead of spending their money in escaping it. Integrating these water bodies while planning for cities will help in tackling the nuisance of storm water. In this regard, rejuvenating the lost water bodies and lakes will not only improve the urban landscape, but more importantly will provide a place for social gathering and recreational places.

2.6 Water Responsive Approach for Urban Planning
By-Jagdish Singh

In this paper the author tried to come up with issues that are important for water responsive strategies and for strengthening any city planning process. In order to determine proper approach for proficient city planning, an in-depth study of water in all its use forms is mandatory. Various governments, semi-government organizations, and NGOs are working in this direction to devise water centered sustainable planning approach for better planning and functioning of the city. However, it is a gigantic task for any one department to procure data related to such an approach. Better opportunity for jobs and availability of modern infrastructure facilities leads to migration from rural to urban areas causing extra burden on city infrastructure leading to unplanned development of the city fringe areas. This tends to shift urban fringe boundaries into green belt of city or agriculture land. This presents a major threat to fresh supply of drinking water due to over exploitation and degradation. Additionally, unplanned and unauthorized constructions are the major cause for flooding during rains and garbage tends to get collected creating unhygienic conditions causing surface water pollution.

Every planned settlement need water free from pollutants, i.e., provision for pure and fresh water, disposal for rain water, conservation of water bodies, over flooding situation caused by rain water, meet out the demand of fresh water with pace of urban development and presently available water bodies, solid waste management options, sustainable planning for heritage areas and water responsive issues that has to be taken care of properly and issues related to this have to be determined to enhance the quality and availability of fresh ground water. Proper coordination amongst different departments and stakeholders related to these issues is mandatory for reducing pressure on storm water drains and for proper functioning in the form of procuring physical planning data related to enhancement of city planning for future need.

Rapid economic growth and transformation is one of basic causes behind over load on water. A wave of urbanization is the other cause. Conversion to modern spatial behavior and improvement of living standards also plays the role for it in the lagging behind regions. Need for excessive housing leads to demand for more urban land space result in decrease of space for water wetlands, forests, arable land surrounding areas and vegetable buffer zones. Excessive urbanization leads to environmental deterioration, water pollution and more frequent environmental disasters in the form of water logging or flooding. Urban regions faces pressure of continuing city expansion, hence integrated city planning and water management is needed. Thus a strong need for identifying deficiencies in present urban development and water management system is mandatory.

Chapter-3

CASE STUDY

[It is very important to make case studies before thinking off any kind of planning, designing or management solutions.

In the following chapter the author makes case studies about Jaipur and Bhopal tries to make inferences after analyzing the water resource conditions of these cities.

The cities have been selected on the basis of the similarity to the study area with respect to climate, topography and physical features.]

Case Study-1

3.1. JAIPUR, Rajasthan

3.1.1. Introduction

Jaipur is known as one of the first planned cities of India. It is the capital of the Rajasthan state .Until eighteenth century, Amber served as the capital and was ruled by the Kachwaha clan of the Rajputs. Sawai Jai Singh in 1727 decided to move his capital to the plains, 11 km south of Amber. The municipality was reorganized in 1926 and a new municipal act was enacted in 1929.

3.1.2 Location

Jaipur is situated in the eastern part of Rajasthan. It is bound in the north by Sikar and Alwar, in South by Tonk, Ajmer and Sawai Madhopur. Nagaur, Sikar and Ajmer in the west and in east by Bharatpur and Dausa districts (Figure 3.1).

3.1.3 Climate

Jaipur region falls under the semi-arid climatic zones. It is characterized by hot summers and cold winters. The month of May experiences the highest maximum temperature of 40.3°C and in January temperature goes as low as 7.8°C.

Average normal rainfall in Rajasthan is 531 mm. Jaipur receives relatively less rainfall compared to the average amount of rainfall received by entire Rajasthan. Normal annual rainfall received by Jaipur is 500 mm.

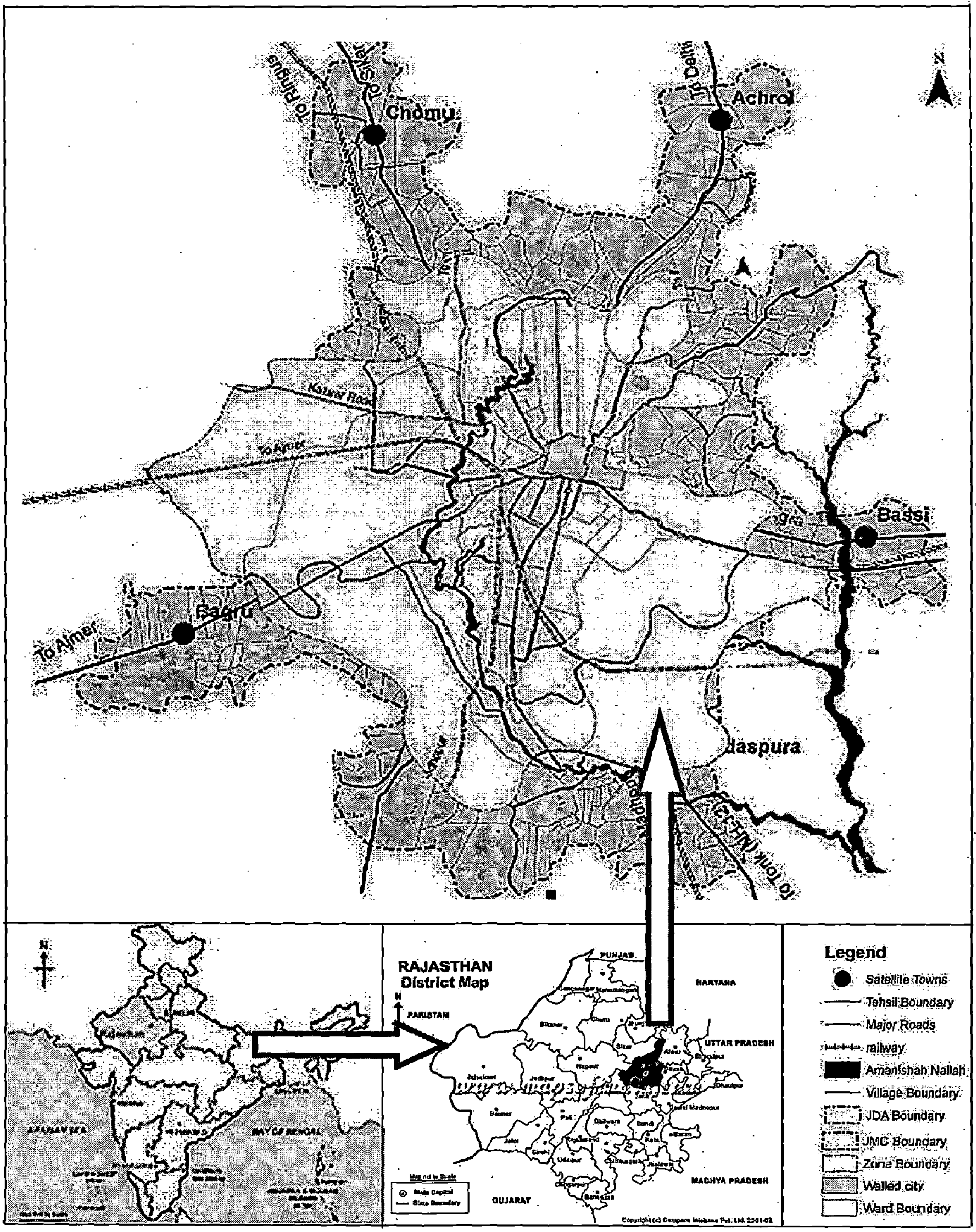


Figure 3.1: Location Map of Jaipur City

3.1.4. Demographic Trends

The Jaipur city/JDA area has an extent of 1464 Sq. Km (Table 3.1) and comprises the following spatial units (Figure 3.3 and Figure 3.4).

- The Jaipur Municipal Corporation (JMC) that includes the walled city and the rest of JMC.
- Rest of JDA area that includes the satellite towns and the villages.

The population of Jaipur city is 2.3 Million as per 2001 census and has shown a consistent increase in the past 50 years (Table 3.1). In fact, in the last decade, the population has increased by 8 lakhs(Table 3.2). The area of Jaipur Municipal Corporation has grown from 200 sq.km in 1981 to 218 sq. km in 1991 to 288 sq.km in 2001. The increase in area in 1991 was a result of addition of Sanganer and Amber tehsils and in 2001 due to the addition of Bagru, Bassi and Chomu tehsils in the municipal area. The area under the jurisdiction of JDA has remained same since 1991.

Table 3.1: Population Growth -Jaipur city 1951-2001

Year	Population (in million)
1951	0.3
1961	0.41
1971	0.64
1981	1.02
1991	1.52
2001	2.32

Source: Census of India- 1991 and 2001.

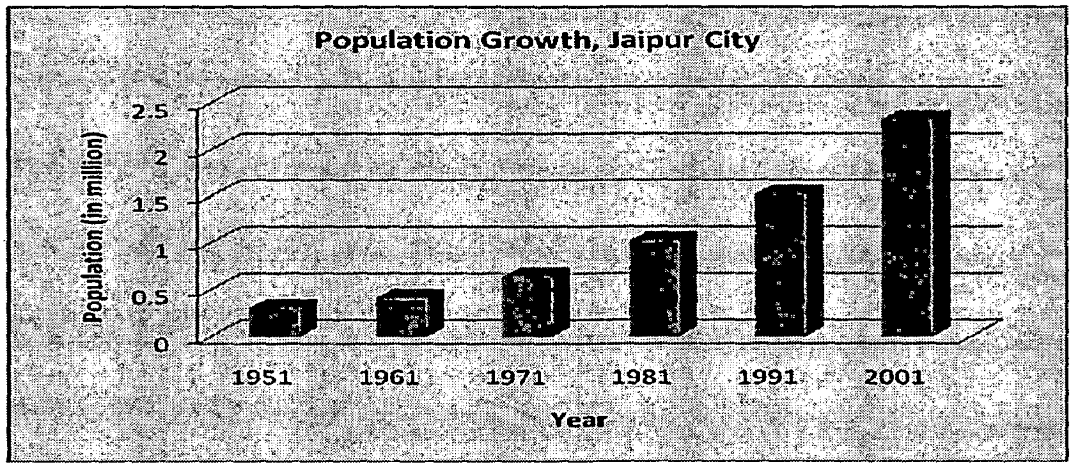


Figure 3.2: Population Growth -Jaipur city 1951-2001

Source: Census of India- 1991 and 2001.

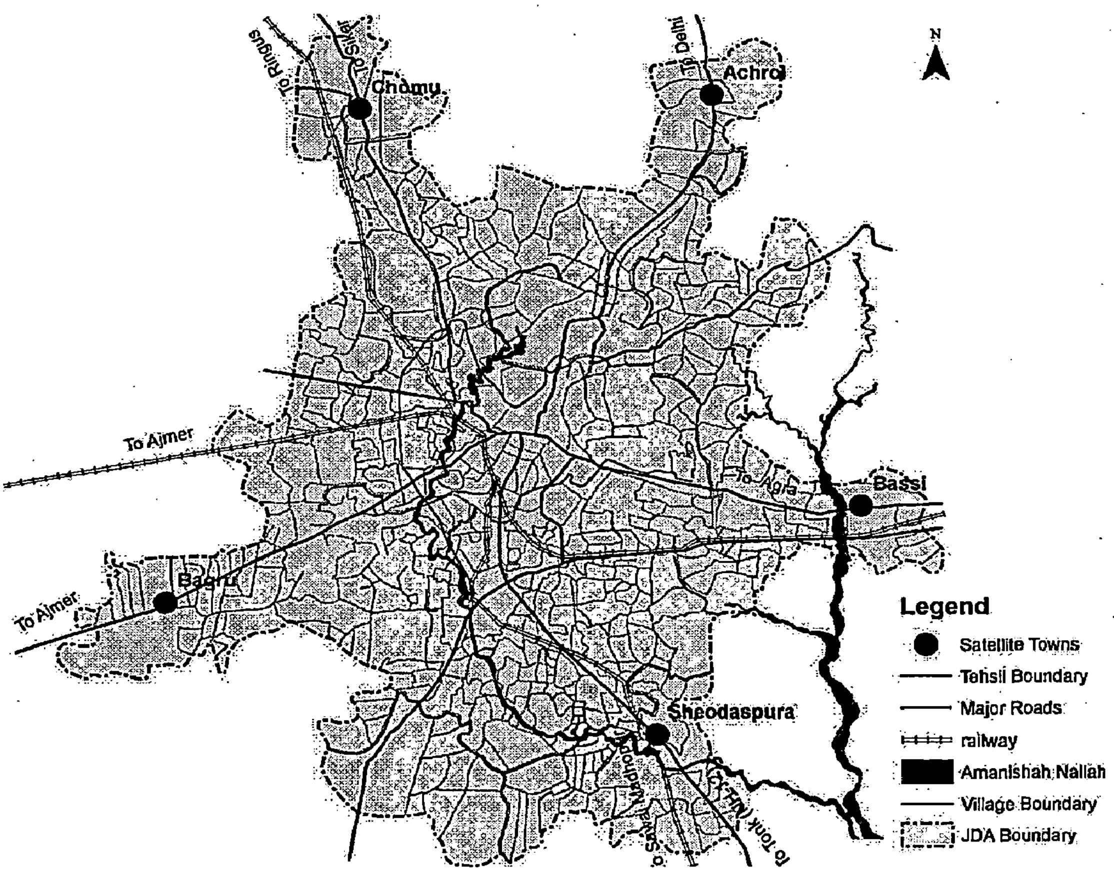


Figure 3.3: Jaipur Region

Source: CDP-Jaipur city under JNNURM Ministry of Urban Development

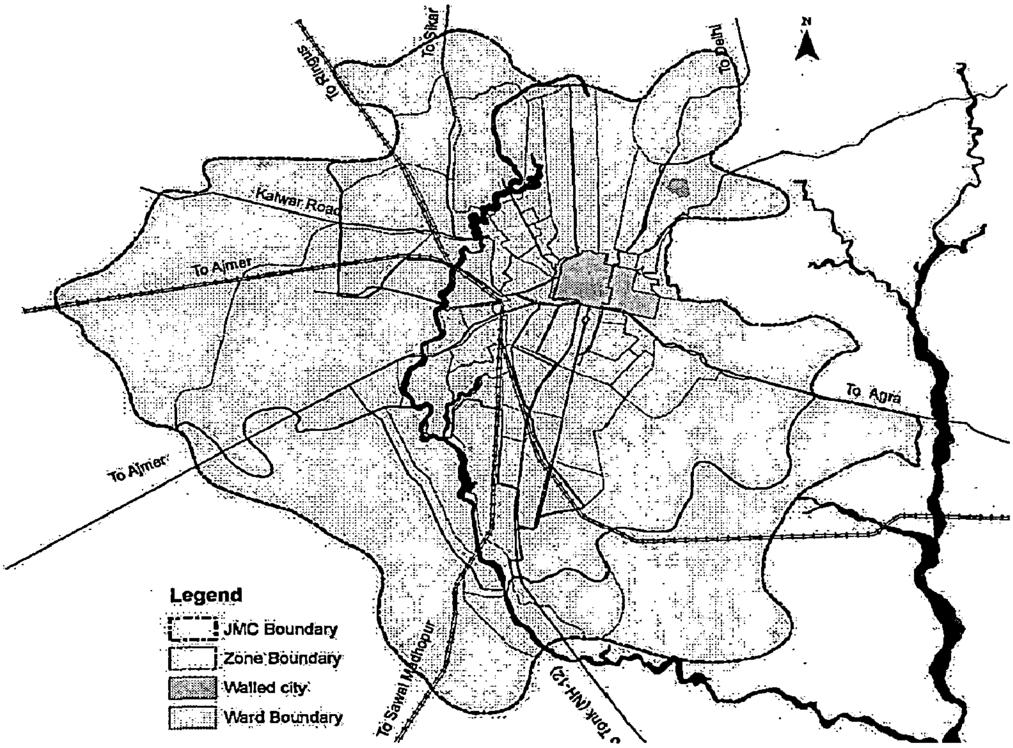


Figure 3.4: Planning Boundary Jaipur Municipal Corporation

Source: CDP-Jaipur city under JNNURM Ministry of Urban Development

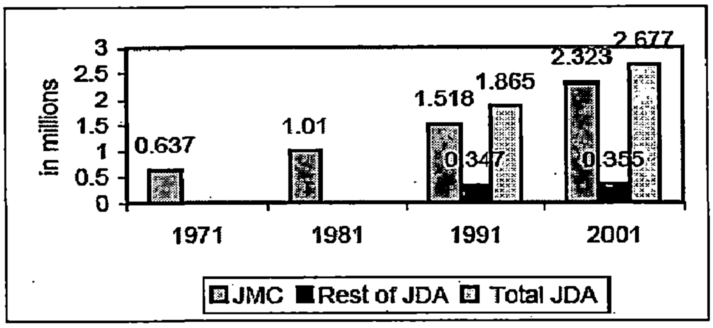
Table 3.2: Area and Population-Jaipur Region (2001)

S. No.	Area	Total Area (sq. km.)		Total Population (Million)		% JDA Population	
		1991	2001	1991	2001	1991	2001
1.	JMC	218.3	288.4	1.52	2.32	81.4	86.8
1.a.	Walled City	6.7	6.7	0.5	0.4	26.4	15.0
1.b.	Rest of JMC	192.3	281.7	1.02	1.92	54.7	71.8
2.	Rest of JDA	1220	1149.9	0.35	0.36	18.6	13.2
3.	Total JDA	1464	1464	1.87	2.68	100	100

Source: Census of India- 1991 and 2001.

In terms of share, 87% of the total population lives in the JMC area, of which 7% lives in the walled city. While the proportion of population living within the JMC has increased (primarily due to expansion in area), the proportion of population in the walled city has declined. This can be regarded as positive phenomena as the walled city is already very densely populated. The Walled City has a spatial extent of only 6.7 sq.km but houses nearly four lakh people. The 2001census shows that the population of the

Walled City has declined from 1991. The reason for this is out movement of inhabitants from the area to new residential colonies being developed in the periphery in want of better living environment.



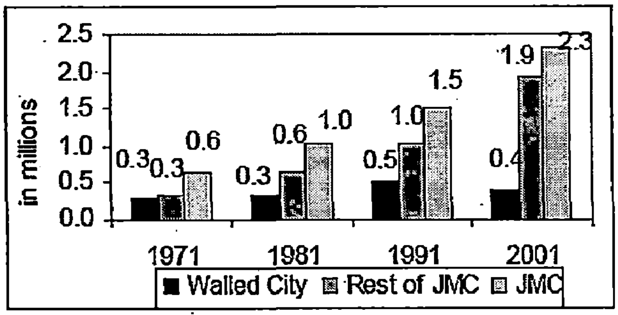


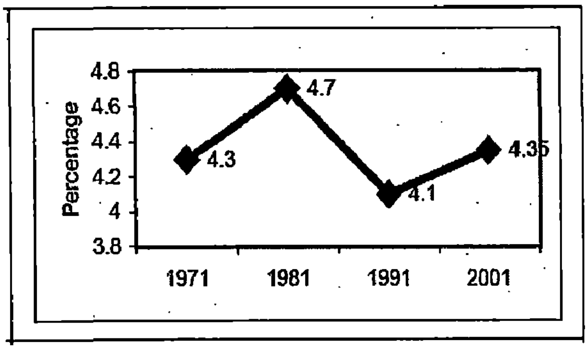
Figure 3.5: Population- JDA Area

Figure 3.6: Population JMC Area

Source: CDP-Jaipur city under JNNURM Ministry of Urban Development

3.1.4.1. Population Growth Rate:

The population of Jaipur city was only 0.3 millions in 1951 (Figure 3.2) but in 2001 it has reached 2.3 Million. The annual average growth rate from 1971 to 2001 has been in the range of 4.1 to 4.7.The population growth rate was the highest in the year 1981 but declined sharply by 0.6 %in 1991 and in grew again by 0.2 % in 2001(Figure 3.8).



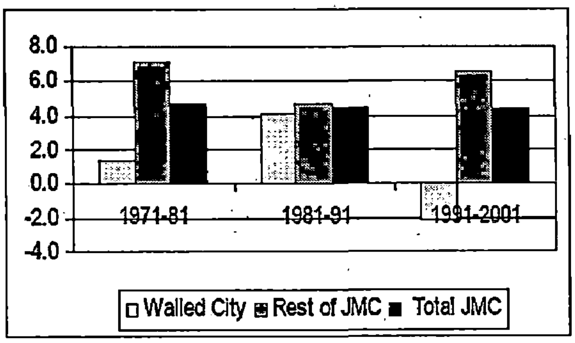


Figure 3.7: Population Growth Rate

Figure 3.8: Population Growth Rate- JMC Constituents

Source: CDP-Jaipur city under JNNURM Ministry of Urban Development

Within the JMC, the major growth has occurred outside the walled city area. The population growth within the walled city was nearly equal to that of the rest of the JMC area between1981-91.

