PLANNING FOR SUSTAINABLE DRINKING WATER SUPPLY SYSTEM IN INDORE CITY

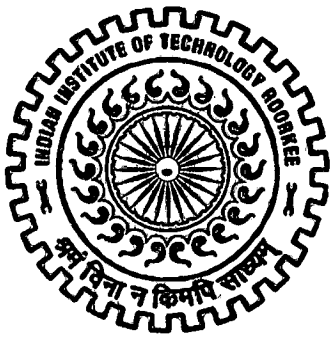
A DISSERTATION

Submitted in partial fulfillment of the requirements for the award of the degree of

MASTER OF URBAN AND RURAL PLANNING

By

SHRADDHA MAHORE



DEPARTMENT OF ARCHITECTURE AND PLANNING
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE
ROORKEE - 247 667 (INDIA)

JUNE, 2006

CANDIDATE'S DECLARATION

I hereby certify that the work which is being presented in the dissertation entitled **'PLANNING FOR SUSTAINABLE DRINKING WATER SUPPLY SYSTEM IN INDORE CITY'** in partial fulfillment of the requirement for the award of the Postgraduate Degree of **MASTER OF URBAN AND RURAL PLANNING** submitted in the Department of Architecture and Planning, Indian Institute of Technology-Roorkee, Roorkee is an authentic record of my own work carried out during the period from August 2005 to May 2006 under the supervision of Dr. V. Devadas.

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

Place: Roorkee

Date: June , 2006

(SHRADDHA MAHORE)

This is to certify that the above statement made by the candidate **SHRADDHA MAHORE is** correct to the best of my knowledge.

Dr. V. Devadas
Associate Professor
Deptt. Of Architecture& Planning
Roorkee-247667

Place: Roorkee
Date: June , 2006

CERTIFICATE

Certified that this dissertation entitled **'PLANNING FOR SUSTAINABLE DRINKING WATER SUPPLY SYSTEM IN INDORE CITY'**, which has been submitted by **Shraddha Mahore**, in partial fulfillment of the requirements for the award of the Postgraduate Degree of **MASTER OF URBAN AND RURAL PLANNING** submitted in the Department of Architecture and Planning, Indian Institute of Technology-Roorkee, Roorkee is the student's own work carried out by her under my supervision and guidance. The matter embodied in this dissertation has not been submitted for the award of any other degree elsewhere.

Roorkee
Date: June , 2006

V. Devadas

Dr. V. Devadas
Associate Professor
Department of Architecture & Planning
Indian Institute of Technology
Roorkee – 247667

ACKNOWLEDGEMENT

I would like to express my deep sense of gratitude, indebtedness and sincere thanks to my guide Dr. V. Devadas, Associate Professor, Department of Architecture and Planning, Indian Institute of Technology Roorkee, Roorkee, for his constant encouragement and invaluable guidance towards the successful completion of this work.

I convey my sincere gratitude to all government, semi government and other organizations that helped me in data collection. I am thankful to school committees for organizing seminars and people of Indore city who helped me while doing primary survey.

I am also thankful to my family members and friends for their source of inspiration, support and faith in me.

Date: June , 2006 SHRADDHA MAHORE

Place: Roorkee

CONTENTS

List of Tables

List of figures

Chapter 1: Introduction

1.1 Introduction

India is enriched with natural resources. These resources have given rise to a rich culture and civilization in the country. Fertile land, iron ore, bauxite, and copper ore are the main resources in India. She is one of the major producers of iron in the world. Gold, silver, and diamonds make up a small part of other natural resources available in India. According to CIA, (2000) India is the fourth-largest coal reserves in the world. It is estimated that India has around 120 billion tons of coal in reserve, enough to last for around 120 years. Other abundant resources are manganese, mica, bauxite, titanium ore, chromites, natural gas, diamonds, and limestone. Huge reserves of petroleum have been found in the coastal regions of India. Being agriculture based country; India has the largest arable land, which is close to 39 per cent of Asia's arable land.

Indians worship everything related to five constituent elements, i.e., air, water, earth, sky, and fire. All the natural resources are worshiped in India in this way. They worship the sun, the moon, forests, trees, mountains and water bodies. Figure 1.1 presents a man worshiping in river water. This worship just not means joining hands in front of it but a regard to conserve, preserve and restore the nature. Modernization has changed the attitude of the people. Man exploited these natural resources since ages, and as a consequence these natural resources, i.e., free goods of past are turned into economic goods at present, and the typical example is 'water'[1].

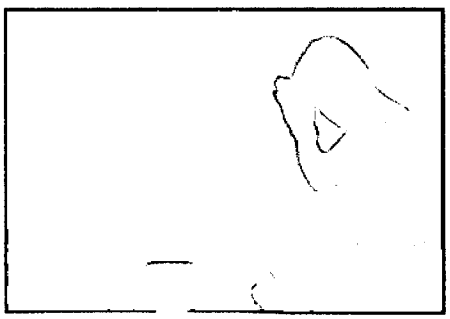


Fig. 1.1 Man worshiping in Ganges water

India has a number of rivers. Rivers have played important river in Indian settlements, architecture and culture. River Ganges has a special place in the psyche of the Indian people as being the most sacred of all Indian rivers. Since time immemorial it has influenced the cultural and religious lives of the Indian people which are eloquently reflected in its awe inspiring references in mythology and folk lore and in being and integral part of various cultural and religious festivals and rituals.

[1] CIA: the world fact book

Deoprayag, Rishikesh, Haridwar, Garhmuketeshwar, Allahabad and Varanasi are some of the holy places on its banks which attract people from all over the country and even from abroad.

Brahmaputra River, as the name states, son of God Brahma; the creator of world is considered as the gift of this creator God for extinguishing the thirst of Indians. Many of the important pilgrimages are confined on the banks of major rivers, so as the people come and worship these rivers too. For example, Shiva is the prime God of Hindus. There are twelve major temples of Shiva and most of them are confined on the edges of water bodies, which are called Jyotirlingas. This is a Sanskrit word and consisted of two words, Jyoti; (that means the light) and Linga (that means Shiva). These twelve pilgrimages are situated in such a way that whole India can be easily approached, in order to take the positive effects of the light of blessing of Lord Shiva. Omkareswar and Mahankal are situated on the banks of Narmada River and Kshipra River respectively in Madhyapradesh. Tryambakeshwar (close to Nasik city) is situated on the banks of River Godavari. Rameshwaram is situated on the shore of Arabian Sea. India is a country of diverse culture, but the main theme of culture is same in all over the country. Water and worship are interlined in the South Indian culture too. There is rocky land in South India and the surface water is less and to come over this problem, approximately one-third of the irrigated area of TamilNadu is covered by *eris* (tanks). The Eris are the temple tanks and it is presented in Figure 1.2.