However, between 1991-2001, the walled city has witnessed a decline in population (Fig: 3.8). On the contrary, the population growth rate in JMC area has increased partly due to migration and also due to expansion in the JMC area.

3.1.4.2. Population Density:

The walled city has the highest population density in the city at 58207 persons/sq km. This is despite the fact that the density has declined from 1991 (74,000 persons per sq.km). The population density of JMC is higher in 2001 than 1991 and has increased by nearly 3000 persons sq. km in spite of expansion of municipal boundary (Figure 3.9). Figure 3.10 shows the population density of the Walled City, the JMC area and the JDA areas. It is evident that the JDA has the lowest density with JMC at the second place and the walled city with maximum concentration of population.

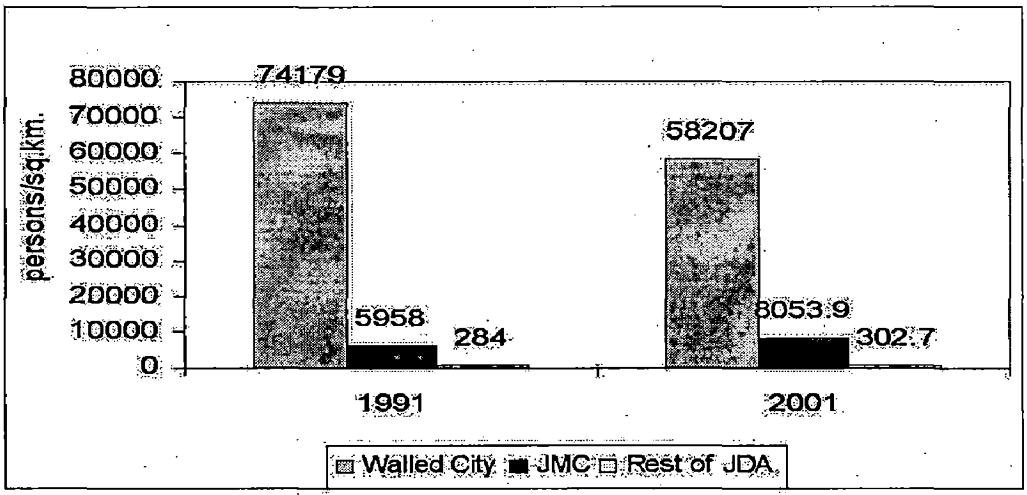


Figure 3.9: Population Density

Source: CDP-Jaipur city under JNNURM Ministry of Urban Development

The densities in the JMC area range from 100 PPH nearly 1000 PPH. However, the density is high only in the walled city. In the rest of JMC area, the densities range from 100 PPH to 550 PPH (Fig.3.10)

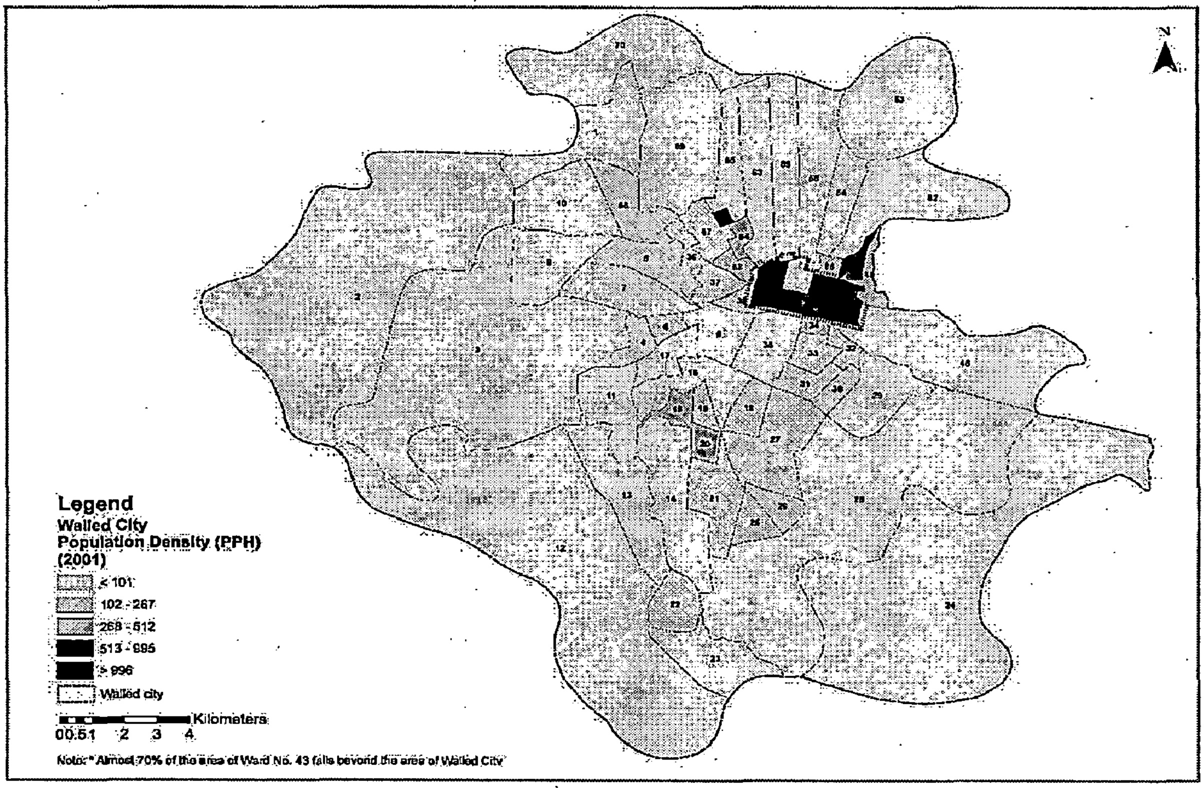


Figure 3.10: Density of Population 2001-JMC Area

Source: CDP-Jaipur city under JNNURM Ministry of Urban Development

The population density in Walled City has also been analysed. Figure 3.11 shows that wards 45, 46 and 56 have relatively higher density of population (more than 12 PPH) than others.

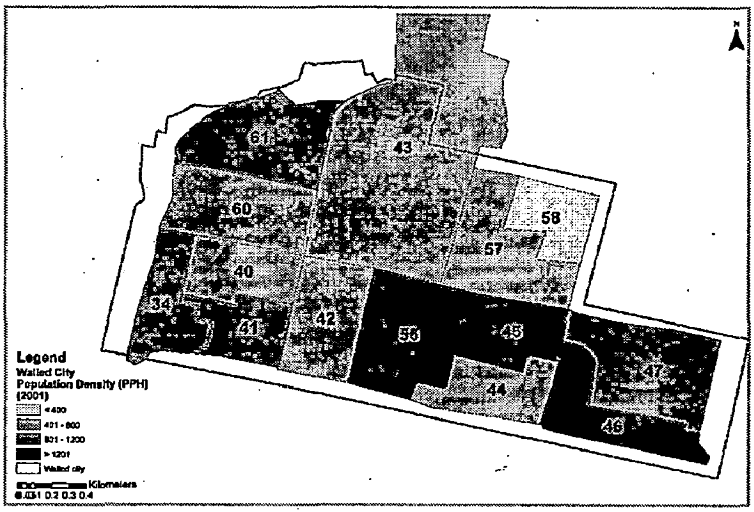


Figure 3.11: Density of Population 2001-Walled City Area

Source: CDP-Jaipur city under JNNURM Ministry of Urban Development

3.1.4.3. Population Projections

The population projections for Jaipur have been done by various agencies. Table 3.3 gives the two estimates. It is estimated that the total population of Jaipur would be around 48 lakhs in 2021. The same estimates have been taken up for estimating infrastructure requirements (water supply, housing and sanitation) and gaps.

Table 3.3: Population Projections (Lakhs) 2021

Year	Estimate - I	Estimate - II
2001	23.23	23.23
2011	35.6	33.96
2021	47.99	49.6

NOTE: Estimate – 1 SAFAGE "Jaipur Water Supply and sanitation Project Feasibility Study; Water Demand' Population, Urban Development, water demand of Jaipur city; Draft final report; Appendix I, Vol I of 2,july 1998" Estimate – 2 Wilbur Smith Associates" Mass Transport Options and Recommendations for Jaipur City – 2005".

3.1.5 Urban Environment

3.1.5.1. Water Resources:

(a) Surface Water Resources

Most of the surface water sources originate from the nearby hills acting as mere drainage channels for rainwater. The region is drained by a number of seasonal rivers of which Banganga, Dhund and Bandi are prominent. There is no perennial surface water source in the city. Amanishah Nallah and Dhund River are two non-perennial streams which flow from north to south. The former passes through Jaipur city while the latter flows on the east of the city and are joined by Amanishah Nallah in southeast of the city.

Figure 3.12: View of Mansagar Lake

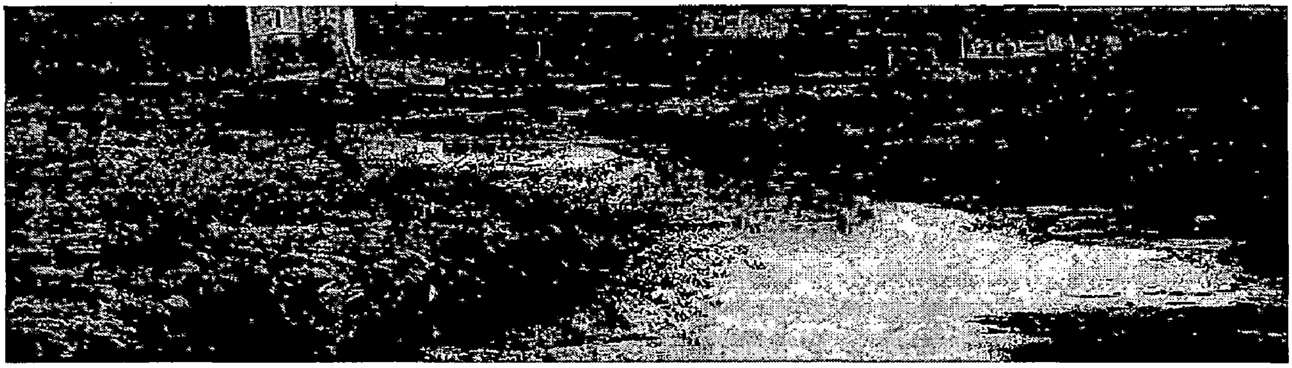


Figure 3.13: One of the Natural Drainage Channels Flowing Through the City

Among the large surface water bodies is Jal Mahal Lake or Mansagar Lake in the north of the city. It is approximately 130 ha in its full spread and has a catchment area of 23.5 sq.km. Approximately, 40% of the total catchment area falls inside dense urban area. A small drainage system in the north foothills which fills up the artificially impounded lake Jal Mahal (Man Sagar). The lake is used for the disposal of sewage. Other historic water bodies the Talkatora Lake in the walled city and the Ramgarh lake have dried up due to urbanization in their catchment areas. The Ramgarh Lake, which used to be the main source of supply more than for 30 years is unable to supply adequate water / to fulfill the demand today.

(b) Ground water Resources

In the absence of perennial surface water sources, major part of the recharge to the ground water in Rajasthan is through infiltration from rainfall. Which is also scare and thus the scope for recharge reduces considerably. This adds to the existing problem of over drawing of ground water. The major source of water supply is only the ground water and approx 92% of the population of Jaipur depends on ground water for meeting their needs.

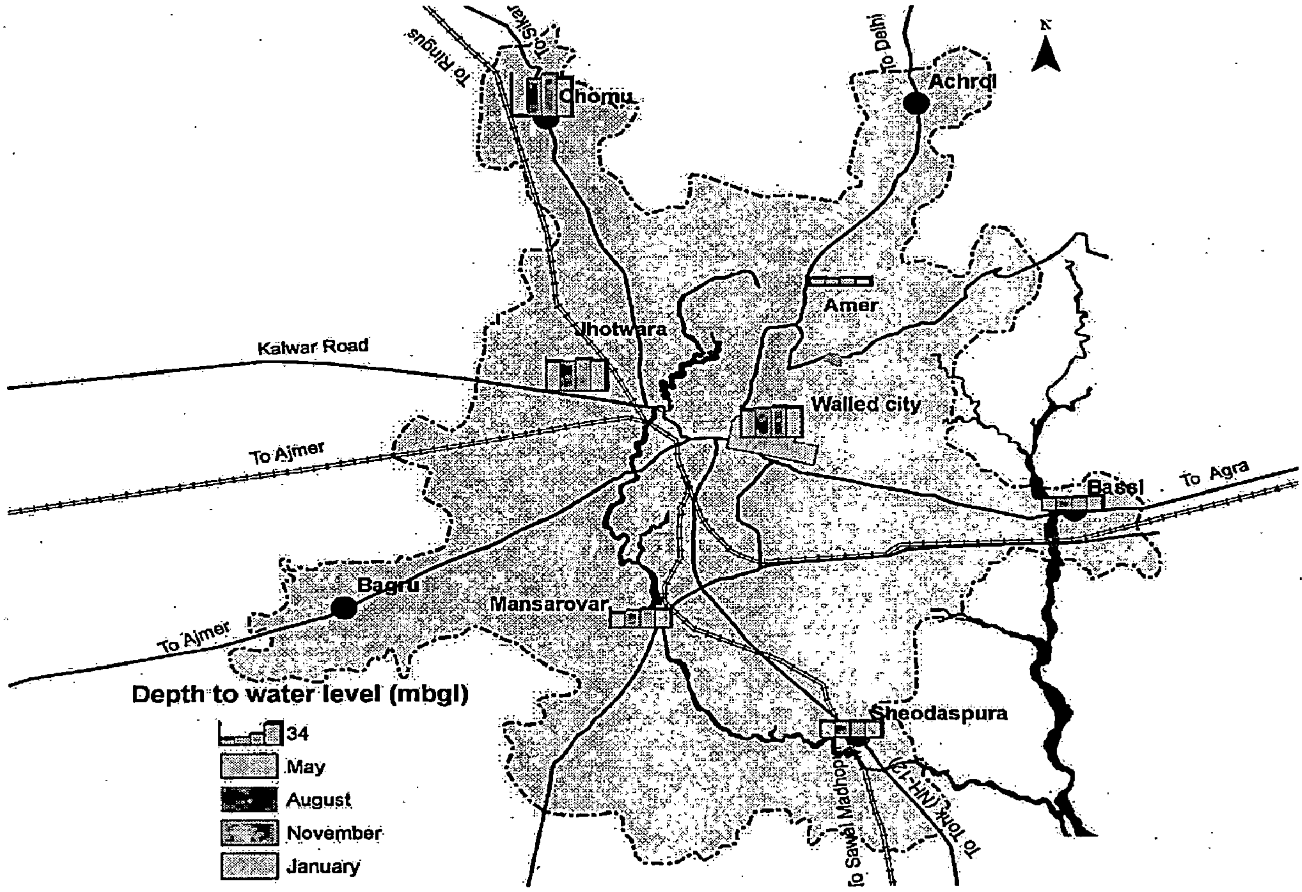


Figure 3.14: Variation in ground water levels across Jaipur city

Source: Ground Water Year Book 2002-2003, Rajasthan

Ground water is the available at the deepest level in the walled city and Jhotwara industrial area (table 3.4). This could be attributed to the high population density in the walled city and it being heavily dependent on ground water. Large amounts of water get drawn everyday. Jhotwara Industrial area also faces the same problem of groundwater being available at great depth. In this case Amber is positioned very well with the water depth going upto 10-11m. Jaipur would have to depend on surface water resources to meet its future water need.

Table 3.4: Depth of Water level in Jaipur Region

Location	Depth to water level (mbgl)			
	May 2002	August 2002	November 2002	January 2002
Amber	10.96	10.50	11.27	10.60
Chomu	-	61.23	67.60	67.60
Walled city	42.7	46.16	48	47.25
Jhotwara	47.30	47.0	52.57	47.90
Mansarovar	24.55	28.75	30.15	29.55
Sheodaspura	25.02	25.21	24.96	25.18

Source: Ground Water Year Book 2002-2003, Rajasthan

Note: mbgl= Meter Below Ground Level

3.1.5.2. Water Quality

(a) Surface Water Quality

Among the surface water resources, the nallahs and Mansagar Lake are in degraded state. The Man Sagar Lake is heavily polluted at present with the city sewage flowing into it through two nallahs, Brahmapuri and Nagtalai.

Other natural drainage channels in the city, the Amanisha Nallah and the Ganda Nallah like the other nallahs have become carriers of raw sewage and refuse. Most of the nallahs are used by slum dwellers to dispose garbage.

Physio-chemical examination of water of the lake shows that water quality has exceeded permissible levels for most parameters. Table 3.4 shows the physio-chemical examination of Manasagar lake water.

Table 3.5: Physico-Chemical Examination of Surface Water, 2000

Particulars	Brahmpuri Nala	Nagtalai Nala	Nala (Amber Rd)	Lake (South of Jal Mahal)	Lake (Centre of water body)	CPCB Standard
PH	8	8	8	8.3	8	6.5–8.5
B.O.D	130	85	40	35	60	<3
C.O.D	462.88	252.48	126.24	126.24	231.44	<0.5
Chloride	340	380	460	540	390	
Sulphate	28	38	130	60	35	
Phosphate	21.5	10.75	7	14	5.25	<0.03
Nitrate	44	24	30	23	36	<0.3
TDS	1160	1760	1920	2000	1840	<400
Total suspended solids	560	490	180	-	-	-
Turbidity	80	34	14	-	-	-

Source: Jal Mahal Tourism Infrastructure Project, LASA,

Surface water quality is also affected due by the industrial processes in and around Jaipur. The visible impact and effects of the direct discharge of industrial wastewater to the storm water drainage systems and to the Nallahs is unsightly and malodorous conditions in the drains, conditions which encourage insect breeding, particularly mosquitoes, creating health risks and increased spending on health care, damage to the surface of roads when spilling of the waste water occurs due to blockage of the drains by garbage and other rubbish, health risks associated with downstream use of the waste water flows for domestic purposes or for agriculture and increased risk of pollution of ground water by direct seepage to the aquifer.

(b) Ground Water Quality

The spread of septic tanks in Jaipur is often cited as a reason for the high concentration of Nitrates in the ground water. The wastewater from the soak pits leaches into the ground contaminating. Among the areas where ground water nitrate levels have been found to exceed permissible limits are Madrampura, Civil, Hawasarak, Civil Line, Shanti Nagar, Hasanpura, Shyam Nagar, and Jyoti nagar, Adarsh Nagar, Bani Park. The nitrate levels in these areas range between 118 mg/l and 308 mg/l. Understanding of trend of contamination of ground water is of utmost concern since nearly 92% of the population depends on ground water for meeting their potable water needs.

3.1.6. Existing Condition of the Water Supply system

3.1.6.1. Present status of demand and production:

The present water supply of the city comes under the Public Health and Engineering Department (PHED), Jaipur. The supply is presented in table 3.6.

Table 3.6: Salient feature of the water supply system of Jaipur city

Total supply of water	348.32 MLD
Population served	23 Lakh
Treatment capacity	54.00 MLD
Per capita supply (Gross)	150 lpcd

Source: Pre- feasibility report, RUIDO, March-1998

Of the total present population of 27.52 lakh, only 86% comes. The rest 14% meets its demand form private source. Further, there is no organized water supply in the outlying district of the city. Where the population is growing fast as the city core has reached its saturation.

The water available for the use of citizens is primarily ground water. the surface water source of the city is insufficient to meet the requisite demand, providing only 10.45 MLD. The city lacks the treatment facilities also, being capable of treating only 54 MLD of water at the treatment plant located at laxman doongri. The rest of the 294.32 MLD water is supplied without treatment and in some cases only after chlorination. the details of water treatment is presented in table 3.7.

Table 3.7: Source & Treatment Details

Surface water source	10.45 MLD
Ground water source	337.87 MLD
Treatment capacity	54.00 MLD

Source: Pre- feasibility report, RUIDO, March-1998

The water available to city in not utilized to its full capacity. The net water available to the city is only 58% of the total supply. It has been observed that 42% of the water is wasted due to leakage owing to faulty transmission and distribution system. The per capita supply is 88 lpcd as against the gross supply of 150 lpcd. The current pattern of water supply is presented in table 3.8

Table 3.8: Current pattern of water usages in Jaipur city

Total supplied water	348.32 MLD
Losses	146.29 MLD
Net supply	202.03 MLD

Source: Pre- feasibility report, RUIDO, March-1998

In Jaipur 1340 tube wells scattered over various parts of the city, are responsible for the bulk of the total production (348 mld). In addition, there are about 1845 hand pumps installed at various locations, which help in meeting the demand of the weaker sections of the society. Details relating to locations of a large number of tube wells, Clear Water and Overhead Reservoirs and their capacities, Hand pumps and productions in over all city are enclosed in Table 3.9

Table 3.9: Source of Water Supply in Jaipur city

S.No.	Service Heads	Levels
	Storage & Distribution Details	
1.	Ground Level Storage Reservoirs (ML)	
a.	Nos.	64
b.	Total Capacity	100ML
2.	Elevated Storage Reservoirs (ML)	
a.	Nos.	78
b.	Total Capacity	50ML
3.	Total Storage Capacity (ML)	150ML
4.	Distribution System (km)	
a.	Transmission Mains	23.74 km
b.	Distribution Mains	2616.28 km
c.	Total Length	2847.02 km
5.	Connection Details	
a.	Metered	
i	Domestic/ Residential	210535 nos
ii	Non Domestic/ Commercial	35872
iii	Industrial	1584
b.	Unmetered	
i	Domestic/ Residential	5194
ii	Non Domestic/ Commercial	0
iii	Industrial	0
6.	Stand posts	1170
7.	Hand pumps	1845
8.	Tube wells	1340

Source: Pre- feasibility report, RUIDO, March-1998

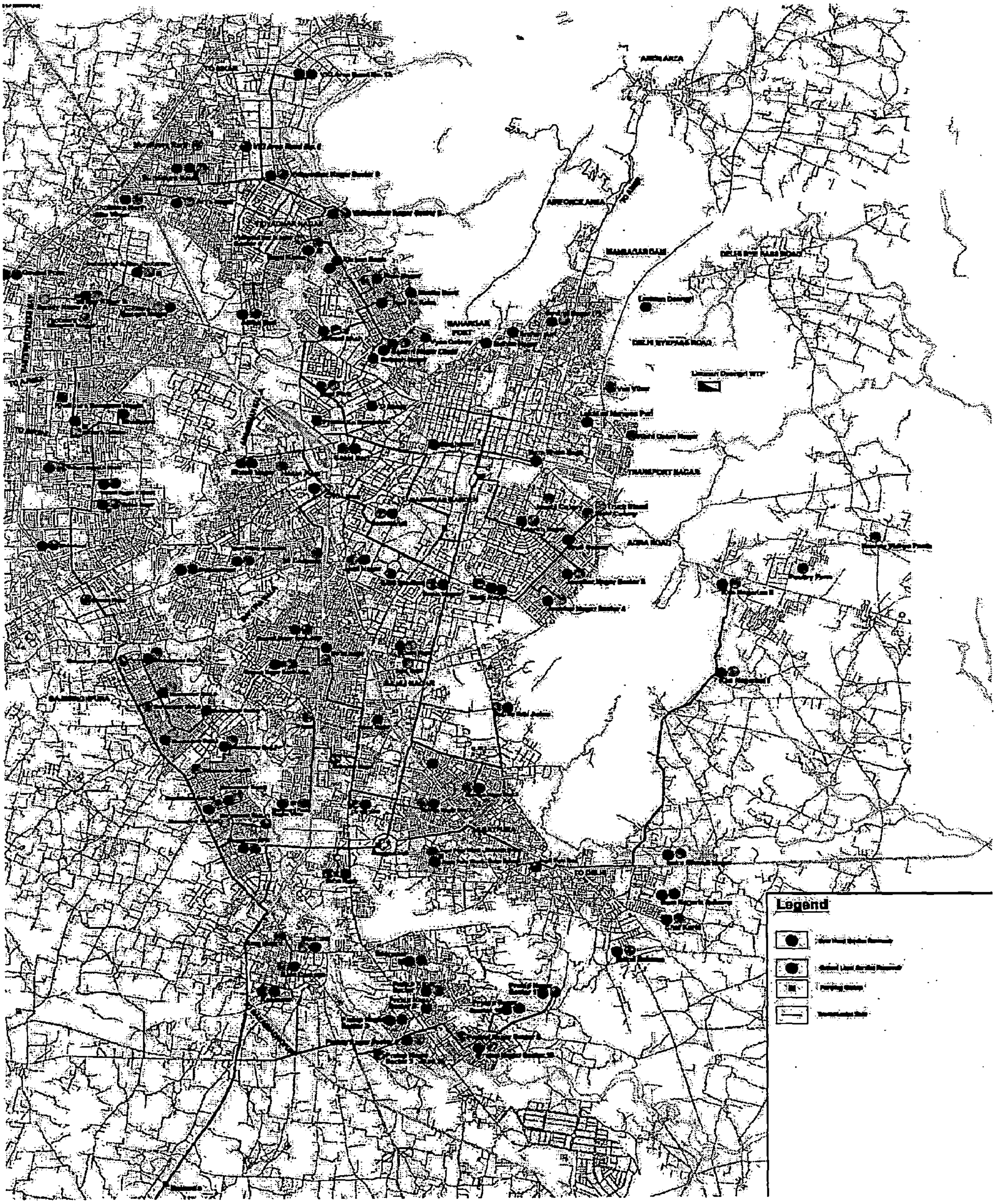


Figure 3.15: Location of Reservoirs and Pumping Station in Jaipur City

Source: Pre- feasibility report, RUIDO, March-1998

3.1.6.2. Extent of coverage:

In 2005, the entire population was not dependant upon Public Health and Engineering Department (PHED) water supply. According to PHED estimates, about 23 lakhs population was being served by PHED water supply system, the rest 3.72 lakhs population was served through other systems developed and maintained by housing cooperative societies or from own sources. Thus in 2005, about 86% population was under PHED supply system.

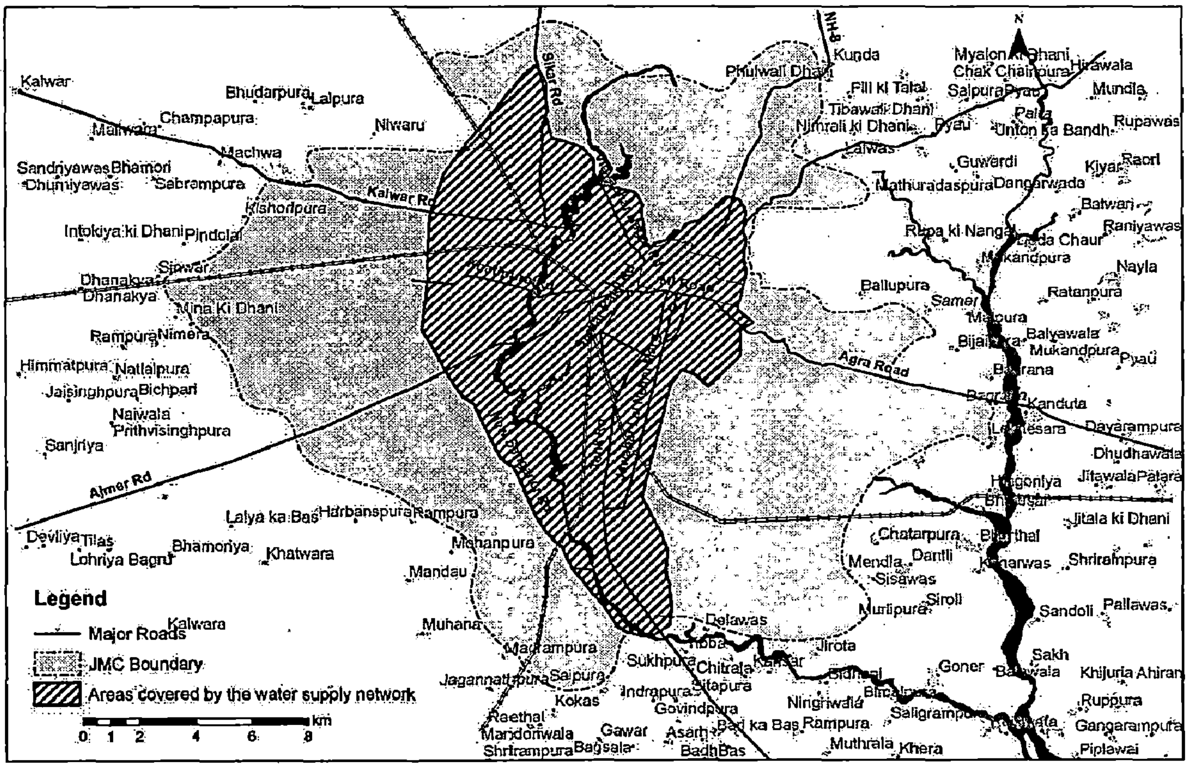


Figure 3.16: Coverage of city by water supply network Access to Sewerage and Sanitation Facilities

Source: Pre- feasibility report, RUIDO, March-1998

3.1.6.3 Water related issues:

a) The city totally dependent on ground water with negligible dependence on surface water.

b) The city lacks treatment facility and capacity to treat only 54 MLD of total demand of 350 MLD.

c) The supply losses are high thus reducing the net supply to 58%. Presently 26% of the city does not have piped water connection leaving-15% population unserved.

d) Out of the rest of the 85% of the population, 35% receives less than 100 lpcd of water.

e) The ground water level is falling at the rate of 1 mt/year.

3.1.7. Future Demand:

The city is facing a very critical situation as regards the water supply is correct. The present master plan i.e. master plan -2011 has estimated the future demand is presented in table 3.9

Table 3.10: future demand for Jaipur city

Year	Population in lakhs	Demand in MLD	Local water supply in MLD	Net water demand for Jaipur MLD	Demand for rural areas MLD	Total net demand MLD
2011	32.09	642.7	205.0	437.70	4.80	442.50
2021	46.82	981.0	197.0	784.0	6.2	790.2
2031	68.33	1450.0	180.0	1280.0	60.0	1340.0

Source: Pre- feasibility report, RUIDO, March-1998

The water demand has been adopted at the rate of 180 lpcd in the beginning. Which will increase to 215 lpcd in year 2021 and 2031. The water requirement shall be met through the Bislpur dam project.

3.1.8. Environment Issues

3.1.8.1. Water Pollution

Water resources in the city are polluted due to disposal of sewerage directly into the surface drains or surface water bodies. Ground water contamination is essentially due to large no of septic tanks in use in the city, leakage and overflowing of sewerage pipelines, mixing of water and sewerage due to faulty lines as happens frequently in walled city etc.

3.1.8.2. Depletion of water sources

In early stage, the city expansion was restricted to foothills of the Aravalli ranges and no drainage system was disturbed. But as the expansion took place, people started filling diverting and blocking the stream. At many places, the natural streams were used to dump the garbage. As a result, 150 streams out of which 113 first order 37 second order and 10 are of third order stream are blocked or filled for the construction purpose due to expansion of Jaipur city. It has direct bearing on the availability of surface as well as ground water.

The Jaipur water supply system is predominantly dependant on ground water. Ground water extraction rate is more than the recharge rate owing to low rainfall and absence of perennial rivers. On an average, 347 million litres per day of ground water is extracted. It is estimated that at the present rate of extraction, ground water will not be available for extraction after 2008.

3.1.9. Strategies for Improvement of Water Resource

Based on the identified issues strategies have been formulated to improve water resource of the city. Table 3.10 identifies the strategies to be taken and the likely projects as part of these strategies to improve Water resource quality.

Table 3.11: Strategies and projects to improve water resource of the city

S.No.	Issues	Strategies for environment improvement	Projects
1.	Loss of traditional water systems	Promotion of rain water harvesting	Incorporation of rain water harvesting in building bylaws
2.	Depletion of ground water	Restoration of catchment areas of natural water bodies and Nallahs	Afforestation programs along Nallahs, water bodies
3.	Degraded water quality	Upgrading /improving infrastructure	Replacement of water pipelines In walled city
4.	Contamination of piped water with sewerage		

Source: CDP-Jaipur city under JNNURM Ministry of Urban Development

3.1.10. Conclusion

The city has adequate water supply with an availability corresponding to 126.5 lpcd covering more than 86.5% population. The net water supply gets reduced to 82 lpcd. The main source of water is ground water, which is fast depleting (at the rate of 1m/annum) as a result of growing population pressure. The water quality is also deteriorating due to disposal of sewerage using soak-pits.

Another major problem is operation and maintenance .The operation and maintenance expenditure of old age system is very high due to leakages and wastage and unauthorized pumping of water from service mains.

Case Study-2

3.2. City of Lakes - Bhopal, Madhya Pradesh

3.2.1 Introduction

Bhopal is a city in central India. It is the capital of the Indian state of Madhya Pradesh and the administrative headquarters of Bhopal District and Bhopal Division. Bhopal is the second largest city in Madhya Pradesh after Indore. Bhopal is known as the *City of Lakes* as its landscape is dotted with a number of natural as well as man made lakes.

3.2.2. Location

Bhopal has an average elevation of 499 meters (1637 feet).The city of Bhopal is situated on a series of rolling hills and valleys interspersed in between. The north-eastern, eastern and south- eastern edges of the Upper Lake and the entire Catchment of the Lower Lake is characterized by rolling hills. The western, southern and the north-western parts of the Upper Lake are relatively flat.

3.2.3. Climate

The area has a dry climate except during the south west monsoon season. The period from March to mid June is the summer season with a mean daily max. temperature of 40.7° C, and mean daily min. temperature 26° C. Coldest month with a mean daily max. Temperature of 25.7° C and the mean daily minimum temperature of 10.4°C.

The monsoon season is effective from June to September. The average annual rainfall for past 21 years is 1179.16 mm. About 92% of the annual rainfall is received during the monsoon months.

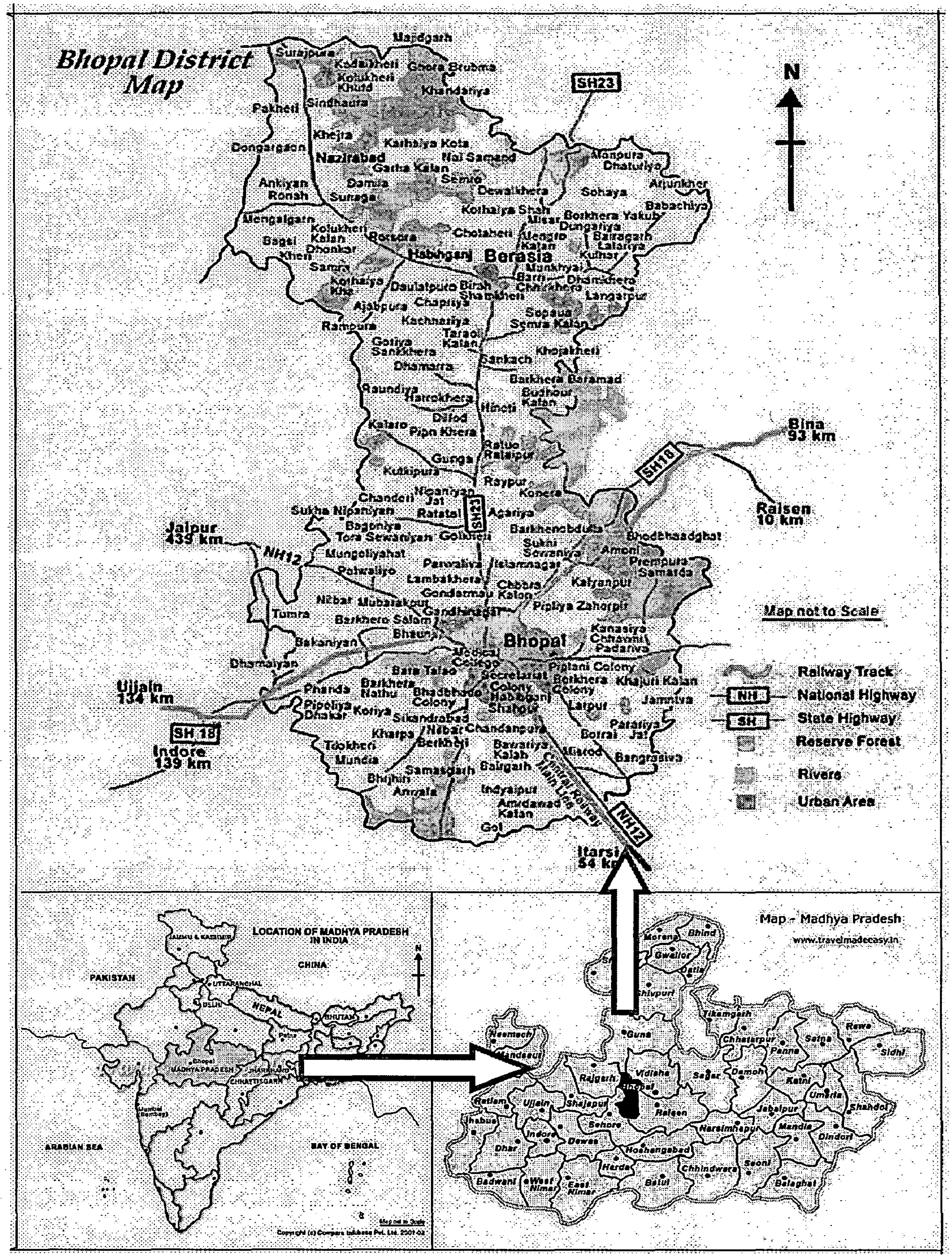


Figure 3.17: Location Map of Bhopal City

3.2.4 Demographics

Bhopal has a population of 14,82,718, which is divided into 781,282 men and 701,436 women, according to the census of 2001. This results in a sex ratio of 898 women for every 1000 men.

3.2.5. Bhopal Water Resource Present Status

Bhopal, the capital of the state of Madhya Pradesh in India has been facing a fast rate of urban development and industrialization, over the last decade population growth was about per year 3.5%, quite higher than the national average of 2%. This has brought about an adverse impact on the available precious water resource.

Bhopal, which is endowed with a number of water bodies developed over a period of about 900 years, is yet facing the problem of decline of water bodies; there is need of a serious thought to this issue.

3.2.5.1. Water Bodies of Bhopal

Bhopal has 16 major water bodies covering an area of 7019.49 hectares. These water bodies are being put to different uses such as water supply, Irrigation, washing, recreation and fisheries etc. water bodies are presently in different ecological status. Detailed information about these water bodies are presented in table 3.10

Table 3.12: Water Bodies of Bhopal - Area, Status and Use

S.no.	Name of water resource/water body	Water spread area (in hectares)	Present Use
1	Upper lake	3100	Water Supply, Recreation & Fisheries
2	Lower lake	129	Raw water supply & recreation
3	Shahpura lake (Third lake)	9.6	Recreation and fisheries
4	Sarangpani lake (piplani)	4.2	Recreation
5	Motia Talab	1.89	Washing and miscellaneous

6	Siddiqui hussain Talab	1.0	Abandoned
7	Munshi Hussain Khan Talab	1.2	Fisheries
8	Lendiya Talab	1.5	fisheries
9	Kolar Dam	2850	Water Supply, Recreation, Fisheries & Irrigation
10	Kalia sote Dam	126	Irrigation
11	Hatai Kheda Dam	113	Irrigation & supply for Industrial area (Govind pura)
12	Lahar Pur Reservoir	150	Irrigation
13	Kerwa Dam	524	Irrigation
14	Char Imli pond	1.2	Recreation
15	Neel Bad Tank	4.5	Recreation
16	Dhamkheda Village pond	2.4	Potable water & Recreation

Source: Bhoj Wetland Project

(a) Upper & Lower Lakes of Bhopal

Both Upper and Lower Lakes of Bhopal are man made reservoirs. The Upper Lake, in a linear east-west alignment, has a catchment area of 361 sq. km & at present has water spread area of 31 sq. km. The Upper Lake has a partial urban component in its catchment on the eastern end while the remainder is Rural.

The Lower lake, locally known as Chhota Talab , is situated towards the east end of Upper lake and is fully surrounded by built-up areas. Compared to the Upper lake, it has a small catchment area of 9.60 sq.km. and a water spread of 1.29 sq.km.

Lower lake which receives seepage water from the Upper lake and drainage from several drains outflows into the Patra drain which subsequently joins Halali river, a tributary of Betwa River.