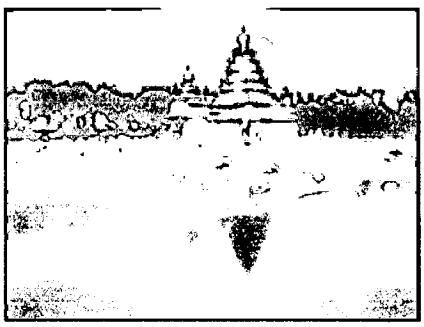


Fig. 1.2 Eri, a typical temple tank in South India

Temple and tank were placed together so that people come here after taking bath to take water. Water is considered as an auspicious commodity, so no contamination can take place in the water body. Urbanization has played major role in overexploitation of this heritage, and as a result these are also not in use for humanity.

In accordance with the principles adopted at the International Conference on Water and the Environment (Dublin, January 1992), it was agreed that "fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment"[2]. Looking at the global scenario, three fourth of the earth's surface is covered by oceans. According to the UN (2000)

[2] Lunven Paul (1992) presentation at Urban nutrition conference, Mexico City

estimates the total amount of water on earth is about 1400 million cubic kilometer (m.cu.km.) which is enough to cover the earth with a layer of 3000 metres depth. However, a very small proportion of this enormous quantity is constituted of the fresh water. Fresh water is just about 2.7 per cent of the total water available on the earth and about 75.2 per cent of this fresh water lies frozen in Polar Regions and another 22.6 per cent is present as ground water. The rest is available in lakes, rivers, atmosphere, moisture, soil and vegetation. Rivers, lakes and ground water resources are exploited much for day to day uses. Most of the water is not available for use, and secondly it is characterized by its highly uneven spatial distribution because the crisis about water resources development and management thus arises. Accordingly, the importance of water has been recognized and greater emphasis is being laid on its economic use and better management.

1.2 Urbanization in India and water scarcity

India often faces draught conditions. The base of economy is agriculture and agriculture is dependent upon monsoon. Women in many rural areas, still have to walk a distance of about 2.5 kms to reach the source of water. Villagers do not get enough employment in villages. These drought conditions have pushed villagers to move to cities in search of jobs. The population of urban India is going on increasing due to the migration. Yet the rate of urbanization in India is among the lowest in the world, the nation has more than 250 million city-dwellers. About 50 per cent of India's population will be living in cities by 2020. This is going to put further pressure on the already water supply systems of urban areas.

According to Central Public Health Engineering Organization (CPHEO) estimates (2000), 88 per cent of urban population has access to a potable water supply and this supply is highly not reliable. Transmission and distribution networks are old and poorly maintained, and generally of a poor quality. Daily water supply in typical Indian city ranges from 2-8 hours. The situation is even worse in summer when water is available only for a few minutes, sometimes not at all.

Even though the rate of urbanization in India is very low 2.9 per cent, which is among the lowest in the world, the nation has more than 285.35 million urban populations as per NIUA. According to planning commission, government of India, report it is projected that by 2021, about 41 per cent of India's population i.e. 550 million will be living in cities. This is going to put further pressure on the already strained centralized water supply systems in the urban areas.

Many of the rivers just cannot reach till sea during the dry season and this is a very serious problem. The basic thing is that that water is a finite resource. It is renewable, but finite, and so the water supply per person tends to decrease as the population increases.

1.3 Problem Identification

In spite of having much resources water scarcity is growing phenomenon in India. Due to improper planning of water conservation, today, India is ranked 122 out of 130 nations for its water quality and 132 out of 180 nations for its water availability.

Annual rainfall in India is 400 million-hectare meters. However hardly 20% of this is utilized, rest of it reaches the sea or evaporates. Rural areas are not developed so this cannot be said that the drinking water availability situation is grim in rural areas, but is also a problem in urban areas. The smaller towns which depend heavily or solely on ground water also suffer from scarcity due to depletion/drying up of ground water sources. According to TERI, an NGO in Delhi, the demand for water in urban areas based upon the projections of population growth is estimated to increase threefold from 13624 MCM in 1997 to 39203 MCM by 2047[3]. As against the demand, the availability of water in India will be critical, as the demand from industrial, agricultural, and other sectors will also increase simultaneously putting pressure on the supply to the domestic sector.

In 1955, India's per capita water availability was 5,300 cubic meters (cu.m.). In 2003 this figure was only about 2,000 cu.m. as compared to the global average of 7,420 cu.m and, in Asia, 3,240 cu.m. Statistics say that by the year 2025 the number can drop as low as 1500 cu.m. due to rising population levels, urbanization and systemic abuses of water.

TERI studies projects that the country's total water requirement by the year 2050 will become 1422 BCM (billion cubic meters), which will be much in excess of the total utilizable average water resources of 1,086 BCM. In addition to the gap between the demand and availability of water, the present limitations and inability of the local bodies to deliver the water supply service equally to all sections of society has led to a degradation in the quality and the coverage of service, resulting in poor health conditions and environmental degradation in urban centers. This results in dissatisfaction among certain categories of customers.

[3] http://www.teriin.org/division/padiv/wrpm/docs/ft02.pdf as viewed on July 4, 2005.

Above data shows the alarming demand supply gap in the country in the near future. According to the Planning Commission report between 91 and 93 per cent of India's urban population takes their drinking water from protected sources, leaving an unserved population of between seven to nine percent, but according to Central Public Health Engineering Organization (CPHEO) estimates, 88 per cent of urban population has access to a (Census data 2001) potable water supply.

According to the Planning Commission, the norm for urban water supply is 135 lpcd piped water supply with sewerage system, 70 lpcd without sewerage system. The above figures exclude unaccounted for water (UFW), which should be limited to 15 per cent. There is a huge disparity in water supply to various parts of the country. The extent of water shortfall in large towns is presented in Table 1.1.

Table: 1.1 Extent of water shortfall in large towns (2001)

S. No	City	Rqd. MLD	Shortfall MLD	% Shortfall
1	Mumbai	4000	1030	26%
2	Delhi	3830	880	23%
3	Kolkata	2258	690	31%
4	Chennai	3000	1050	35%
5	Bangalore	840	135	16%
6	Hyderabad	956	186	19%
7	Indore	318	134	42%
8	Bhopal	335	70	21%
9	Lucknow	560	120	21%
10	Jaipur	349	313	90%
11	Jabalpur	239	94.5	40%
12	Vaizag	305	146	48%

Source: a: http://www.unhabitat.org/habrdd/conditions/socentasia/india.htm

- Three per cent of the population receives more than 450 lpcd daily: areas under the New Delhi Municipal Council (NDMC) get 462 lpcd; Delhi Cantonment receives 509 lpcd. Thus, this three per cent receives 11 per cent of the water the Delhi Jal Board supplies.