Table 3.13: Characteristics of the Bhopal lakes

Descriptions	Upper Lake	Lower Lake
Period of Construction	11th Century A.D.	1794
Type of Dam	Earthen	Earthen
Location : Latitude Longitude	23°12' - 23°16' N 77°18' - 77°23' E	23°14' - 23°16' N 77°24' - 77°25' E
Catchment Area (Sq.Km.)	361	9.6
Full Tank Level (MSL) (M)	508.65	499.88
Dead Storage Level (MSL) (M)	503.53	499.88
Storage Capacity (Million Cu.M.)	117.05	4.3
Maximum DEPTH (M)	11.7	9.4
Designed Flood Discharge (Cu.M./Sec)	2208	-
Source Of Water	Rain Water	Seepage from Upper Lake and Domestic Sewage
Main Use of Water	Potable Water Supply	Washing and Boating
Inflow Points (Nos.)	31	28
Sewage Water Inflow (MLD)	50.47	31.63

Source: Bhoj Wetland Project

3.2.6. Water Supply and Demand

The water supply schemes in Bhopal have been developed in different phases depending on the projected requirement from time to time. The three land mark decisions for augmenting the supply where:

- 1970's - Increase in upper lake capacity (local)
- 1980's - Kolar scheme ---32K.M. away from Bhopal
- 2005 - Narmada water scheme---67.3K.M. Away from Bhopal

3.2.6.1. Water Supply Zones:

Earlier Bhopal was divided into three zones based on the water supply agencies covering the areas. They are:

1. **Bhopal municipal corporation (BMC) zone**(consisting of 37 wards)
2. **Public Health & Engineering Department (PHED) zone** (consisting of 13 wards)
3. **Bharat Heavy Electricals Limited (BHEL) zone** (consisting of 6 wards)

Establishments: such as railways and MES have their own water supply system. After transfer of the water supply department to Bhopal municipal corporation (BMC), there are only 2 supplying agencies remains. So we can divide Bhopal into 2 zones, BMC zone and BHEL zone.

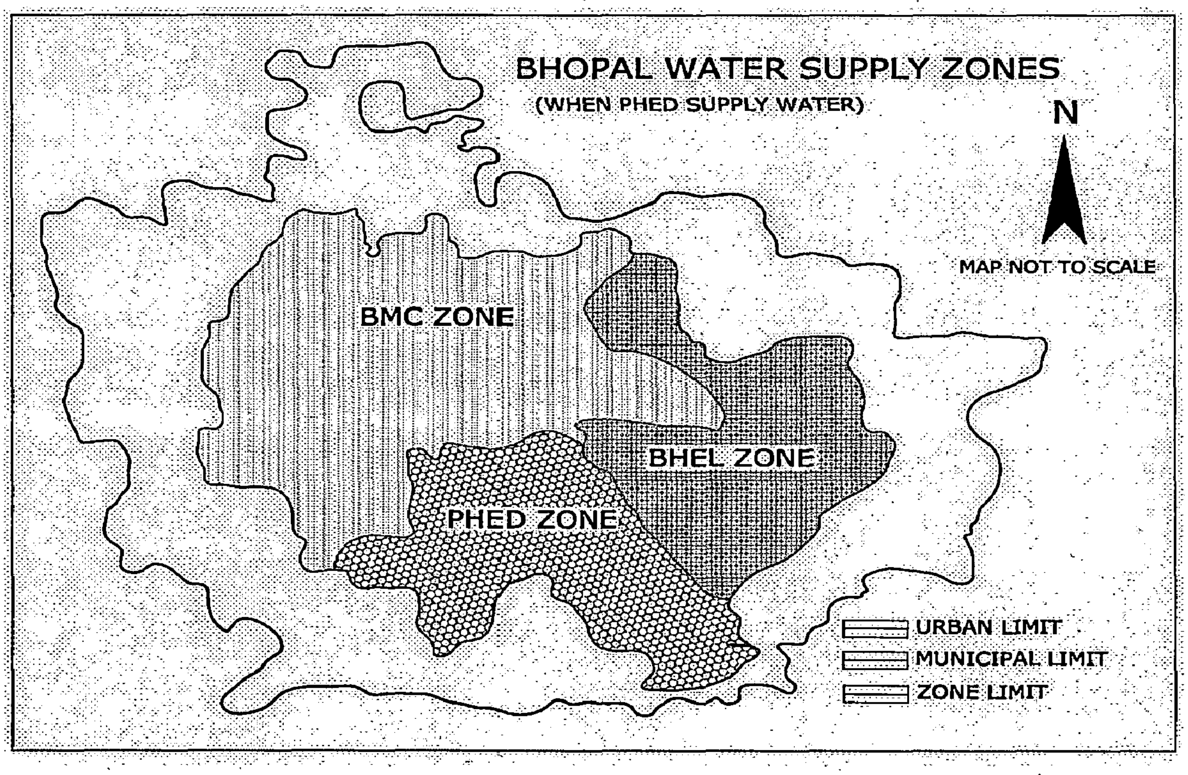


Figure 3.18: Water Supply Zones (PHED Water Supply), Bhopal City

Source: Water supply Deptt. BMC

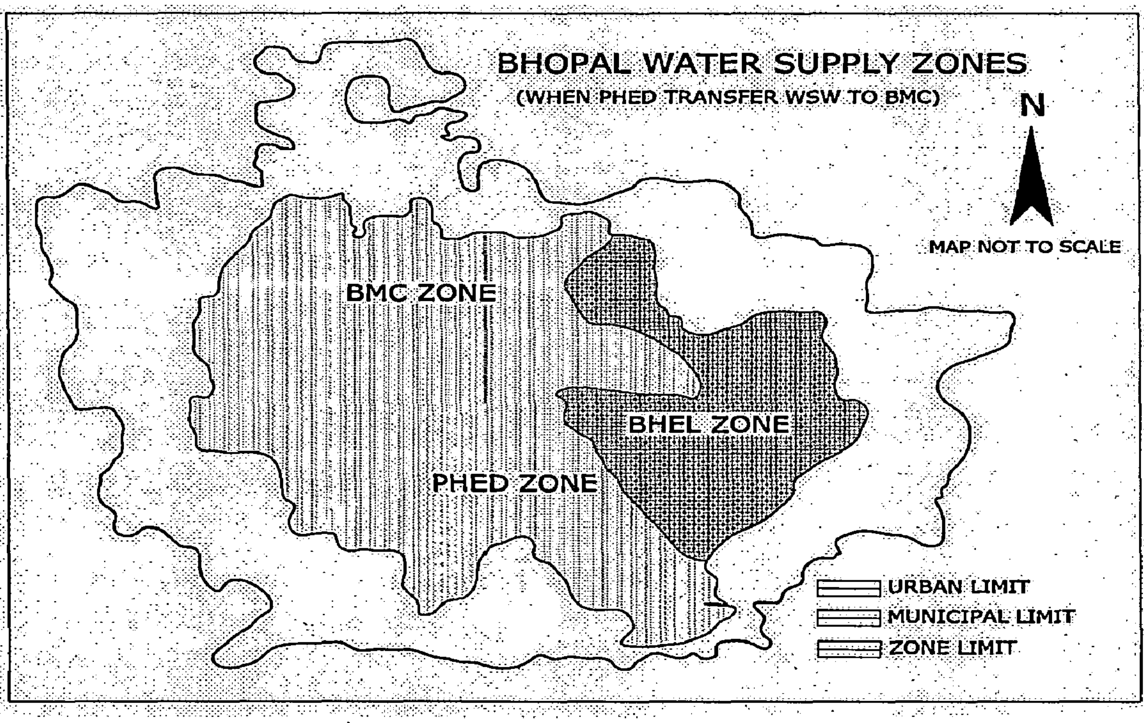


Figure 3.19: Water Supply Zones (BMC Water supply), Bhopal City

Source: Water supply Deptt. BMC

1. BMC Water Supply:

BMC draws water from upper lake (6.0 mgd), Kolar project (7.0 mgd), mini (2.5 mgd). it has intake points at (1) Yatch club (2) Karbala (3) Pulpukhta. Treatment plants are located at (1) Shyamla Hills (capacity 4.5 mgd) (2) Idgah (3.0 mgd) (3) Pulpukhta(2.0 mgd)

2. PHED Water Supply:

It draws water from kolar project 5 to 15 mgd. its intake points on upper lake are: kamala park pump house, yatch club pump house. it has treatment plants at kamala park (capacity 5.0 mgd), this plant is used only when kolar water is stopped, other wise water from kolar directly reaches here gets diverted . (2) Shyamla Hills (capacity 2.0 mgd), presently kolar water is directly reaching too. (3) treatment plant for BHEL (8.0 mgd). (4) hamidia treatment plant (0.5 mgd).

(Note: water supply of PHED is now transferred into BMC, but every thing remains the same only ownership status has changed. now PHED only responsible for feeding water to Bhopal from Kolar.)

3. BHEL Water Supply:

It draws water from upper lake during normal period and from kolar (6.0 mgd) during scarcity period. Pumping and filtering is done by BMC while supply is done by BHEL. The comparatively higher intake, as compared city area is due to industrial use (The area includes Govindpura industrial area apart from BHEL itself).

Earlier there were three agencies in bhopal, involved in water supply work independently. But at present the whole water supply (feeding and distribution) has been carrying by water supply department under BMC. BHEL take care of only their industrial area, excluding Govindpura, which was earlier supplied by it. PHED now its only take care of the sewerage disposal system, quality control measure of water supply and feeding OHTs, sumpwells and treatment plant from Kolar project.

3.2.7. Issues Related to Water Supply:

3.2.7.1. Area Grossly Affected by Water Storage:

OLD CITY: Shahjahanabad, Kazi camp, karond square, lakherapura.

NEW CITY: Lajpat Nagar, Trilanga, Gulmohar Colony Alka Puri, Indrapuri.

Problems Related to Water Supply-

a. Low very low pressures and little duration.

b. Duration of supply is very little with tolerable pressure.

c. Longer with almost no pressure.

d. Hence consumers dig pits for increase of some pressure & install booster pumps-

3.2.7.2. Duration & Timing of supply:

Duration of water supply is 3/4 to 1.5 hr in most of the area of Bhopal. In many areas there is no fixed time of supply e.g. Indrapuri, old city. Even the supply is at odd hours e.g. 4.0 am. The consumers have to keep constant watch and have to keep awake at odd hours in all sorts of weather.

- Inadequate distribution system
- Grossly under capacity service storage to meet the peaks.
- A common practice nowadays is to provide a sump of larger capacity and an elevated storage of smaller capacity with pumps on the sump for filling the ESR. Since the ESRs are comparatively expensive. However due to the erratic power supply conditions the pumping arrangement fails to meet the peaks resulting in the drawbacks stated earlier
- Grossly under size and inappropriate, old distribution pipe lines e.g. 2", 3", 4" dia G.I pipes – rusted – leaking resulting in wastage and pollution
- Very poor operation and maintenance of the system. Almost no preventive maintenance by unqualified and incompetent staff

3.2.7.3. Pollution :

- At the source upper lake mostly bacteriological-due to city drainage
- In tube wells and bawdis due to faulty construction, poor O & M and proximity to drains, dumps, polluted nalahs polluting ground water
- In the defective distribution lines and service lines of the consumers through public drains in the old city. during off supply hours polluted liquid enters the empty pipes and is carried to the taps of consumers. pollution from the city's main sources is expected to be mitigated in the treatment plants of water works of each main source. due to poor O & M no preventive maintenance and due to financial constraints some times the appropriate equipment initially provided becomes defective resulting in improvised methods e.g. bleaching powder in place of gas chlorine etc.

3.2.7.4. Tariffs:

At present there is no correlation between consumption and billing, as the billing is on the basis of flat rates / per connection the sufferer is the consumer barring a few lucky ones. This encourages massive wastage. The tariffs are also high.

Table 3.14: Water Tariffs -Bhopal city

Water tax for public sectors	Domestic purpose	Non-domestic
½" water connection	150/-	500/-
¾" water connection	300/-	1000/-
1" water connection	600/-	1500/-
Raw water rates for following supplies		
BHEL	Re 1.25/-	Per 1000 Ltr.
Railway	Re 1.25/-	Per 1000 Ltr.
Military	Re 1.25/-	Per 1000 Ltr.

Source: Water supply Deptt. BMC

3.2.8. Number of Connections Given BY BMC:

In year 2004 the total number connection given by BMC are 1,35,570. Their details are given in table

Table 3.15: Details of connections given by BMC

S.No.	Type	Number
1.	Domestic connection(Old Bhopal)	82,000
2.	Domestic connection(New Bhopal)	42,000
3.	Stand Post	3,570
4.	Religious Place (Free Service)	3,500
5.	Non Domestic(Office, hospital, factory)	4,500
Total		1,35,570

Source: Water supply deptt. BMC

3.2.9. Devices for Water Supply, Purification and its Distribution:

Table 3.16: Details of Devices Used for Water Supply, Purification and its Distributions by BMC

S.No.	Device	Numb[redacted]
1.	OHT	54
2.	Sump well	73
3.	Well and Babdi	44
4.	Water Treatment Plants	11
5.	Bore well with Power Pump	575
6.	Hand Pump(In working condition)	1096
7.	Mobile Tanker	33
8.	Standing Trolley	38

Source: Water Supply Deptt.BMC

Table 3.17: Details of Ward Wise Distribution of Hand Pumps and their Existing Condition.

Zone	Wards	Handpumps				Population	WHP* Per 10,000 Person
		Total	Working	Not working but repairable	Not working & not repairable		
1	1,2,3,4,65,66	176	158	6	12	194,542	8
2	5,6,7,8,9,10	72	70	1	1	102,357	7
3	11,12,13,14,15,16	107	105	2	0	131,530	8
4	17,18,19,20,21,22	145	139	0	6	83,210	17
5	23,24,25,26,27,28	89	86	0	3	104,570	8
6	29,30,31,32,33,34	121	108	13	0	117,180	9
7	35,36,37,38,43,44	71	71	0	0	105,952	7
8	39,40,41,42,45,46	69	65	4	0	150,596	4
9	47,48,49,50,51,52	128	103	19	6	153,608	7
10	53,54,55,56,57,58	148	110	32	6	124,391	9
11	59,60,61,62,63,64	109	81	18	10	169,418	5
Total	66 wards	1235	1096	95	44	1,437,354	

*WHP-Working Hand Pumps

Source: Water Supply Deptt.BMC

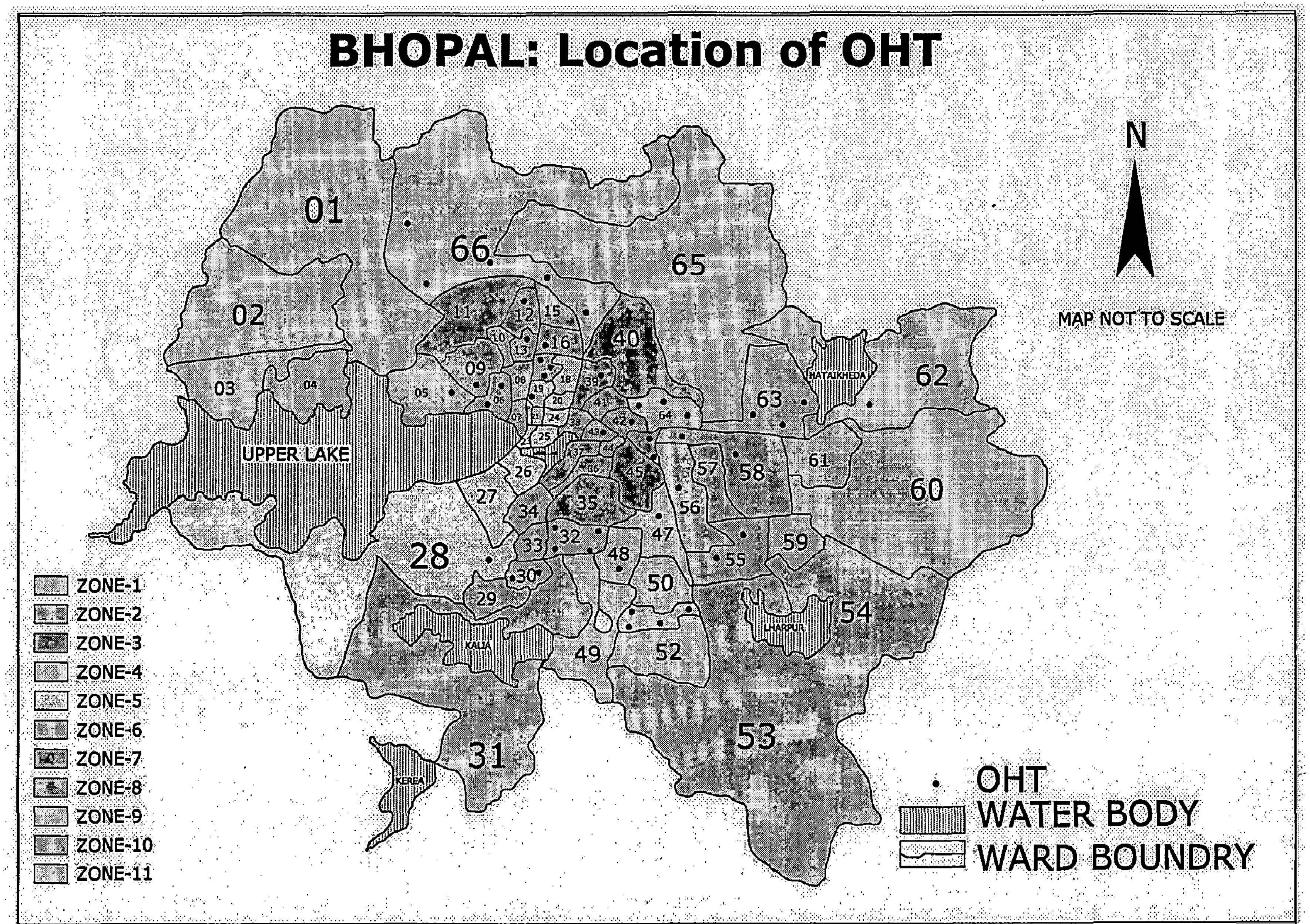


Figure 3.20: Location of OHT's in Bhopal
Source: Water Supply Deptt. BMC

3.2.10. Water Resource in and Around Bhopal:

3.2.10.1 Upper Lake:

It is the major source of water supply in the city with capacity of 28 mgd. if normal rainfall occur.

3.2.10.2 Hataikheda:

It is a mini source of water with capacity of 1.5 mgd, again the same condition if normal rainfall occurs.

3.2.10.3. Under Ground Tubewell And Other Source:

Their combined capacity is 5.0 mgd but this could reduce to 2.5 in summer.

3.2.10.4. Kolar:

Kolar dam is located at a distance of 35 km. From Bhopal. It has a treatment plant near by it at Jhuri Hills. It can supply 34 mgd. When installed fully. But present capacity is 21 mgd.

3.2.10.5. Narmada:

Narmada river one of the most holly river of Hindus. It is a perennial river. Estimated 211 mgd. But it is too far from Bhopal and there is a level difference of 200 m between Hosangabad and Bhopal, so it will be very expensive to bring its water to Bhopal.

3.2.11. Demand & Supply of Water

3.2.11.1. Demand of Water:

According to 2001 data the total water requirements of the city was 57.03 mgd according to population projection future water requirement are given below.

Table 3.18: Demand of Water in Bhopal

Year	Population	Demand @ 180 lpcd	Demand @ 250 lpcd
2001	14,37,354	57.03 mgd	79.22 mgd
2011 (Proj.)	18,11,046	71.87 mgd	99.86 mgd
2021 (Proj.)	21,84,738	86.7 mgd	120.41 mgd
Note : According to WHO norms water supply in a city is 250 lit/capita			

3.2.11.2 Withdrawal of Water:

Table 3.19: Total Water Generation

Source	Capacity (mgd) (Existing***)	Capacity (mgd) (supply)	Remark
Upper lake	28	26	Major source
Kolar Dam	34*	21	Largest source, 35 km from city
Hataikheda	1.5	1.5	Mini source
G.W.& Other	5**	5	Smaller source
Total	68.5	53.5 (51.0 mgd during scarcity)	

***But presently supply 21 mgd. ** 2.5 mgd during scarcity period.**

*** The existing yield capacity of above reservoirs and lake are only true in normal rainfall takes place.

3.2.12. Government Initiatives

Following are the some of new the project to towards conservation the water bodies and capacity augmentations of water supply of Bhopal are:

1. Augmentation of Kolar Project
2. Augmentation of Bairagarh Project
3. Asian Development Bank Project
4. Narmada Project
5. Bhoj Wetland Project

3.2.13. Conclusion

The major problems of water supply both qualitatively and quantitatively. The water supply is non-uniform or inequitable distribution of available supply due to inadequate pressure in different areas. Another major problem is the operation and maintenance of supply system; unaccounted water due to leakages and wastage; unauthorized pumping of water from service mains and faulty layout of distribution pipelines along with sewer lines. Unmetered connections in the city result in loss of revenue.

A new water supply project for augmentation is under consideration now. It is suggested that all the options/ alternatives must be studied in depth particularly its tariff (which affects the consumer directly) before any project is finalized. for example, Augmentation of Kolar project, Augmentation of Bairagrh project, water supply in affected area of gas Tragedy, Narmada project etc.

3.3. Analysis

Form the case studies of water supply system in Jaipur (Rajasthan) and Bhopal (Madhya Pradesh) it has been observed that the problems related to water supply face in the respective cities vary but they have almost common reasons for their occurrence. The problems found in these cities can be summarized as follows

a) High demand and supply gap
b) Lack of metered connections
c) Improper operation and maintenance
d) Illegal tapping form the supply lines
e) Improper tariff structure
f) Excessive extraction of ground water
g) Lack of awareness about rainwater harvesting and use of waste water
h) Lack of management of the resource

Chapter-4

STUDY AREA PROFILE, UDAIPUR

[Udaipur, which is better known as the city of lakes or the Venice of the east contains four lakes. However the call of the hour is to manage the existing available resources as the conditions of most of the lakes is worsening. The following chapter investigates the physical and water resource conditions of the city of Udaipur. This is highly essential before recommending any design, management or planning solutions.]

4.1 About the City

Udaipur is famous around the world as the City of Lakes or Venice of the East. The Pichola Lake, Fateh Sagar, Udai Sagar and Swaroop Sagar in this city are considered some of the most beautiful lakes in the state. Fateh Sagar contains two small islands, one of which contains USO (Udaipur solar observatory), and the other one has a beautiful garden called Nehru Garden.

Udaipur is well connected to the world through land, rail and air. It is known for its Rajput-era palaces. Particularly famous is the Lake Palace, which entirely covers a small island in the Pichola Lake. Many of the palaces have been converted into luxury hotels. The City Palace, or the Palace of the then King of Mewar, is one of the most beautiful places to visit in the city.

Udaipur is also home to the Udaipur Solar Observatory, one of the six stations participating in the international Global Oscillations Network Group (GONG) which is aimed at the determination of the physical properties of the solar interior.

4.2 Geography

Udaipur is located at 24.58° N 73.68° E. It has an average elevation of 598 metres (1961 feet). Located at the foothills of the Aravalli Range, Udaipur lies in southern Rajasthan near the Gujarat and Madhya Pradesh borders. It is bounded on the north by Rajsamand district, on the south by Dungarpur and Banswara. on the east by Chittaurgarh and on the west by Pali and Sirohi districts of Rajasthan and Sabar Kantha district of Gujarat state. The district covers an area of 12412 sq. km. Headquarters of this district is Udaipur (Figure 4.1).

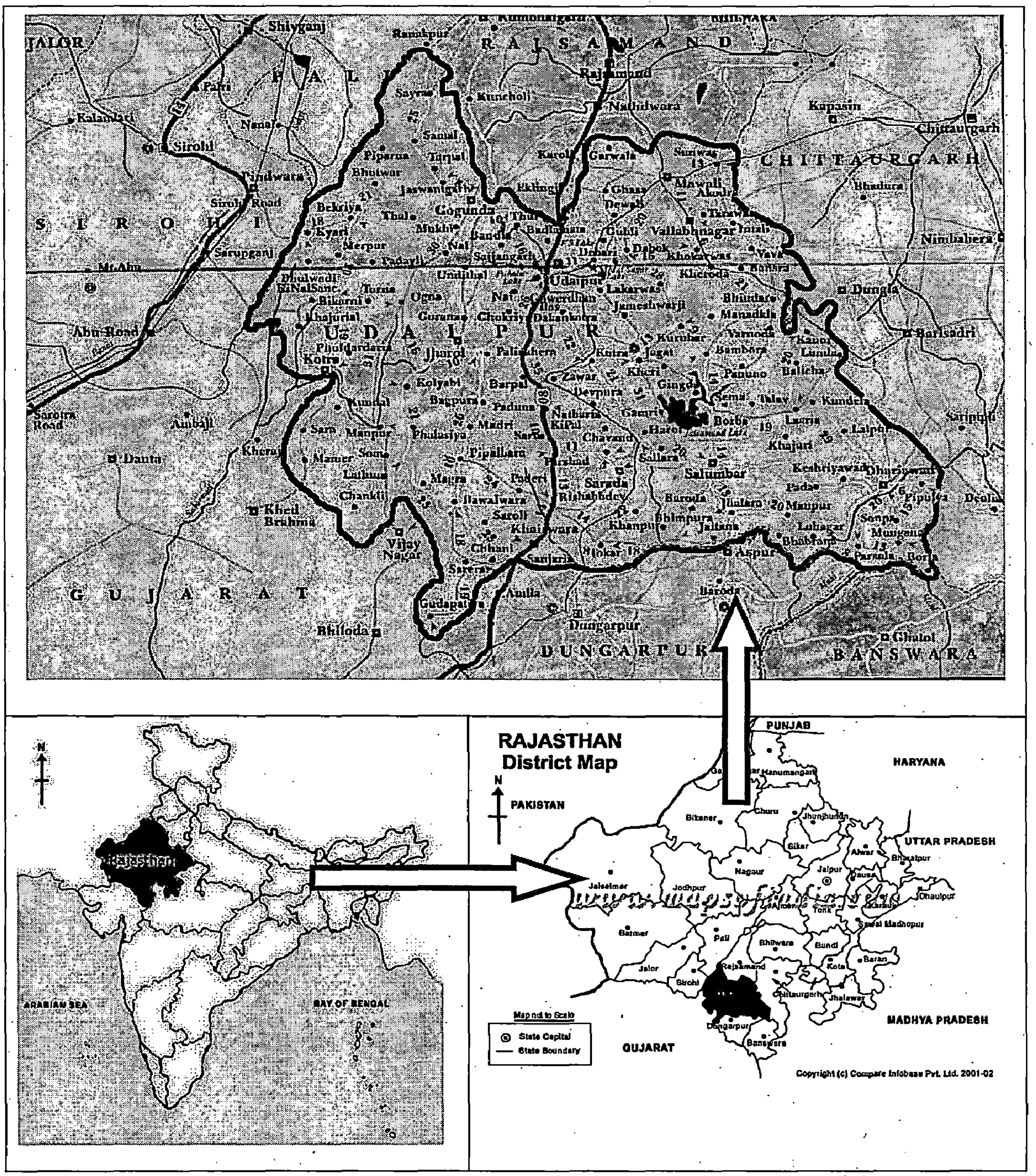


Figure 4.1: Location Map of Udaipur City

4.3. Climate

The climate of Udaipur is tropical with the mercury staying between a maximum of 42.3°C and a minimum of 28.8°C during summers. Winters are a little cold with the maximum temperature rising to 28.8°C and the minimum dipping to 2.5°C. The annual total rainfall received at Udaipur is 63 cm.

4.4. History

Udaipur was the capital of the Rajput kingdom of Mewar, ruled by Ranawats of the Sisodia clan. Founder of Udaipur was - Rana Udai Singh. The ancient capital of Mewar was Chittor or Chittorgarh, located on the Banas River northeast of Udaipur. In 1568 the Mughal emperor Akbar captured Chittor, and Udai Singh moved the capital to the site of his residence, which became the city of Udaipur. As the Mughal empire weakened, the Sisodia ranas, and later maharanas, reasserted their independence and recaptured most part of Mewar except the fort of Chittor. Udaipur remained the capital of the state, which became a princely state of British India in 1818. After India's Independence in 1947, the Maharaja of Udaipur acceded to the Government of India, and Mewar was integrated into India's Rajasthan state.

4.5. Demographics

According to census of 2001, Udaipur had a population of 3, 89,317. Males constitute 53% of the population and females 47%. Udaipur has an average literacy rate of 77%, higher than the national average of 59.5%: male literacy is 83%, and female literacy is 72%. In Udaipur, 12% of the population is under 6 years of age.

Table 4.1:Population Growth of Udaipur City 1881-2001

Year	Population	Difference	Growth(in percent)
1881	38,264		
1891	48,530	10,266	26.83
1901	45,976	-2,554	-5.26
1911	33,229	-12,747	-27.73
1921	34,789	1,560	4.69
1931	44,035	9,246	26.58
1941	59,648	15,613	35.46

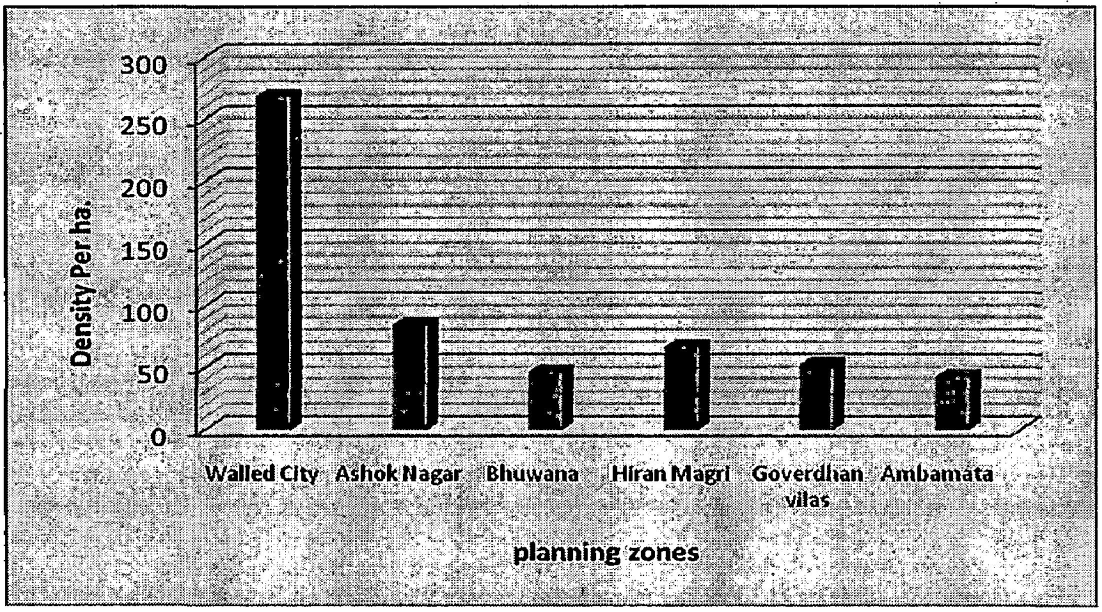


Figure 4.3: Residential Density in Planning Zones, Udaipur-2022

Source: Udaipur Master Plan 1997-2022

The proposed boundary of urban control area, urbanized area, urbanizable area and municipal area shows in figure 4.4 and figure 4.5 shows the boundary of various planning zones.

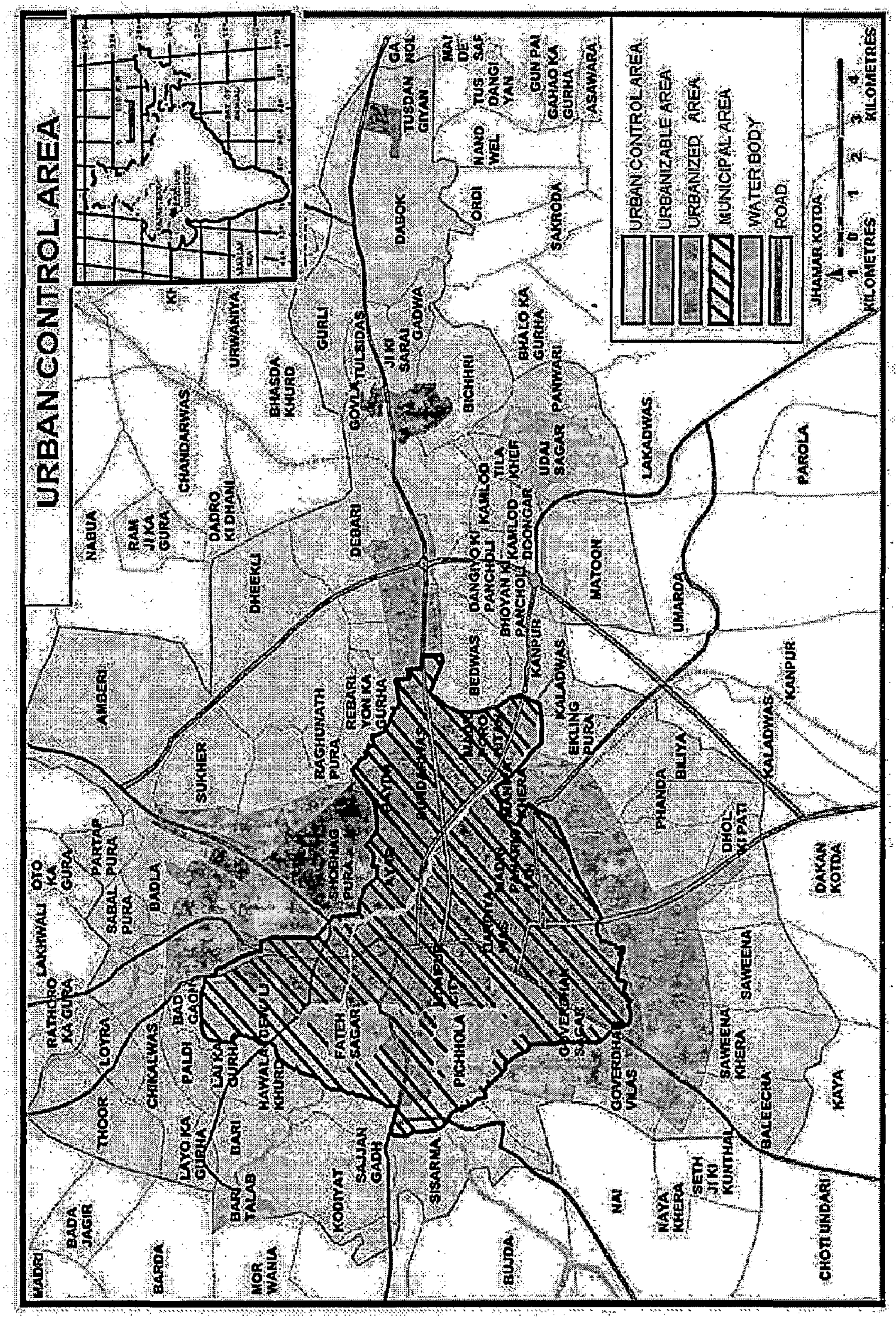


Figure 4.4: Urban Control Area in Udaipur city
Source: Udaipur Master Plan 1997-2022

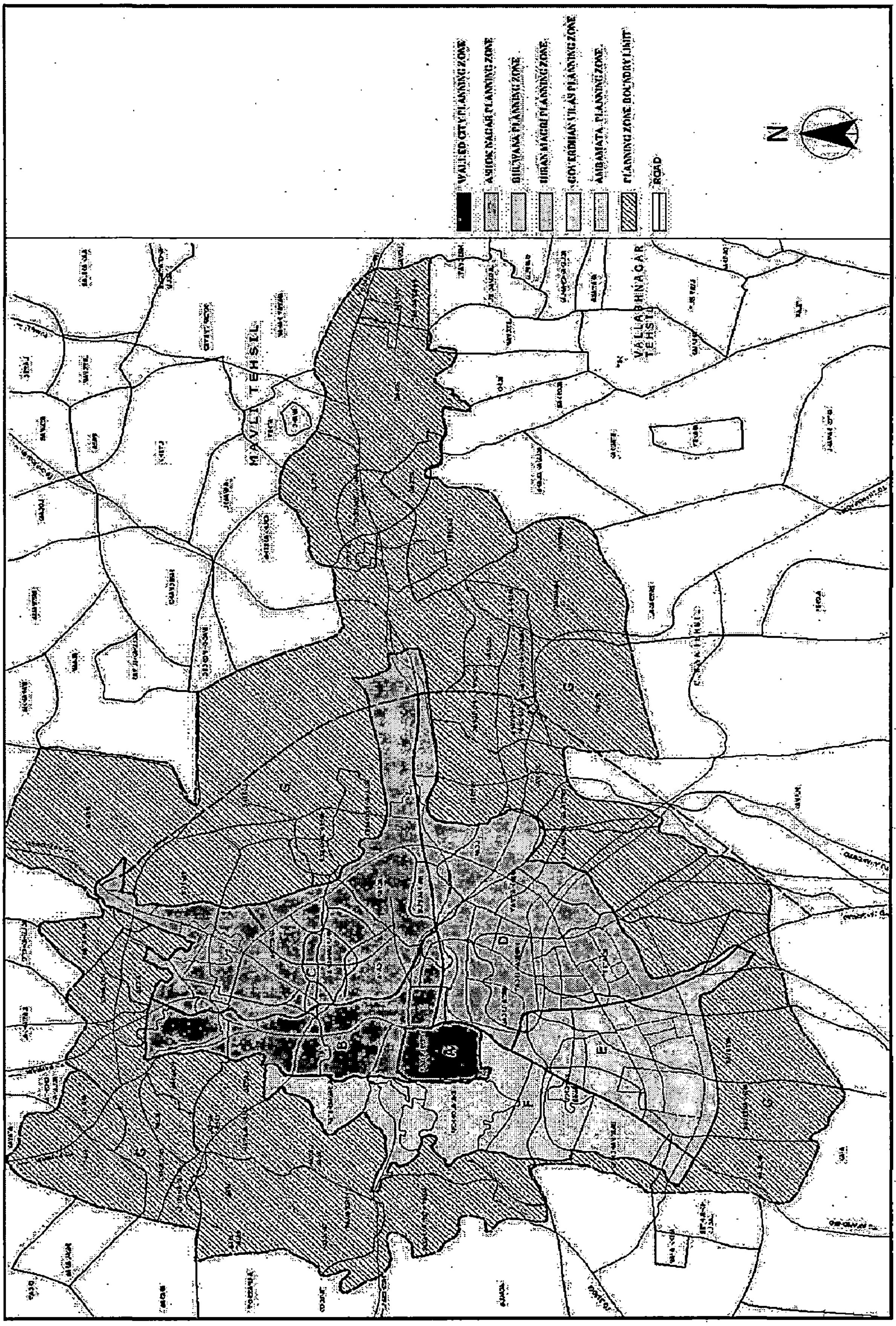


Figure 4.5: Planning Zones Udaipur city
Source: Udaipur Master Plan 1997-2022

4.6.2 Land-use and Master Plan

4.6.2.1 Existing Land use distribution

The master plan (1997-2022) (figure 4.7) proposed a land use pattern for 1997 with 9146 ha. as urbanizable. The developed area proposed for 1997 was 9879 ha. Out of the total developed area of 9879 ha. 50.5% was allocated for Residential use, 11.16% under Circulation, 16.52 % as Public and Semi public, 11.64% as Industrial, 5.54% as Commercial, 3.67% as Recreational and 0.97% as Governmental (figure 4.6).

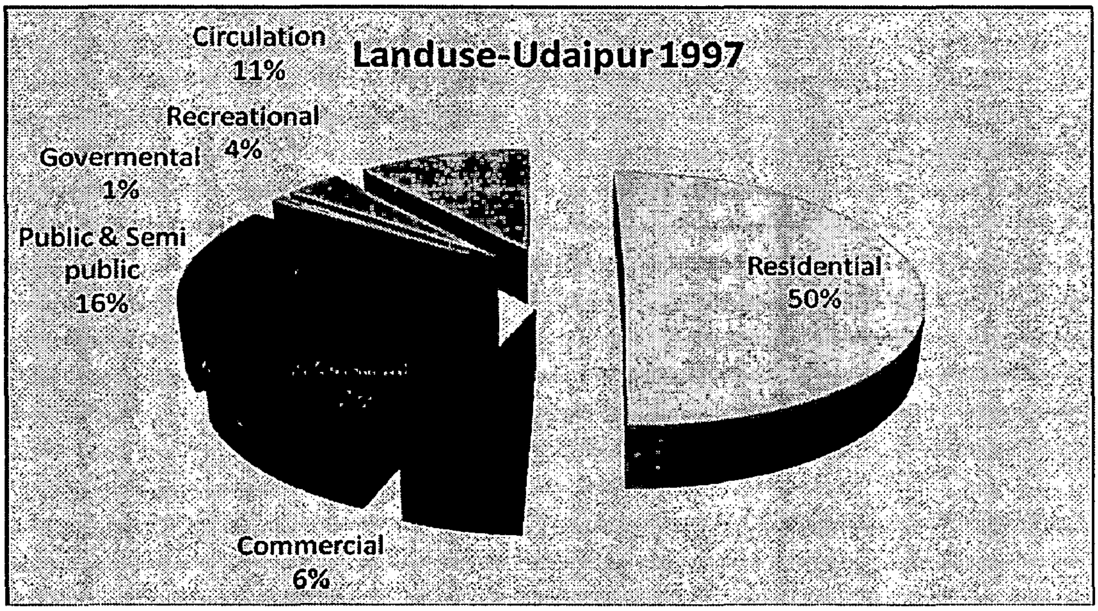


Figure 4.6: Landuse in year 1997

Source: Udaipur Master Plan 1997-2022

4.6.2.2. Proposed Land use distribution

The master plan (1997-2022) proposed a land use pattern for 2022. Out of the total developed area, 57.23% was allocated for residential use, 10.61 % under circulation, 10.35% as public and semi public, 4.75% as industrial, 5.22% as commercial, 10.39% as recreational and 1.45% as Governmental (figure 4.7).