- In Karnataka, the demand for water in urban areas is 124 lpcd, but the supply is hardly 60 litres. During summer, it goes down to as low as 20 lpcd in some towns.
- Large cities like Ahmedabad, Surat, Vadodra, Jaipur, etc., support thriving ground water business, that draw water from tube-wells in the neighboring hinterlands for supply. The groundwater table in these cities and neighboring areas is falling at the rate of 5-10 feet per year.
- More than six million people in the IT city of Hyderabad and surrounding areas get water for just up to two hours that too on alternate days and even this is uncertain.

Looking at the Indian perspective and a large series of naturally available water resources, the investigator is inspired to make a sustainable drinking water supply plan in the study area 'Indore city '. Having the above in mind, a set of objectives are framed in the investigation.

1.3 Objectives

The Investigator developed a set of objectives to evolve a plausible sustainable development plan for the city with environment considerations. The following objectives are framed.

- To assess the existing condition of the study area pertaining to physical, social, economic, ecology, and environment.
- To assess the water resources availability in the system.
- To assess the water consumption pattern in the system.
- To study the control parameter, which decide the function of the system.
- To project the demand and supply of water resources in the system for 2031 A.D...
- To involve a set of policy guidelines for drinking water supply.

1.4 Scope

The present investigation attempts to evolve a sustainable water supply plan with environmental considerations in the study area. The investigator hopes that the recommendation of the proposed investigation are employed constructively in the study area, the study area will achieve sustainable development.

1.5 Methodology

1.5.1 The survey research methodology

Survey Research Methodology has been employed to carry out the present investigation. Fig. 1.7 presents the methodology.

1.5.2 Research Techniques

Survey Tools:

Survey tools, such as, schedules, questionnaire, etc., are employed to collect the data from people and other tools like quick measuring kit to examine the quality of soil, water and air.

Survey Techniques:

Random Sampling technique has been employed to identify the households to conduct the survey at grass root level. The study area is classified into 11 zones and further classified as 69 wards for development administration. The investigator covered all the 69 wards for conducting the survey. As the output all 69 wards are identified and one household from each ward was selected randomly for conducting the survey, through which 69 households were identified. Further, 31 households were identified from 31 water scarcity prone wards. A total of 100 households were identified and conducted the survey for this present investigation.

Analytical Tools:

Relevant analytical tools, such as code sheets, computer hardware, software (Excel, Auto-cad, and Photoshop) shall be used for data processing & analysis.

1.5.3 Data:

Two sources of data will be collected and shall be employed in this investigation. They are:

a) Secondary Sources: Published literature and unpublished literature, documents, Data from different organizations such as Pollution Control Board, Indore Municipal Corporation, Indore Development Authority etc., pertaining to this investigation.

b) Primary Sources: Conducting survey at various levels for obtaining the requisite data.

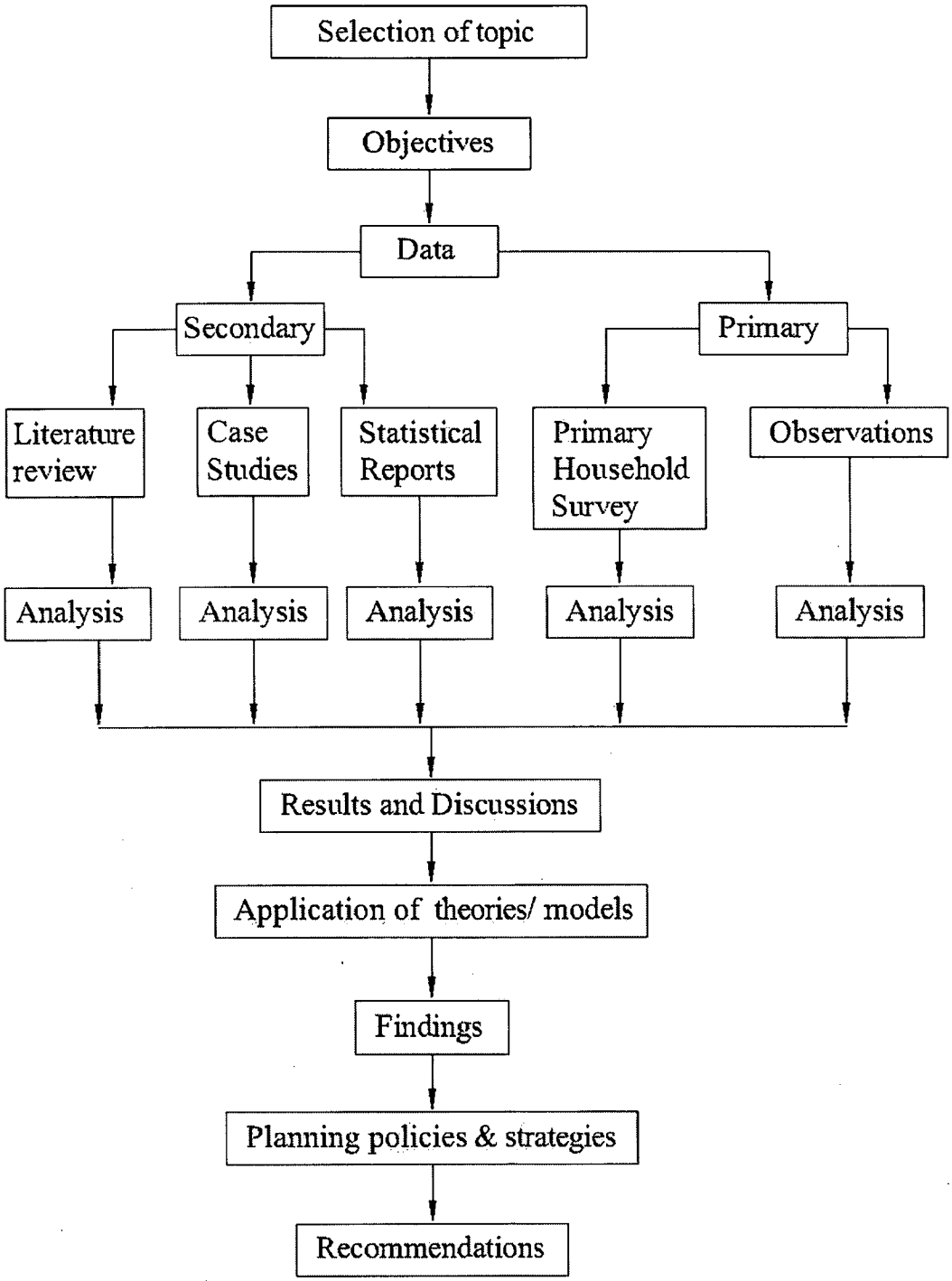


Fig.1.3 Methodology

1.5.4 Analysis

Analysis will be done on the basis of literature survey, and survey results.