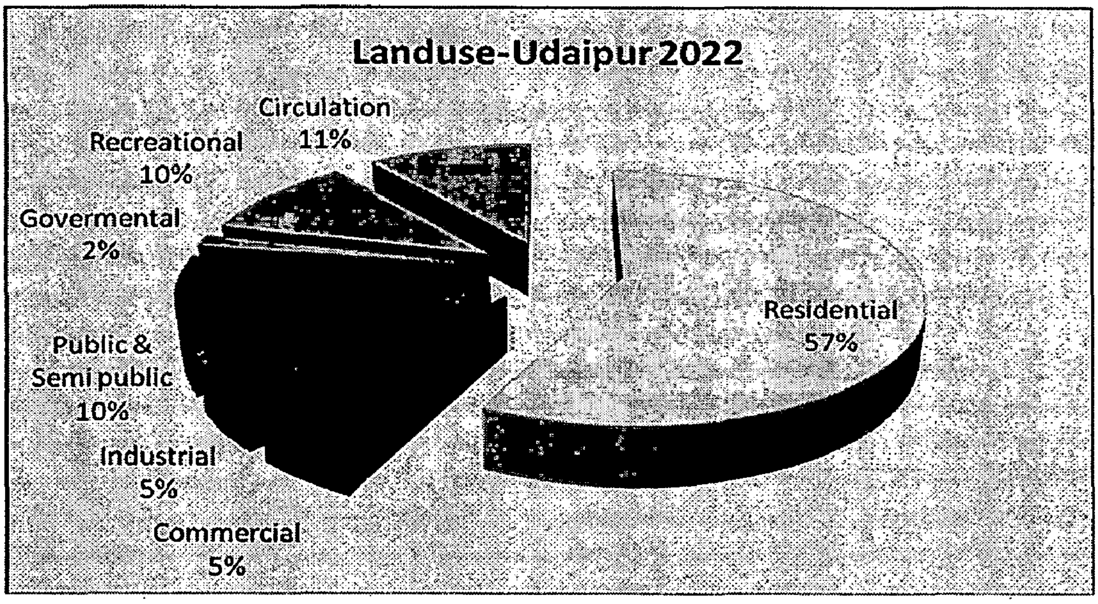


Figure 4.7: Proposed Landuse year 2022

Source: Udaipur Master Plan 1997-2022

4.6.3. Growth Directions

Northeast part of Udaipur has plain area so secondary and tertiary activities are increasing in this direction. Amberi, Sukher, Sobhagpura, Raghunathpura and Bhuwana located in north/northeast direction of Udaipur have small-scale industries and maximum minerals activities. Hindustan Zinc Ltd. established near Lake Udai sagar in east direction of Udaipur urban control area. Dabok, Gudli and Gadwa area in developed Mewar industrial area and other small-scale industries have also come up along this corridor towards Chittorgarh. Major development activities have increased near water bodies and highways of Udaipur. Udaipur is essentially developing along NH8 to Ahmedabad and NH76 to Chittorgarh. Figure 4.8 shows the growth direction of Udaipur and figure 4.9 shows the satellite image of the Udaipur city with different planning zoves.

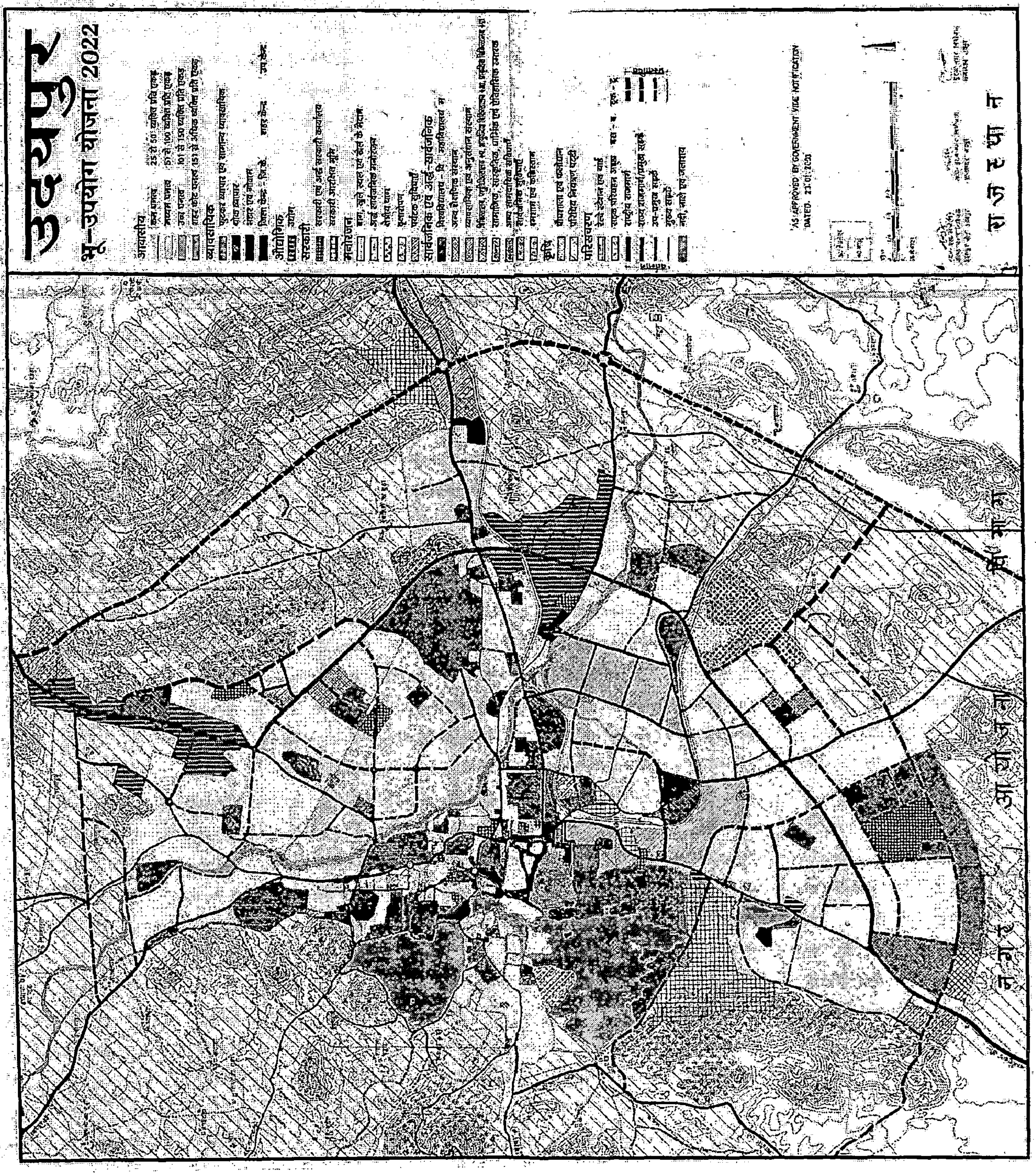


Figure 4.8:Proposed Land use Plan for Udaipur 2022
Source: Udaipur Master Plan 1997-2022

Figure 4.9: Satellite Image of Udaipur city with different Planning Zones
Source: Google Earth Image

4.6.4. City Development Plan for Udaipur

One of the key components of the City Development Plan is long term strategic Vision for development of the city. This Vision defines the overarching objective of the city in terms of its long-term aspirations. Supporting this Vision is a set of development objectives. These objectives put forward specific targets that the city wishes to achieve in a given time frame. These objectives are defined along various sectors and form part of a Sector Plan. Each Sector Plan covers the current status in that sector, emerging issues in the sector, likely future demand, development objectives and strategies for improvement and identified projects to meet these objectives. The sectors covered in the CDP Udaipur are:

- Land Use and Spatial Growth
- Roads and Transport
- Water Supply
- Sewerage and Sanitation
- Drainage
- Lake Rejuvenation
- Solid Waste Management
- Tourism and Heritage Conservation
- Basic Urban Services for the Poor
- Institutional Strengthening

Some of the core issues which emerged during interaction with stakeholders include provision of adequate and quality water supply to all the residents of the city, improvement in solid waste management and augmenting the sewerage systems in the city (both currently impacting the physical environment in a negative manner), rejuvenation of lakes, and reducing traffic bottlenecks in Udaipur, the need to develop tourism (with the associated infrastructure and services) as a sustainable long term option for resource mobilization by leveraging existing tourism related assets and creating new assets, conservation of heritage monuments and improving the financial and technical capacity of the municipal body.

4.7. Water Supply System in Udaipur

Udaipur is famous all over world for its enchanting lakes. The interconnected network of lakes emerged for both recreational and irrigation purpose. Groundwater recharged through the lake system and seepage from wells and stepwells was utilized for drinking purposes. The two main lakes of Udaipur are Pichhola, and Fatehsagar, situated within city, and Udaisagar, with other smaller lakes either interconnecting or feeding them. Pichhola has a natural catchment of its own and is also fed by Sisarma, a non-perennial river.

Below Pichhola and Fatehsagar are numerous wells and bavdis (step wells). In past, these wells were the only source of drinking water, as lakes were not used for drinking water purposes, as done today. With this web of lakes and wells, most of rain falling within Udaipur basin was kept within the basin itself, with very little losses.

4.7.1. Water Bodies in Udaipur

Udaipur region water supply depends upon surface and underground water sources of water such as lakes, step wells, tube wells, wells etc. these sources of water supply obtain water during rainy season. Udaipur has numerous lakes in its vicinity those are Pichola, Fateh Sagar, Bari and Jaisamand lakes. In past these lakes along with Step wells, tube wells have been major sources of drinking water for Udaipur. The location of varios lakes in Udaipur city shows in figure 4.10.

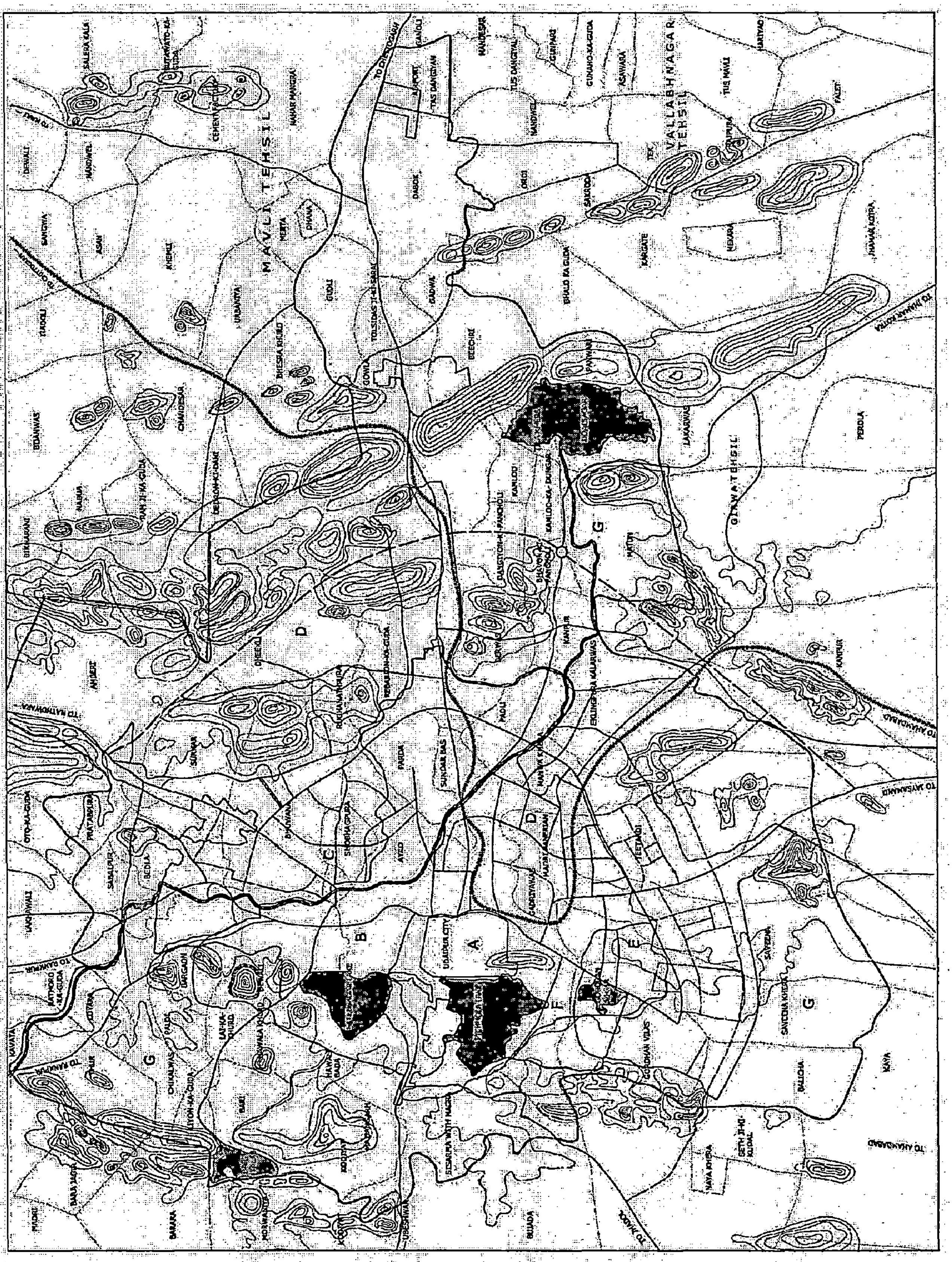


Figure 4.10: Water Bodies in Udaipur City
Source: Udaipur Master Plan 1997-2022

4.7.1.1. Pichola Lake

Pichola lake is man made and dates back to 14th century. Capacity of Pichola is about 13,700 million liters, whilst at its minimum draw able level its corresponding capacity is 2,250 million liters.

4.7.1.2. Fateh Sagar Lake

This is man-made constructed in 19th century. Its capacity is 12,100 million liters and at its minimum drawable level its corresponding capacity is 2,300 million liters (Figure 4.11).

4.7.1.3. Jaisamand Lake

This is located approximately 50 kms from Udaipur. It was constructed during 1730 A.D. for irrigation. Gross storage is 415,000 million liters and 300,000 million liters (live). Minimum storage capacity is 75,000 million liters. Jaisamand Lake has a much larger storage in comparison to Pichola and Fateh Sagar and therefore offers prospects of future development for water supply for Udaipur. (Figure 4.12).

4.7.1.4. Swaroop Sagar

This Lake is located southwards to the Rang Sagar and is the ultimate part of Lake Pichola. The Lake provides a combined water weir for Pichola and Rang Sagar. Moreover the lake also links Pichola and Rang Sagar with adjoining Fateh Sagar Lake through a canal. This canal is sometimes employed to draw water in the Fateh Sagar during the Monsoon when Pichola maintains a high water level (Figure 4.14).

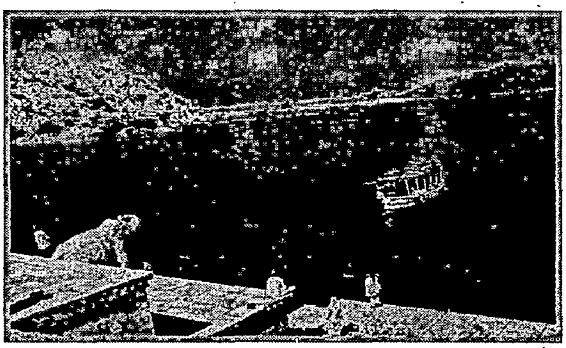


Figure 4.11: View of Fateh Sagar Lake

Figure 4.12: View of Jaisamand Lake

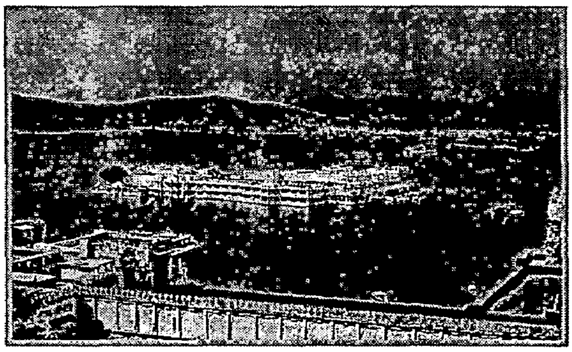


Figure 4.13: View of Lake Palace

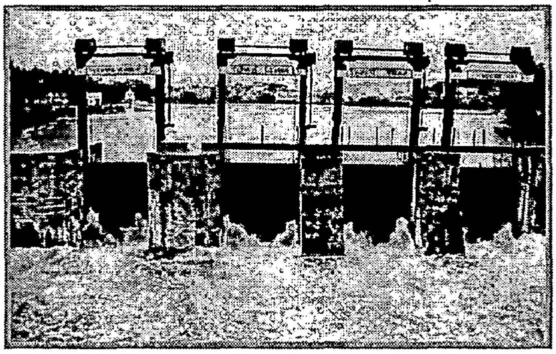


Figure 4.14: View of Swaroop Sagar Lake

4.7.2. Existing Situation:

Source of water to Udaipur city are its various lakes viz. Pichola, Fatehsagar, Jaisamand, and ground water from Jhamar Kotra mines and local tube wells & bawaries. During last few years, Udaipur has faced drought years and experienced severe shortage of water. To cater to increasing water demand, diminishing yield of existing water sources, it is planned to tap more sources of water and augment existing sources.

4.7.2.1. Udaipur Water Sources and Requirements

Metric features of various water bodies in Udaipur shows in table 4.3.