1. Results & Discussions

Results of all types of analysis, such as, literature review, household survey, regression, forecasting etc., will be discussed is detail to draw inferences.

2. Application of theories/ models

In the present investigation, the Investigator intends to employ theoretical conceptualization of System Dynamics theory to establish the functions of the urban system. Finally, the role of sustainable drinking water supply, which is conducive for sustainable development, shall also be established for total development.

3. Findings

Plausible findings will be drawn from the investigation for evolving a set of policy guidelines and for developing a drinking water supply plan for the development of the system.

4. Recommendations & Conclusions

Plausible recommendation will be made to achieve sustainable drinking water supply system in the study area. The study will conclude with plausible recommendation.

Chapter 2: Literature Review and Case Study

2.1 Review of literature

The cities are growing in size. According to World commission on Environment and Development (1987), the future will be predominantly urban, and the most immediate environmental concerns of most people will be urban ones. People start living together in cities and the population density of the urban area goes on increasing. This growing size of cities is becoming the problem of not only in India, but the whole world. Human activities mark harmful impact over the environment. There should have been a check over these harmful activities. Awareness has been observed for the environment related activities. The concept of sustainable development is the result of the growing awareness of the global links between increasing environmental problems, socio-economic issues and inequality and concerns about a healthy future for humanity. It strongly links environmental and socio-economic issues[4]. The fulfillment of human needs and control over these activities when are brought together, this approach leads towards sustainable development, although these two are just contradictory.

Keeping this in mind, the Author has reviewed few more relevant research papers and few books that cover sustainable development, natural resource management, water resource planning, waste water management, rain water harvesting, ground water recharging, various government policies regarding water supply and public participation in planning etc. and are presented as below.

2.1.1 Sustainable Development

Human needs can be classified into two parts; one part is an access to adequate shelter and healthy environment and the second is an access to adequate livelihood. The access of adequate livelihood means the exploitation of natural resources to generate economic activities and employment generation, while access to adequate shelter and healthy environment requires the provision of adequate infrastructure. Any area cannot fulfill all the needs of a settlement independently and people start taking use of distant or alternate sources. There are two issues in

---

Byrne, J. etal. (1985), 'The post industrial imperative: energy, cities and the featureless plain' In Byrne, J. and Daniel Rich (editors), Energy and Cities, Energy Policy studies, Vol. 2 Transaction, New Brunswick

sustainable development i.e. sustenance of the cities in terms of life of the city, and sustenance of the system, where inhabitants development needs are met without imposing unsustainable demands on local or global natural resources and system.

The natural environment of site is converted into the built environment in order to develop the city. A kind of environment is built in city that has unique form of natural, built and cultural environment[5]. High density urban living in particular fundamentally alters the ecology of an area, not least in terms of human health, often leading to more physical injuries, from industry and transport[6].

Many authors have given different definitions for Sustainable development and most of them have focused upon how present environmental constrains might be overcome and standard of living maintained and a thought is given for all people in world might obtain the resources they need for survival and development.[7]

Haughton has summarized the ideas of sustainable development in five principles based on equity: futurity- inter-generational equity; procedural equity- people treated openly and fairly; inter-species equity- importance of bio-diversity. These principles help give clarity to the ideas of sustainable development, link human equity to the environment, challenge the more bland and meaningless interpretations and provide a useful basis for evaluation of the different trends of sustainable development.

World Commission on Environment and development (WCED, 1987), also known as Brundtland Commission defines Sustainable development as; *"Sustainable development is development which meets the needs of the present without compromising the ability of future generations to meet their own needs."*

The present and future environment is seriously affected by the growing number of people and changing technologies. Planning for sustainable drinking water supply is a part of Sustainable

---

[5] Byrne John, Young-Doo Wang, Bo Shen and Xiuguo Li. *"Sustainable urban development strategies for china"* Environment and Urbanization, vol. 6, No.1, April 1994, pp. 174-187

[6] Rees William E. and Westra L. "Cities, communities and environmental justice"

[7] McMichael 1993

Development. The scope of planning is increasing day by day with the advent of bringing sustainable development in the system. This has attracted the attention of many environmentalists and planners, as it is concerned with combining the growing concern about a range of environment issues with socio-economic issues. All the aspects of sustainable development, including drinking water supply have the potential to address the fundamental challenges for humanity, now and into the future.

A widespread response has been given to Sustainable Development throughout the world[8]. A preference that is given to objectives of Sustainable Development is addressable. Generally the first preference is given to economic sustainability. Social sustainability stands second followed by the ecological sustainability. Lamberton G. referred Gautam Buddha's philosophy to define sustainability and a hierarchy of its objectives. Buddha has given a value system and paths to follow it. Right action, Right livelihood, Right effort, Right mindfulness were the main paths amongst this eightfold path. Economic sustainability is important hence Buddha has given some principles of economics which contribute a lot in the theory of Sustainable development. Inoue (1997) identifies three aspects of Buddhist Economy. He says that Economy should benefit oneself and others, it must be of tolerance and peace and finally it should save the earth. According to Schumacher (1973), five key principals of Buddhist economics pertain to work, consumption, simplicity, non-violence and natural resource conservation. There is a clear distinction of human welfare from material greed in Buddhist economy. Modern world assumes that happiness is in abundance and luxuries, while Buddha emphasised upon relatively lower rate of consumption and human beings must be satisfied with this. Less consumption will definitely save the earth and natural resources.

The meaning of sustainable development in today's context is the creation of sustainable livelihoods[9]. The resources to provide basic services (food, shelter and clothing) as well as a system of generating employment by means of flow of resources should be sustainable. It is about the preservation and conservation of resources. Ecological sustainability and equitable socio- economic development go hand in hand, that each is prerequisite for the other.

---

[8] Patara Shrashtan "Shelter andsustainable development" Development alternatives Jan1993 p.17

[9] Rees William E. and Westra L. "Cities, communities and environmental justice"

2.1.2 Natural resource management

Natural resources are the wealth of the Nation. Massive destruction of these resources is the result of utilization without protection. The other reasons behind this destruction are massive population growth, rapid development of urbanization and industrialization etc. New technologies are developed which make work easier and at the same time no consideration is kept against destruction[10]. For example, to reduce the distances, speedy vehicles are introduced, which consume fuel and also produce smoke. All the Indian cities are suffering from pollution by diesel engines. India is dependent upon Arabian countries for petro- products. Nature has its limit for extraction of such fuels, and on the other hand, it's absorbing or sink capacity is also definite.

Natural capital can be estimated according to its carrying capacity. Ecologists define this carrying capacity as the population of a given species that can be supported indefinitely in a given habitat without permanently damaging the ecosystem upon which it depends. Natural Environment provides a sink for society's waste products. For human beings, carrying capacity can be interpreted as the maximum rate of resource consumption and waste discharge that can be sustained indefinitely in a given region without progressively impairing the functional integrity and productivity.

The inverse of carrying capacity provides an estimate of natural capital requirements in terms of productive landscape. This productivity is just not relevant with urbanization and growing population. The cities are growing irrespective of the carrying capacity of the land. The world's great cities are amongst the finest achievements of civilization[11]. These cities play major role in the economic development of any nation. Industrialization and urbanization go parallel. These parallel processes bring many changes in the ecosystem. The natural transformation is observed in the form of river channel diversion or altering of natural flows of energy, water, food and materials. It is possible to see the urban environment as a distortion of natural ecosystem, and by high artificial flows of energy.

---

[10] Ludwig Harvey F. "Moving toward Economic-cum-Environmental Sustainability in Asian Developing Countries", The Environmentalist, vol.10 Number 4 (1990), p. 258

[11] Rees William E. "Ecological Footprints and appropriated carrying capacity: what urban economics leaves out" Environment and Urbanization, vol. 4, No.2, Oct 1992, pp. 121-129

The development of infrastructure in the form of strong communication and transport system, manpower attract people and give rise to consumption[12]. The resources are intensively used and given value according to economic priority to expand production. Technologies are developed to utilize these resources, then further technologies are developed for economic utilization of these resources and when the danger is seen that resources are non renewable and will be finished one day then technologies are developed to save these. The goals are set to save the energy and other resources. The primary means for achieving these goals is through large scale, centralized and capital intensive technological system.

The economic value of natural resources is purposefully kept low to spur rapid growth, and pollution is treated as an unavoidable side effect of economic progress.[13] As a result the world is facing many environmental problems. Lack of safe drinking water, inadequate waste management and pollution control, accident linked to congestion and crowding, occupation and degradation of sensitive lands are the common problems in third world countries.

Cities behave like parasites over the natural environment. According to Peter Berg (1990 c), "Cities are not sustainable because they have become dependent on distant, rapidly shrinking sources for the basic essentials for food, water, energy and materials. At the same time they have severely damaged the health of local system upon which any sensible notion of sustainability depend....In addition, the social system that make cities liveable, such as a sense of community and wide civic participation, are more typically eroded rather than strengthened."

The local resources in the city are needed to be identified. Most of the cities are settled on the river banks. Water is the basic resource of development. The other resources are fertile agricultural land, human resource for agriculture and industrialization, raw materials for industries etc.. Fertile land and water both are ample in India. These resources are worth, but the problem comes when the waste is produced after utilization. Land is utilised in the form of housing, industries, agriculture and market, and also for disposal of waste. The sink capacity is limited, when the disposal of waste is out of the limit then it causes pollution. Wastes are not the problematic, but if properly utilised then it can definitely help in sustainable development.

---

[12] Byrne, J. etal. (1985), 'The post industrial imperative: energy, cities and the featureless plain' In Byrne, J. and Daniel Rich (editors), Energy and Cities, Energy Policy studies, Vol. 2 Transaction, New Brunswick

[13] Byrne John, Young-Doo Wang, Bo Shen and Xiuguo Li. *"Sustainable urban development strategies for china"* Environment and Urbanization, vol. 6, No.1, April 1994, pp. 174-187

Wastes have been considered as a resource in many of the third world countries. Solid waste and waste water which could be collected easily are utilized in many ways. Metal glass and paper are recycled in Europe, Japan and North America. This practice reduces pressure over sinking capacity and also generates employment opportunities.

The concept of Urban Agriculture has become popular in the field of resource management. Agriculture within urban and peri-urban areas has capability to convert the urban wastes into resource. In this way the underutilized and vacant land is taken into productive uses and the natural resources outside the city are conserved well and the urban environment is improved.

Urban agriculture is a large and growing industry, which uses urban waste water and solid waste as inputs which close ecological loops when processed on the idle land and water bodies. Improved nutrition and health, an improved environment for living, increased entrepreneurship and improved equity are the positive impacts of this industry. Still this industry comes under neglected ones[14].

2.1.3 Rain Water Harvesting

Rain Water harvesting involves the collection of water from surfaces on which rain falls, and subsequently storing this water for later use. It can be defined as connectivity of direct collection of rain water and storage of rain water as well as other activities aimed at harvesting and conserving the surface and the ground water. This includes prevention of the loss through evaporation, seepage and other hydrological studies including engineering inventions aimed at most efficient utilization of rain water towards the best use for the humanity. This is an inexpensive and simple technology, and very helpful to conserve and protect the ground water.

Water harvesting structures and water conveyance systems specific to the eco-regions and culture has been developed in all over the ancient India. Ancient Indians harvested the rain drop directly. They collected water from rooftops, and stored it in tanks built in their courtyards. They collected the rain from open community lands and stored it in artificial wells. Another way of rain water harvesting was storage of monsoon runoff by capturing water from swollen streams

[14] Smit Jac and Joe Nasr "Urban agriculture for sustainable cities: using wastes and water bodies as resources" Environment & Urbanization Oct. 1992 vol. 4, No. 2. pp. 141-151

during the monsoon season. Water from flooded rivers was also harvested. Few examples are given below.

- In the Jammu and Himanchal Pradeshregion an irrigation systems called *kuhls (Fig. 2.1)* is popular. *Kuls* are water channels found in precipitous mountain areas. These channels carry water from glaciers to villages. In the muddy terrain, the *kul* is lined with rocks.
- Naula (Fig. 2.2) is a surface-water harvesting method typical to the hill areas of Uttaranchal. These are small wells or ponds in which water is collected by making a stone wall across a stream.
- The *zabo* (the word means 'impounding run-off') system is practiced in Nagaland in north-eastern India (*Fig. 2.3*). Also known as the *Ruza* system, it combines water conservation with forestry, agriculture and animal care. The rain falls on a patch of protected forest on the hilltop; as the water runs off along the slope, it passes through various terraces. The water is collected in pond-like structures in the middle terraces; below are cattle yards, and towards the foot of the hill are paddy fields, where the run-off ultimately meanders into.