Table 4.4: Metric Feature of five Water Bodies

	Parameters		Fateh Sagar	Pichola Lake	UdaiSagar	Jaisamand	Bari lake
1	Location	Longitude	73º42'E	73º41'E	73º36'E	73º--'E	73º44'E
		Latitude	24º35'N	24º34'N	24º41'N	24º--'N	24º37'N
2	Average Annual Rainfall (mm)		635	635	635	635	635
3	Gross catchment Area (Sq. Km)		53.6	55	478.96	1813	28
4	Water spread (Sq.Km)		4	6.96	4.75	160.6	1.7
5	Capacity at FLT (MCM)		12.1	13.08	31.13	560	3.4
6	Mean depth (M)		7.21	4.32	7.5	-	5.3
7	Maximum depth (M)		12.46	8.5	15	-	9.8

Source: Zheel Sanrakshan Samiti Report

- Water Requirement of Udaipur in year 2001 = **70.00 MLD (Million liters per day)**
- Water Supply of Udaipur in Normal year = **62.87 MLD**
- Short fall = **7.13 MLD**

Requirements: (MLD)

- Domestic = **60.9** (~ 5.0 mlpd to Bulk Supply, viz. Railways, Military, Dairy, etc.)
- Industrial = **2.3** (MLD)
- Commercial = **4.70 MLD**
- Others = **2.10MLD**

(PSP = Public Stand Post, SULABH, SARVAJANIK supply)

- Irrigation not recorded

Total ....70 MLD, includes 15% Distribution losses

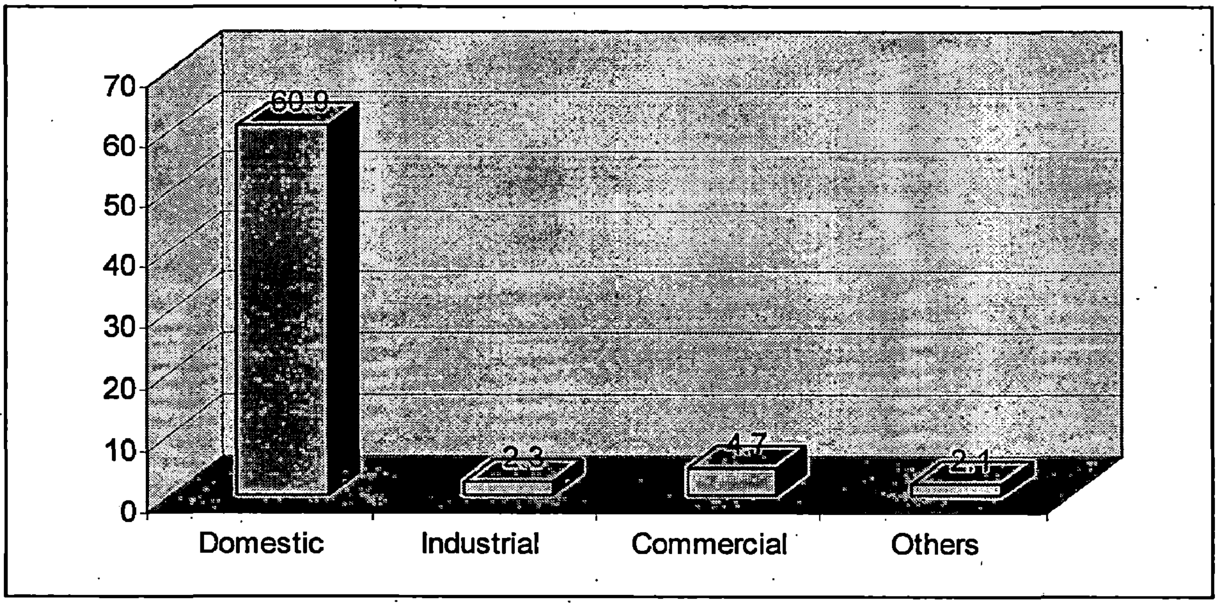


Figure 4.15: Requirements of Water in different sectors

Source: Water Works Department Udaipur

Table 4.5: Water Supply Indicators in Udaipur City

S. No.	Indicator	Unit	Value
1	**Population year 2007**	**lakhs**	**4.82**
1.1	**Total House holds (5 persons per house hold)**	**Nos.**	**96400**
2	**Water Supply**		
2.1	**Water Supply(Liters Per Capita Daily)**	**LPCD**	**110**
2.2	**Water Supply from Tube Wells and Other Source**	**MLD**	**11**
2.3	**Water Supply from Surface Source**	**MLD**	**55**
2.4	**Total Urban Water Supply**	**MLD**	**66**
3	**water resource**		
3.1	Surface Source	Nos.	4
3.2	Open Wells	Nos.	32
3.3	Tube Wells	Nos.	50
3.4	Hand Pumps	Nos.	2141
4	**Water Treatment Plants**	**Nos.**	**9**
5	**Existing Rising Main**	**Km**	**40**
6	**Transmission Losses**	Percentage	**2.54**
7	**Existing distribution mains**	**Km**	**142.5**
8	**Water supply duration**	**Hrs**	**1.5 - 3**
9	**Water distribution interval**	**Hrs.**	**24**
10	**House connections**	**Nos.**	**53826**
10.1	Domestic	Nos.	51506
10.2	Commercials	Nos.	1563
10.3	Industrial	Nos.	817
11	**Metered Connections**	**Nos.**	**53826**
12	**Non metered Connections**	**Nos.**	**42574**
13	**Meters Operational**	**Nos.**	**13373**
14	**Percentage of Operational Meters**	**Percentage**	**24.84**

Source: Rapid Urban Assessment, UMC, PHED, Concept note on mass balance of water source and distribution for Udaipur city, RUIDP

Ground water is drawn from 50 tube wells and 32 step wells/open wells located in city. Besides, there are 8 tube wells located at about 8-14 kms from city in Jamar Kotra Mines and Kharbadiya Mines supplying water to city through Kaladawas Pumping Stations. Water is collected from tube wells in CWRs and pumped by series of 3 pumping stations (Purohiton Ki Madri and Pratap Nagar Zones, Sahelion ki bari & Gulab Bag). 2141 hand pumps and 102 panghats (system consisting of low yield tube wells, automatically electrically operated submersing pumping sets, low capacity PVC water tanks, and 3-4 public taps) also supplements water supply.

Table 4.6: Showing Availability of Water from various Sources during Normal and Draught Conditions

Sources	Availability of Water (MLD) during draught years (1998 onwards)	Availability of Water (MLD) during normal rainfall years
Surface Water Sources		
Lake Fatehsagar	3	13.5
Lake Pichola	8	19.5
Lake Jaisamand	21	21
Lake Badi	1	Not considered
Ground Water Sources		
Sahelion ki Badi	1.5	3
Gulab Bagh	1.5	3
Kanpur	1	2
Jhamar Kotra mines	6	8
Total	43	70

Source: Rapid Urban Assessment, UMC, PHED, Concept note on mass balance of water source and distribution for Udaipur city, RUIDP.

The potential of utilizable water is 55 MLD and 11 MLD from surface source and ground water respectively. However potential from Pichola and FatehSagar is diminishing since past 3 to 4 seasons drastically and their present levels are unprecedented low due to rainfall deficit in their respective catchments area (in fact in recent times water is not being tapped from Pichola and FatehSagar Lakes). Ground water table is also depleting and there are chances of reduction. Deficit between demand and supply has further widened due to gradual closing down of bowries and reduction in supply from lakes, mainly due to low rainfall, silting and pollution. The table shows current availability of water to Udaipur city from various sources during draught years.

4.7.3. Status of Pollution

The physical setting of the city enhances the flow of pollutants into the lakes. It has hills on all the sides rising from 20 meters to 150 meters. Thus the natural drainage leads towards the lake complex from all the sides.

Most of the Hotels (53 in number) along with 6000 residential houses accommodating 33,000populaion are located on the lake slopes releasing all drain water into the lakes. Even the garbage collected from the roads, dirt thrown from the houses, small -sized dead animals are thrown on the banks meeting the lake water. Slopes have about 300 hanging latrines, 73 ghats used for bathing and washing, 45 drain spots, 53 hotels, 42 garbage spots and 118 open air defecation spots which release a shocking quantity of pollutants into the lakes.

The inhabited part of the lake region consists of the residential areas of the walled city and outside. The former is of pre-independence existence with traditional set -up of small sized rooms, whereas the latter usually has open houses of bungalows pattern constructed in a planned manner. Many people in the walled city use the river for bathing and sanitary use. Further, many traditional rituals and ablutions are performed along side the lakes. The lakes are thus subjected to organic contamination.

The Municipal sewerage lines open directly into thee lakes and thereby increase the bacterial material and organic load. The 73 Ghats situated on the banks of the lakes are traditionally used for bathing purposes and for washing clothes. This releases large amount of detergents in to the lake, which increases its phosphate content. Similarly, increased commercial activity, especially of Hotels in the vicinity of the lakes, has also contributed considerably to water pollution. In the catchment area of Fateh Sagar Lake, chemical effluents from synthetic fiber mills are discharged every day in a drain, which carries water to Fateh Sagar. The boating activity has spread an oil layer in the waters near Navghat, Piplighat of Pichola and boat booth of Fateh Sagar. In summers, vehicles are washed between the filter house and hotel site of Fateh Sagar.

In addition to the above, about 400 -500 tones of solid waste is dumped on the banks of the lake. The places around Navghat, Lalghat, Gangaur Ghat, Ghat of Gadi Devra, Satapole, Chandpole Bridge, Samla area, Hanuman ghat, Amet ki Haveli and Naga nagri of Pichola are the dumps of solid wastes amounting to 100 tonnes are deposited at 8 different spots. Some other spots, worth mentioning, are near Public Park at Yadav colony and near new bridge. Kalalia tanks have 5 waste dump points of 50 tonnes and the Lake Swaroop Sagar has 11 spots. Lake Fateh Sagar is polluted at 7 spots with about 90 tonnes of waste.

All the above squarely explain the disastrous situation of Udaipur Lake -system and call for an urgent action to remedy situation.

Figure 4.16: View of Lake Rang Sagar

Figure 4.17: View of Lake Swaroop Sagar

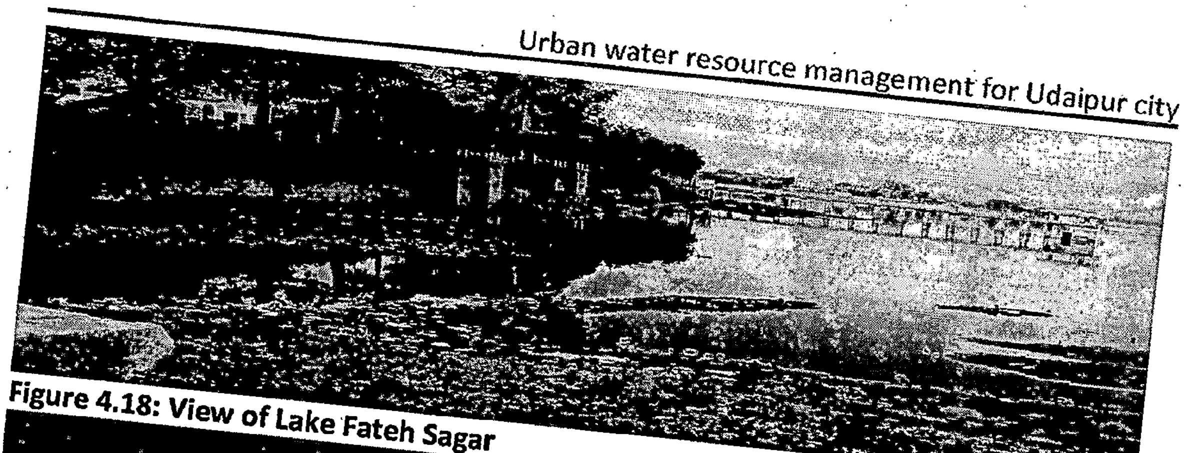


Figure 4.18: View of Lake Fateh Sagar

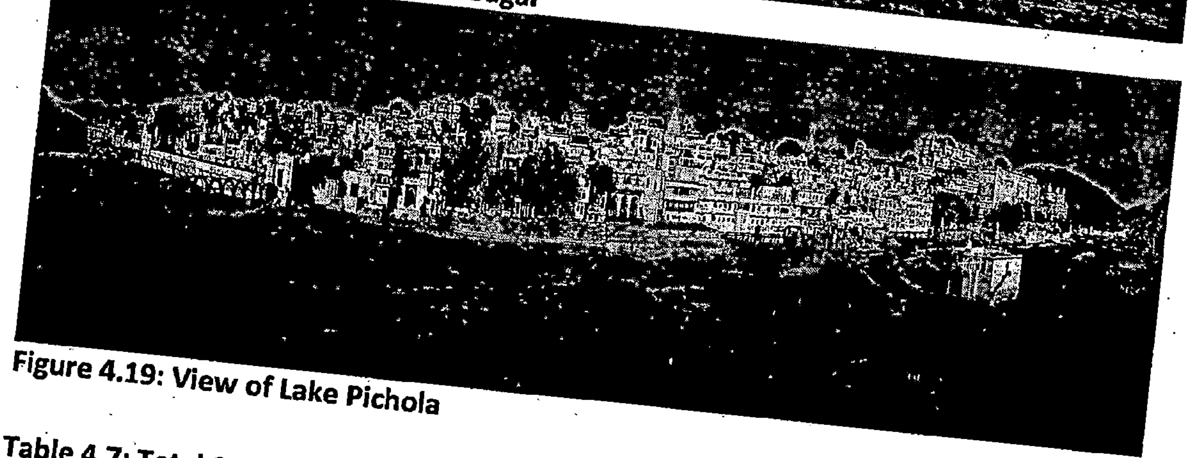


Figure 4.19: View of Lake Pichola

Table 4.7: Total Solid Waste Disposed in Udaipur Lakes

S. No.	Name of the Lake	Total Solid Waste (in Tonnes)
1	Lake Pichola	95.00
2	Lake Rang Sagar	120.00
3	Lake Kalia Talav	50.00
4	Lake Swaroop Sagar	150.00
5	Lake Fateh Sagar	90.00
TOTAL		505.00

Source: Zheel Sanrakshan Samiti Report

4.7.3.1. Chemical Pollution Levels

pH: All the water bodies of Udaipur lake system exhibit moderate to high alkaline pH. The pH data pooled from different studies are given in table 4.7.

Table 4.8: pH of Water Bodies

Year	Pichola	Rang Sagar	Swaroop Sagar	Fateh Sagar	Bari	Madar
1974-76	7.7-7.8	-	-	7.4-9.2	8.2	-
1984-86	7.8-8.7	-	-	7.8-9.5	-	-
1987	7.7-8.4	-	-	7.5-8.35	-	-
1988-91	7.5-8.6	-	-	7.5-8.0	-	7.5-8.4
1994	8.0-8.7	8.0-8.4	7.8-8.5	8.2-8.7	-	-

Source: Zheel Sanrakshan Samiti Report

4.7.3.2. DO (Dissolved Oxygen):

The variations in dissolved oxygen contents of Udaipur lakes have been wide from zero values in the bottom water to values as high as 17ppm. The dissolved oxygen levels in surface waters of Udaipur Lakes are as follows: (Table 4.8)

Table 4.9: DO (Dissolved oxygen) Content of Water Bodies

Year	Pichola	Rang Sagar	Swaroop Sagar	Fateh Sagar	Bari	Madar
1974-76	4.4-11	-	-	0.5-12	-	6.8
1984-86	9.2-23.2	0.8-8.6	8.4-23.2	8.0-22.8	-	-
1987	6.37	-	-	6.57	-	-
1988-91	3.5-13.0	-	-	5.6-14.30	4.53-11.0	-
1991-92	-	-	-	-	-	6.8-11.6
1994	5.0-8.4	3.4-14.0	4.6-17.0	4.4-9.4	-	-

Source: Zheel Sanrakshan Samiti Report

4.7.3.3. BOD (Biological Oxygen Demand):

During 1984 -86 the levels of B.O.D. in surface waters of Udaipur ranged between 4.6 -19.4 ppm depicting following specific ranges: (Table 4.9)

Table 4.10: Range of B.O.D. (Biological Oxygen Demand):

S.no	Lake	Range of B.O.D.
1.	Rang Sagar	7.6-14.2
2.	Swaroop Sagar	8.2-16.2
3.	Fateh Sagar	4.6-12.0
4.	Pichola	6.4-13.5

Source: Zheel Sanrakshan Samiti Report

4.7.3.4. COD (Chemical Oxygen Demand):

The 1974 -76 Tidy's test performed on the water samples of Pichola, Fateh Sagar and adjoining water body Dudh Talai, which indicate the following values. (Table 4.10)

Table 4.11: COD (Chemical Oxygen Demand) value in water bodies

S.no	Lake	Value
1.	Pichola	2.8
2.	Dudh Talai	6.0
3.	Fateh Sagar	0.8

Source: Zheel Sanrakshan Samiti Report

In Udaipur, over 70% of daily water supply from PHED pumping station is drawn from the lakes, which are highly polluted by anthropogenic activities. The human inference in the lake ecology has greatly enhanced the risk of water borne diseases.

4.7.4. Water Treatment

Udaipur has nine water treatment plants. These are tabulated below indicating their installed capacities. Figure 4.20 shows the location of treatment plants in Udaipur city.

Table 4.12: Showing Existing Water Treatment Plants

Description	Capacity (MLD)	Construction year
Patel circle RGF Plant	7.57	1997
Neemach Mata RGF Plant	11.35	1996
Doodh Talai RHB	2.85	1994
Ambavgarh Slow Sand Filter Plant	1.36	1994
Doodh Talai RGF Plant	13.64	1976
Fateh Sagar RGF Plant	2.27	1970
Gulab Bagh RGF	4.54	1968
Gulab Bagh Pressure Filter	2.27	1968
Fateh Sagar Pressure Filtration Unit	1.72	1968
Total	47.57	

Source: Concept Note on Mass Balance of Water Source and Distribution for Udaipur City, RUIDP.

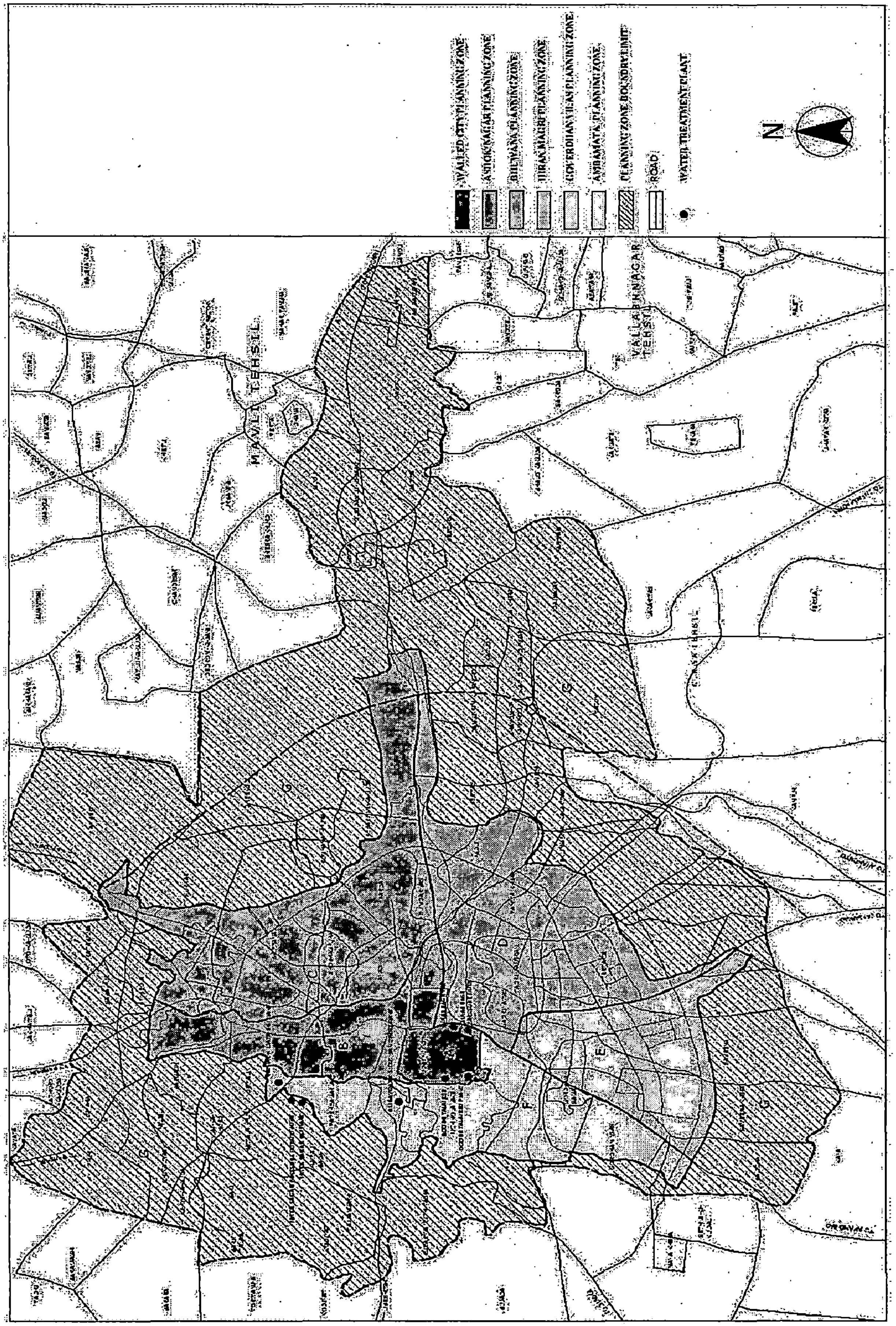


Figure 4.20: Location of Water Treatment Plants in Udaipur City
Source: Udaipur Master Plan, 1997-2022

Chapter-5

ANALYSIS AND FINDINGS

[After obtaining the information about the city and its water resources it is time to analyze the conditions before suggesting recommendations. The following chapter analyzes the situation based upon the information gathered by various primary and secondary sources of information.]

The present scenario of available water resource in Udaipur can be understood clearly from the results of primary & secondary data found by investigation with in the city. To assess the available water resources and their management, the control parameters responsible for provision of water, are identified. In the present investigation the parameters identified under water resource management. Are as follows:

1) House holds covered by public water supply system.
2) Household dependent on private water supply system.
3) Household using community sources of water supply.
4) Household getting adequate water.
5) Quantity of water supply consumption in liters.
6) Duration of daily water supply.
7) Water supply maintained by public agency.
8) Community organization on water supplies resource management.
9) Affordability in paying the water tariff.
10) Usage of treated waste water.
11) Usage of rainwater harvesting system.

5.1 Primary Household Survey

An effort was made to give equal importance to the three categories of household namely, LIG, MIG and HIG. The following facts came out from the household survey.

5.1.1. LIG Category

- The duration of water supply this category was found @ 1 hr. to 1.5 hr. per day.
- The usage of water in this category was calculated to be 70 lpcd and people depend on private sources of supply such as tankers etc. in summers.
- The quality and quantity of water supplied is unsatisfactory.
- Some of the households use public water supply and public stand post.
- No awareness about rainwater harvesting. Conservation of water is not practiced.

- Pressure of water found very low.