Fig. 2.1 Kuls
Source: www.cseindia.com

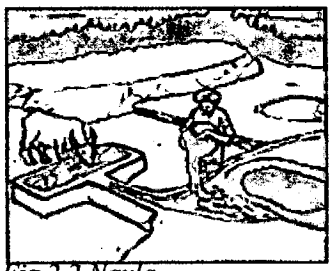


Fig.2.2 Naula
Source: www.cseindia.com

Fig. 2.3 Jabo
Source: www.cseindia.com

There are so many similar techniques which are been used since ages in all over the India. These are Khatri, Apatani, Cheo-oziihi, Bamboo- drip irrigation, Dongs, Dungs, Ahar- pyne, Bengal's Inundation channels, Dighis, Baolis in Gujrat, etc. Yet these are very simple and inexpensive techniques, but are at dying stage. There is a need to encourage the programs which promote use of such techniques.

Nowadays rain water harvesting has become essential because, Surface water is inadequate to meet water demand and dependency over ground water is much and Infiltration of rain water into

the subsoil has decreased drastically and recharging of ground water has diminished due to the rapid urbanization.

There are two main techniques of rain water harvesting.

- Storage of rainwater on surface for future use
- Recharge of ground water

Benefits

- Reduced pressure over storage dams.
- Reduced need of expansion of dams and new dams

Modern system of Installation

The parts of a complete system include the catchment area (a roof), a rainwater conveyance system (gutters and leaders), holding vassals (cisterns), a roof-wash system (usually the first 10-20 gallons of rain are diverted from the cistern), a delivery system (pumps) and a treatment system (filters and purifiers). The cost of installation is dependent over the type of component parts used in assembling the system. Many simple techniques have been developed in many cities. According to soil type and land profile the suitable methods can be adopted.

Government of India has made it compulsory to adopt rain water harvesting in all the government building. The percentage of area of roofs covered residential buildings is always greater then the government buildings, hence the attempts are required by the public. Residential building are equally distributed, this factor is most useful for assessing a greater catchment area.

2.1.4 Contamination of water

Most of the Cities are developed along the banks of rivers. The river water in cities is no more usable in many areas, as these have been polluted badly. Rivers are contaminated with the disposal of Industrial effluents, agricultural chemicals and domestic sewage. Contamination of shallow aquifers, deteriorating surface water quality is creating grim situation and health-hazards (waterborne diseases). Following points show some facts about contamination of water resources in India.

- 1800 ml liters of untreated sewage flow in to the Yamuna River daily.
- Fecal coli form count can go up to 3,000 times the level acceptable for humans at Ganges, Varanasi.
- 65 Million People in the country are already affected by fluorosis .This may be dental/Skeletal
- West Bengal: 40 million people are at risk from arsenic toxicity, skin problems and liver ailments.
- The arsenic problems are geographically expanding- more areas are getting affected in Bihar, UP, Assam, and West Bengal. Arsenic may take a shape of national calamity in near future.

This implies not only to water, but all the resources that if the resources are not used in a planned way, it will stop the life of the humanity. India is at a point now where she is about to see a big jump in the number of people in the world living in so-called "water-stressed" countries, where the renewable supply per person is below the level considered adequate to meet all food needs, ecological needs, industrial needs, household and drinking water needs.
Planners have been researching over the renewable and non-renewable resources, since the time when the concern of limited resources was felt. Fortunately water is renewable source.

2.1.5 Waste Water Management

The basic motto of this study is to asses a plan which assures sustainable water supply. The factors which increase the availability of usable water and preservation and conservation of the existing resources are studied. Reuse of waste water is such a measure. Untreated wastewater is disposed in rivers, canals and lakes in urban areas and in this way the quality of surface water is degraded. If this water is reused for agriculture then the problem of water scarcity can be overcome. Waste water is rich in nutrients and it prevents a precious agricultural input. It is a very good substitute for fresh water. Proper utilization of waste water reduces pressure over fresh water bodies. The advantages of reuse of waste water are:

- Direct pollution of rivers, canals, and other surface water is avoided;
- Water is Conserved;
- Reduction in the need for chemical fertilizer as it is rich in nutrients;
- Disposal of municipal wastewater in a low-cost, sanitary way; and

- It provides a reliable water supply to farmers.

This practice is also become popular in third world countries. It has been estimated that one tenth or more of world's population is dependent on waste water use for food production[15]. The live examples of waste water use are given below;

- Calcutta produces one-third of its fish in sewage-fed lagoons and vegetables are grown in sewage irrigated areas.
- More then hundred cities in Mexico use waste water for vegetable production
- Large Chinese cities produce 90 per cent and more of their vegetable requirement within their urban regions.
- In America one- third of the agricultural product is produced within metropolitan areas[9].
- A community garden known as Matahalib Garden is created in an idle, rubble-strewn parcel between two shanty areas of Manila.
- In Indore Environment project for river in the heart of the city was awarded with AGA KHAN AWARD. The river is almost converted in to a Nallah, and is polluted badly. A part of it which comes in the heart of the city was treated with beautiful landscape (Fig. 2.4) and the polluted water was diverted in the main sewer line along the river bank to take the load of sewage. This water front was used for recreational purpose. Unfortunately it had not been maintained well, but still Indore will remember this project forever.

Fig. 2.4 Krishnapura Lake The nallah in front of this monument was developed as a lake. This project got Aga Khan Award

However, there are a number of disadvantages of wastewater reuse which cannot be ignored:

- Health risks for the irrigators and communities in pro-longed contact with wastewater;
- Health risks for the consumers of produce irrigated with wastewater;
- Contamination of groundwater with nitrates;

[15] Heimlich, Ralph E. (1989), Land Use Transition in Urbanizing Areas, proceeding of workshop, ERS/USDSA, Washington DC

- Build-up of heavy metals and other chemical pollutants in the soil;
- Creation of habitats for mosquitoes and other disease vectors; and
- Possible limiting of marketing options (particularly for export) of agricultural produce. To safeguard the health of irrigators and consumers, the World Health Organization (WHO) has formulated international guidelines on wastewater reuse in agriculture and aqua-culture. The guidelines establish the number of fecal coliform bacteria and worm eggs allowed for unrestricted irrigation.

2.1.5 Water Resources in India

Ganges, Indus, Bhrahmaputra, Kaveri, Yamuna, Narmada, Krishna, Godawari, Mahanadi etc. are the perennial rivers in India while apart from these main rivers a number of them are seasonal. Major river basins in India are given in Table 2.1.