5.1.2. MIG Category

- The duration of water supply in this category was found same as LIG category (@ 1 hr. to 1.5 hr. per day) but the pressure of water has found better as compared to LIG category.
- The usage of water in this category was calculated slightly higher than LIG category it is to be 80lpcd there is heavy dependency on tankers and other private sources of supply in summer time.
- Dissatisfaction over quality and quantity of water supplied.
- Most of the households use public water supply, and some are using own source like tube well etc.
- Awareness about rainwater harvesting but conservation of water is not practiced.

5.1.3. HIG Category

- The duration of water supply in this category was found higher slightly than LIG and MIG (@ >1.5 hr. per day) and the pressure of water also found better as compare to MIG category.
- The usage of water in this category was calculated higher than MIG category it is to be 90lpcd there is lees dependency on tankers and other private sources of supply in summer time.
- Satisfaction over quality and quantity of water supplied.
- Most of the households use public water supply, and some are using own source like tube well etc.
- Awareness about rainwater harvesting but conservation of water is not practiced.

5.2. Analysis Based on Secondary Data

- 83.33% i.e.55mld of total water supply is met through 4 nos. of surface water sources, that are located in western part of the city and rest of 16.67% i.e. 11mld of total water supply is met through the 50 nos. tubewells and 32 nos. open wells located in all other parts of the city
- The most of low income group's household depends on public stand posts. There are 2,141 public stand posts.
- 70 % the residents are not satisfied about the present water quality in term of water pressure, duration of water supply (1-1.5 hr/day) and quality of water etc.
- It is observed during the survey that the high-income group residents consume slightly higher quantity of water approx. 90lpcd compare to LIG and MIG category.
- Resident use to store water during supply hours in their own water storage tank of 300-1000Lt. capacity to meet their demand.
- At some places i.e. walled city sewage contaminates the water supply lines, (the pipe lines being very old)
- At present there are 9 water treatment plants only having the total capacity to treat water of 47.57mld.(figure 5.1)
- Transition loss is 2.54 % i.e. 1.67mld of total supplied water.
- Around 53 hotels and 6000 residential house accommodating 33,000 people are located on the slopes surrounding the lake, releasing all untreated water into the lakes.
- Apart from this, a total of 505 tones of solid waste is also being disposed in lakes.

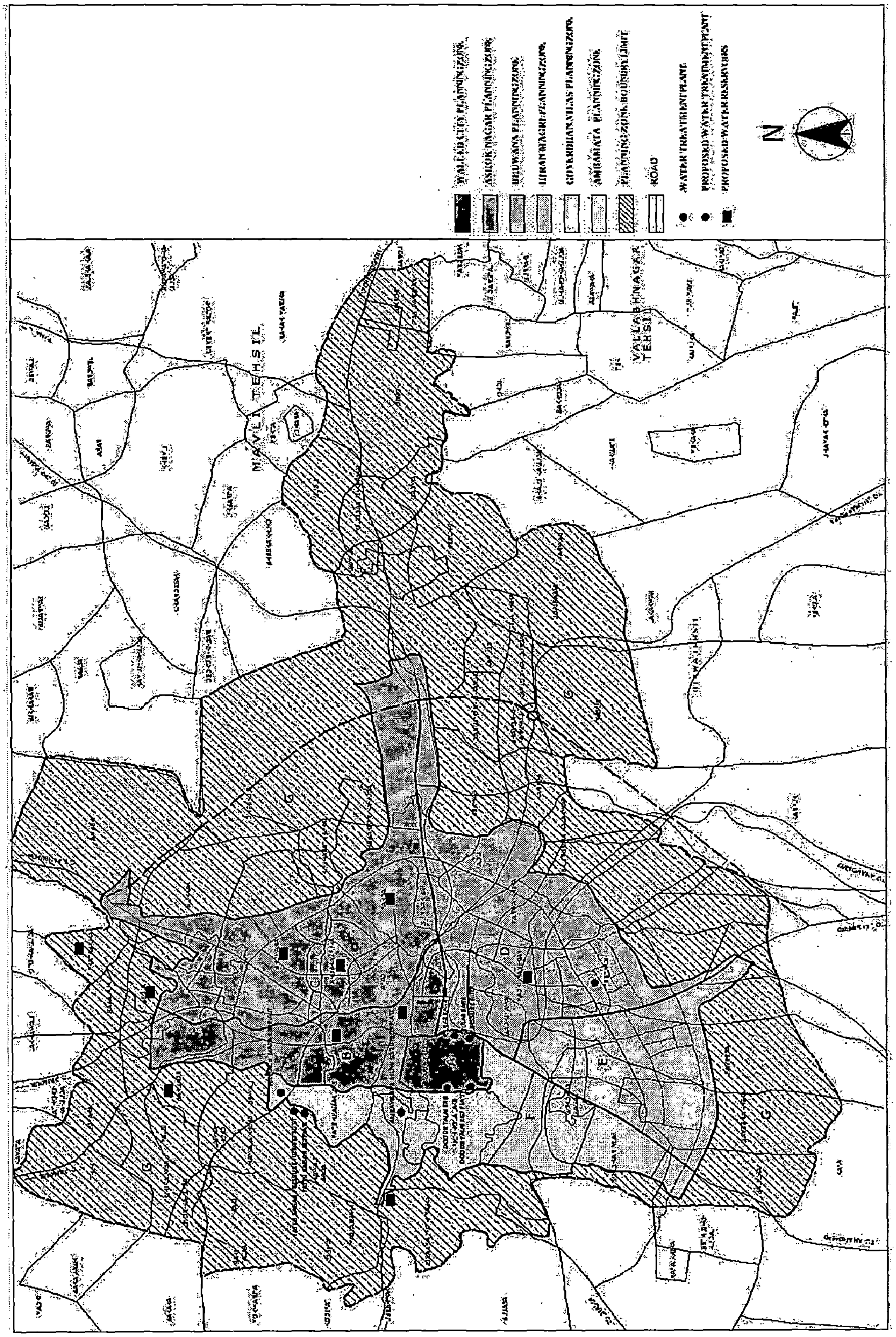


Figure 5.1: Location of existing, proposed (WTPs) and proposed Water Reservoirs in Udaipur City
Source: Rajasthan Urban Infrastructure Development Project

Chapter-6

PROPOSAL AND RECOMMENDATIONS

[After analysis the data and the findings. The following chapter gives some proposal and recommendation for improving the water resource and water supply system in Udaipur city.]

The planning proposal for water resource is based on providing additional requirements for present shortage and future requirements for year 2011 and 2022 & also improving the present system by better management.

6.1 Demand Calculation

6.1.1 Additional water supply provision required for present and future population

In Udaipur municipal area Present water supply is 66mld. Table 6.1 shows the existing & proposed population in Udaipur city along with the existing average per capita supply & additional present and future requirement. The additional requirement has been arrived on the basis of adopting a per capita requirement of 210lpcd (for the population 2lacks – 5 lacks) and 240lpcd (for the population of 5lacks – 10lacks) as recommended by Bureau of Indian Standards.

Table 6.1 Existing Supply & Additional Supply Requirement

Area	Population	Water supply required	Additional supply required
Udaipur Municipal Area	4.82 lacs (2005)	101.22mld@210lpcd	35.22mld
	5.99 lacs (2011) Projected	143.76mld@240lpcd	42.54mld
	8.30 lacs(2022) Projected	199.20mld@240lpcd	55.44mld

Hence within the municipal boundary of Udaipur city additional supply of 35.22mld is required to meet the present shortage and additional water supply required in year 2011 is 42.54mld and in year 2022 is 55.44mld.

This demand is too high to be met by either the existing water supply system i.e. surface water supplied through Fateh Sagar treatment plant, Gulab Bagh Pressure Filter etc.or through the proposed water treatment plant, proposed overhead water reservoirs and water supply scheme i.e. **Mansi Wakal Water Supply Scheme** under Rajasthan Urban Infrastructure Development Project (RUIDP) .the proposed water treatment plants and water reservoirs shows in figure 5.1.

6.1.2. Proposed Water Treatment Plant and Over Head Water Reservoirs under (RUIDP)

In order to provide proper water supply to the city of Udaipur under water supply sector RUIDP has taken up construction of 2 nos. WTP's of 13.35 MLD at Teetardhi & 23.35 MLD at Nandeshwar, 12 Elevated Reservoirs, 4 Clear Water Reservoirs, 55 Km distribution pipe lines, 58.80 Km rising mains. Out of these 13.5 MLD capacity filter plant, at Teetardhi has been fully commissioned and connected with the existing system. Commissioning of System at Teetardhi has increased water supply to Udaipur city and has also resulted on saving of power charges. Water supply from service reservoir at Ambamata, Badgaon, Bhuwana, Shobaghpura, Bedla, Kumbha Nagar, Town Hall, Keshav Nagar, Pahada, Pratap Nagar, Purohito Ki Haveli, Kanwarpada, Tekri, Panerion Ki Madri, Sector 11, & Eklavya Nagar has been started. Total 114.00 Km pipe line Distribution pipe line has been laid and all are connected & commissioned.

In Mansi Wakal zone from Nandeshwar to Dudtalai and in Jhamer Kotda zone 32.65 km pipe line has been laid to connect over head water reservoirs. Construction of over head water reservoir in Eklavya Nagar, Tekri, Paneryo ki Madhdi, Purohito ki Haweli, Sector 11 and Kavarpada School is to be done. In Pratap Nagar construction of ground water reservoir has also to be done.

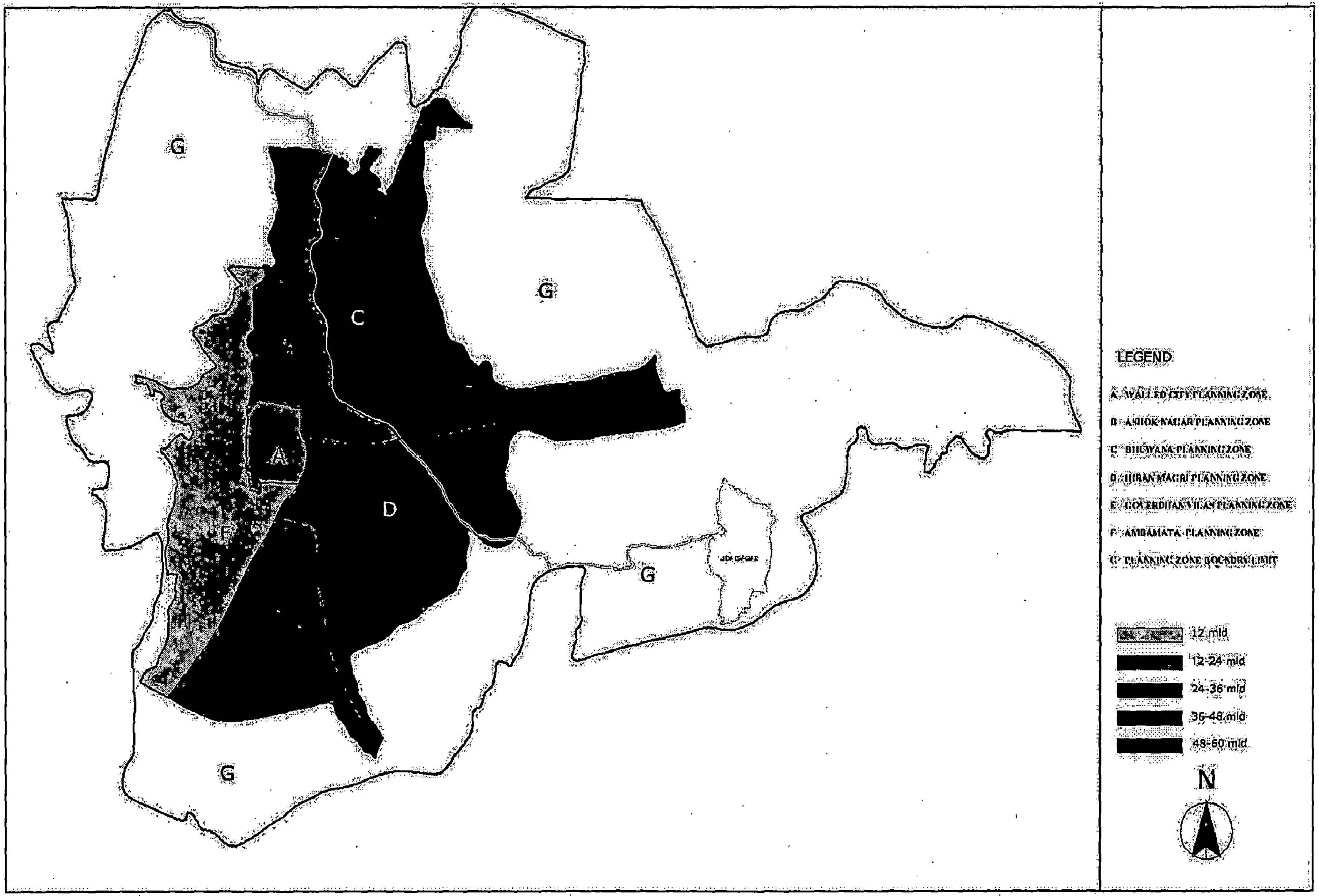


Figure 6.1: Future Water Demand (2022) in Udaipur city
Source: Udaipur Master Plan, 1997-2022

6.2 Proposed water supply

The water demand in the developed area of Udaipur city as been met by four sources these are:

6.2.1 **Rainwater harvesting**

6.2.2 **Recycling of waste water**

6.2.3 **Surface water system**

6.2.4 **Ground water system**

6.2.1 Rainwater harvesting

The total area that has been developed in 2022 is 94.616 Sq.km.(23,380 acres) The proposed landuse and thus, rainwater that can be harvested with in this area in given in table:6.3

Table 6.3: Amount of Rainwater to be harvested

Landuse	Landuse %	Area under use (Sq.mts.)	Coefficient of runoff	Avg. annual rail fall (in mts.)	Total Water Harvested (per year in ML)
Residential	57.33	$54.15X10^6$	0.6	0.63	20468
Commercial	5.22	$4.94 X10^6$	0.82	0.63	2551
Industrial	4.75	$4.49 X10^6$	0.75	0.63	2122
governmental	1.45	$1.38 X10^6$	0.82	0.63	711
Recreational	10.39	$9.83 X10^6$	0.82	0.63	5080
Public/ Semi Public	10.35	$9.79 X10^6$	0.82	0.63	5059
Circulation	10.61	$10.04 X10^6$	0.82	0.63	5185
TOTAL					41176

Thus, the water that can be harvested on daily basis is 113 MLD on an average.

6.2.2 Recycling of waste water

According to the standards, for a total demand of 270 lpcd, 30 lpcd id used for flushing. Thus 11% of the total demand is wasted i.e. this water does not any scope of recycling.

Thus, from a total demand of 199.20 MLD, 21.91 MLD is wasted. Out of the rest 177.29 MLD, it is estimated that 60 %is usually wasted and rest amounts is 71.92 MLD.

This is the amount that is proposed to be recycling. Assuming 4% water losses in conveyance, finally 69.08 MLD is proposed to be supplied back into the area after proper treatment.

6.2.3 Surface Water System

The rest of the water demand i.e. the amount is excess of demand met by rainwater harvesting and recycling, is finally met by the surface water system. Above two sources meet a total demand 182.08 MLD. Thus, only 17.12MLD water needs to be supplied to city by distribution system.

6.3 Recommendations for Improving Water Resource

The opportunities to improve the water resource and fresh water supply situation in the city are very few. These recommendations are chosen for their simplicity of implementation. They do not constitute the only set of solutions, but from the analysis of the data and experience gained, represent the most pragmatic methods of reducing the demand for water while ensuring the greater availability of the most precious of resources. Saving and conserving of water irrespective utility must be adopted as a principle by each and every citizen thinking that "By Saving Water, They are Saving The Nation" as a whole.

6.3.1 People's participation

i) A campaign to encourage people to practice water-conservation and attempt ground water recharge to ensure sustainable fresh water supply within the city.

ii) Non-domestic sector initiatives providing fiscal incentives for reusing wastewater, and promoting, identifying and propagating water saving technologies can reduce the demand for water.

iii) Data regarding the various stages of surface water and groundwater development has to be published, widely announced to among agricultural sectors, Water User Groups and Industrial Sectors so that every individual should aware how much they are able to save so that how much they are keeping the water resources reserve for the future generation, as a forerunner for "Sustainable Development".

iv) In this respect all Government, Educational Institutions and NGO's who are dealing the water resources assessment and its allied studies should share their knowledge and findings, so that repetition of same works can be avoided.

6.3.2 Use of surface water

i) The use of surface water should be guided by the principle that any excess available must be instrumental in reducing ground water usage.

ii) Implementation of better Participatory Watershed & Irrigation Management and Conjunctive use Techniques, forming of Water User Groups, improved irrigation systems, Water Harvesting Techniques, etc should maximized to reduce the utilisation of water resources and also reduce the runoff, so that the surface water collected can be make use off for other primary uses.

6.3.3 Water storage

i) Aquifers must be viewed as storage systems, and all initiatives to augment the ground water availability must be encouraged and supported.

ii) While preserving the groundwater availability for sustainable development, care should be taken not to contaminate or pollute the existing groundwater aquifer.

iii) Specifically, adoption of low-cost rain water harvesting/storage systems and water treatment systems for ground water recharge at a domestic-level. For domestic purposes where the saturation is very less and the thickness is very minimum, roof water / rainwater harvesting can be done by ground level storage system by constructing sump below each of their houses in their respective basement itself, so that the harvested water can be used to meet their daily requirement after proper purification.

6.3.4 Restructuring Transmission mains system, rehabilitation of WTPs

It is proposed to restructure the transmission main system to rectify problems caused by varying pressures in the system. Measures for upgrading pumping stations efficiency, construction of new booster pumping stations and ground level reservoirs to serve new areas, identification of tappings and unauthorized distribution off-takes in the transmission mains, and their removal needs to be also undertaken with immediate effects.

6.3.4 Pricing for water

i) Water metering - There is an immediate need for accurate cost-effective water meters that can be used for the intermittent supply system in Udaipur.

ii) Collection of water charges should be enforced strictly.

iii) There is a proverb that anything gets free, it does not have any value or the consumptions cannot be controlled.

iv) Unless if the beneficiaries pay and incur some monthly expenses, then only they feel how to conserve the precious water.

v) Previously the water resources were enormous but whereas the beneficiaries were very less, that is why nobody feels any difficulty.

6.3.5 Corrective Measures to solve the Water Pollution Problems

i) The main factors responsible for ground water resource development assessments are geology, geomorphology, lineaments; hydrology etc. Water potential zones are demarcated as high low and medium, sewage system for entire city has been identified.

ii) The drainage system of an area gives important clues of the sub surface conditions, which helps in deciphering ground water condition of that area. Water divide zones are delineated with the help of drainage map because; the zones where no percolation of water takes place are not suited for ground water storage.

iii) The solid waste management is also an important aspect. Wherein best suitable land has been selected looking to the available topography and geological condition of the city. Safe distance from habited area suitability of treated affluent

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Annexes-1 **Survey Schedule**

1. **Demographic Characteristics:**

1.1 Name of the family Head:..

Age............ Occupation.............................. Education.................... Income............

1.2 Total numbers of persons in family....................

1.3 Present Address:..

2. **Housing type**

a. HIG ☐ b. MIG ☐ c. LIG ☐

3. **Water Supply:**

3.1. Source of water supply

a. Public ☐ b. Tube well ■ c. Other ☐

3.2. Frequency of water supplied

a. Twice in a day ☐ b. Once in a day ■ c. Alternate day ☐

3.3. Duration of water supply

a. >1.5 hr. ☐ b. 1 – 1.5 hr. ☐ c. < 1 hr. ☐ d. Round the clock ☐

3.4. Is there an acute water shortage during summers (Y/N).......................

3.5. Do you need Water tankers to augment water supply (Y/N)...................

3.6. If yes, how frequent

a. Once in a week ■ b. Twice in a week ■

c. Fortnightly ☐ d. occasionally ☐

3.7. What is the cost for tanker...................Rs.

3.8. Are you satisfied with the water quality (Y/N)..................

3.9. If no, which one among these is a problem
a. Colour □ b. Odour ■ c. Taste □

3.10. Pressure of supplied water
a. Adequate □ b. Inadequate ■

3.11. Do you have to use electric motor to augment water pressure
a. No □ b. Yes ■

3.12. Rain Water Harvesting in practice (Y/N)..........................

3.13. Recycling/ reuse of waste water
a. Yes □ b. No □

3.14. Do you have underground water tank (Y/N).....................

3.15. What is the size of your under ground water tank.........................

3.16. Do you have bore well (Y/N).....................

3.17. What is the typical water supply bill...............................Rs.

3.18. Quantity of water being used ....liters per day

3.19. Billing period
a. Monthly □ b. Bimonthly □ c. Quarterly □
d. Half yearly ■ e. Yearly □

Remarks ....