Table 2.1: Major river basins in India

Sl. No.	Name of the River	Origin	Length (Km.)	Catchment Area (Sq. Km.)
1.	Indus	Mansarovar (Tibet)	1114 +	321289 +
2.	a) Ganga	Gangotri (Uttar Kashi)	2525 +	861452 +
	b) Brahmaputra	Kailash Range (Tibet)	916 +	194413 +
	c) Barak & other rivers flowing into Meghna, like Gomti, Muhari, Fenny etc.			41723 +
3.	Sabarmati	Aravalli Hills (Rajasthan)	371	21674
4.	Mahi	Dhar (Madhya Pradesh)	583	34842
5.	Narmada	Amarkantak (Madhya Pradesh)	1312	98796
6.	Tapi	Betul (Madhya Pradesh)	724	65145
7.	Brahmani	Ranchi (Bihar)	799	39033
8.	Mahanadi	Nazri Town (Madhya Pradesh)	851	141589
9.	Godavari	Nasik (Maharashtra)	1465	312812
10.	Krishna	Mahabaleshwar (Maharashtra)	1401	258948
11.	Pennar	Kolar (Karnataka)	597	55213
12.	Cauvery	Coorg (Karnataka)	800	81155
			Total	2528084

Source: www.waterresourcesofindia.com

Apart from these perennial rivers the rainfall and groundwater resources are also enough in country. Table 2.2 shows National water resources at a glance.

Table: 2.2 National water resources at a glance

S. No.	Items	Quantity (Cu.Km)
1.	Annual Precipitation Volume (Including snowfall)	4000
2.	Average Annual Potential flow in Rivers	1869
3.	Estimated Utilizable Water Resources	1122
	(i) Surface Water Resources	690 Cu.Km.
	(ii) Ground Water Resources	432 Cu.Km.

Source: www.waterresourcesofindia.com

India has perpetual drought conditions. Summer season spans for four months (typically from March to June) when most water bodies including dams dry out.

This table illustrates that Uttaranchal, Madhya Pradesh, Bihar and Karnataka are the states having origin of the major rivers in India. However, these rivers feed the other states and even countries also. For example Ganges River basin is a part of the composite Ganga-Brahmaputra-Meghna basin. The basin lies in China, Nepal, India and Bangladesh and drains an area of 10,86,000 sq.km. Its catchment lies in the states of Uttar Pradesh (294,364 km^2), Madhya Pradesh (198,962 km^2), Bihar (143,961 km^2), Rajasthan (112,490 km^2), West Bengal (71,485 km^2), Haryana (34,341 km^2), Himachal Pradesh (4,317 km^2) and Delhi (1,484 km^2). The other example is of River Narmada. It is originated from Amarkantak in Madhya Pradesh. Its basin lies in the States of Madhya Pradesh (85,859 km^2), Gujarat (11,399 km^2) and Maharashtra (1,538 km^2). Ganges River has maximum catchment area, i.e, 861452 sq.kms. , followed by Indus, Godawari and Krishna.

2.2 Findings from Literature Survey

The effective management of water resources demands a holistic approach linking social and economic development with protection of natural ecosystems. There is a requirement of development of economic and easy techniques for waste water treatment. This requires that the policymakers, governments, donors, international organizations, and the research community appreciate the close links between water used for food production and water used for drinking. It will be a good measure to link the gaps between the water resource management. Water

development and management should be based on participatory approach involving users, planners and policy makers at all the levels.

The urbanization has become necessary for development, but because of rapid urbanization and lack of planning the development will not be sustainable. Availability of water has been the main cause of the development of a civilization, and if water is not there, none of the occupation or life can survive. Investigator has taken sustainable water supply as a basis for development. The theory of system dynamics has been adopted in the present investigation. The theme of this theory is that, that all the subsystems of the urban system are interrelated to each other. Drinking water supply is also a part of this urban system; its sustainability will support the sustainability of the urban area.

2.3 Case Study- Chennai water supply system

The origin of the Chennai water supply system dates back to the year 1872 when the nucleus of the present system was formed. The main sources of public water supply in the city have been the three reservoirs - Poondi, Redhills and Cholavaram - with an aggregate storage capacity of 175 MCM. Even when the reservoirs are not full, they get inflows from intermittent rains, which are then drawn. On the other hand, losses due to evaporation from the reservoirs result in the effective availability being lower than the storage. Later the system was gradually expanded over the years. Water was drawn from Red Hills Lake through masonry conduits and treated at Kilpauk and distributed through radial trunk mains. Water resources in Chennai have been presented in Fig.2.1.

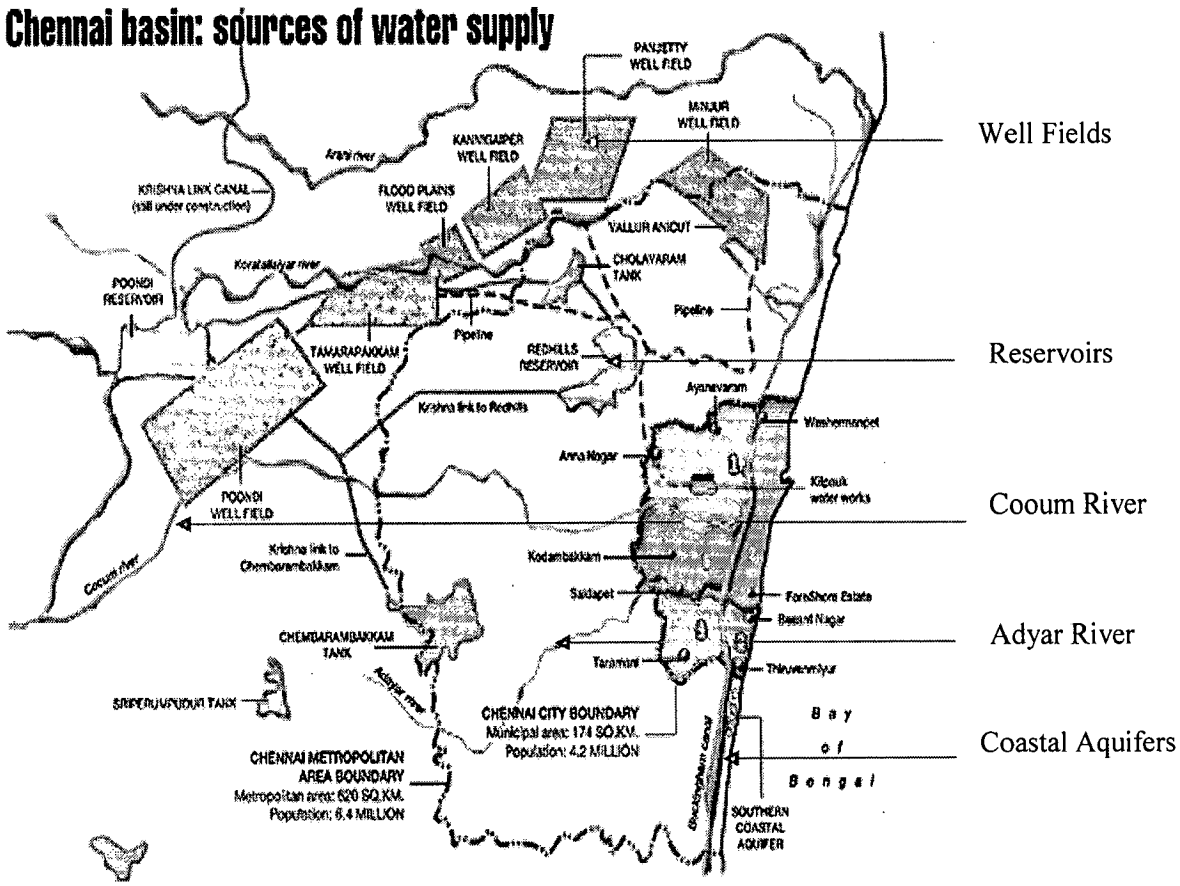


Fig. 2.5 Water Resources in Chennai
Source: Chennai Metro Water Supply & Sewerage Board

Chennai's water search turned southwards, beyond Pondicherry, to the Veeranam Lake 235-km away in the 1970s. The project was completed in June 2004, when the lake was dry (it remains

dry from February to July every year). To feed the pipeline, borewells were sunk in a 25km stretch, causing the water table to plummet and the farmers to agitate (Fig. 3.2).

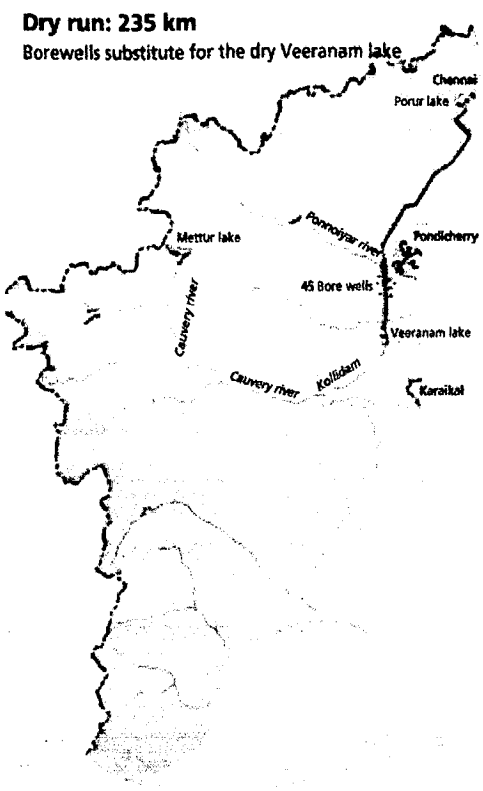


Fig 2.6 Borewell substitute for dry Veeranam Lake

2.3.1 Present water supply distribution in the city

In view of the poor storage in the lakes, the water is mainly distributed through mobile water tankers to the public and the water supply through pipes has been considerably reduced.

Mobile Water Supply: Mobile water supply is maintained at about 7,700 trips per day for filling 9184 tanks and also by street supply for the benefit of 35 lakhs population at an average rate of 20 litres per capita per day and total quantity of 70 million litres daily is supplied through mobile water supply.

Additional Filling Points: Prior to this year, filling points were available only at 9 locations viz. (1) Anna Poonga, (2) Southern Head works (3) Kilpauk, (4) K.K.Nagar, (5) Thiruvanmiyur, (6) Pallipattu, (7) Muthamizl Nagar, (8) M.K.B.Nagar (9) Anna Nagar.

New Filling Stations have been commissioned in 8 locations i.e. at Patel Nagar, Kolathur, Choolaimedu, Kannappar Thidal, Mylapore-Nandanam, Triplicane Velachery and Ekkattuthangal With a view to cope with the increased fleet strength of tankers and increased demand for mobile water supply.

Installation of additional stationery tanks: Metro water supply is through 2000 Nos. of additional stationary tanks in defective streets to provide water to the public. So far 809 tanks have been installed additionally, making a total of 9184 tanks. Installation of further tanks is in progress.

Hiring of additional Lorries: To streamline the mobile supply within the City, the existing fleet of tankers has been augmented by 152 Mini lorries and 149 tractors. Apart from this, there are 462 lorries carrying water from Neyveli and 396 Lorries carrying water for the city from locations like Mamandur, Palur, Poonamallee etc.

Erection of bore-wells with pumping arrangements and stationary tanks to supply water to Slums: While every effort has been made to satisfy the water supply needs of Chennai, another scheme has been evolved to take care of the non-potable water needs of slum dwellers. This envisages construction of 100 deep borewells and connecting them to HDPE tanks for filling water by electrical motors. Public fountains have been provided to facilitate drawal of water. The estimated cost is Rs. 76 lakhs., 37 of the 100 wells have already been constructed and put to use.

The average Chennai household spends about Rs. 316 per month for its water use, which works out to Rs. 36 per KL. The whole city spends Rs. 1 Crore daily for drinking water.

2.3. 2 Drought management during 2001

The unprecedented water crisis the year 2000, which was the worst drought hit in recent memory was handled with concern and competence, and earned the goodwill of the people of Chennai. Government had taken urgent and immediate measures to transport water from sources such as Neyveli, Mamandur, Palur and Kannigaiper by road and from Mettur and Erode by rail to maintain the City water supply,. Two Reverse Osmosis Plants of capacity of 1 lakh litres each to treat brackish water were provided at Ayodhyakuppam and Kasimedukuppam. To supplement the surface water, ground water from 214 private agricultural wells were drawn on hire and linked to the existing system of well fields and an additional about 100 mld of ground water was thus supplied to the City. As a innovative measure, for the first time, the water from the Kolavoy lake near Chinglepattu was transported to industries by tankers, thereby ensuring that vital industries remained unaffected during the drought.

2.3.3 Present Water Supply

Due to the improvement of storage in the three lakes, the supply was gradually increased from 140 MLD in December 2001 to 220 MLD from 12.1.2002. Industrial supply was stepped up to 40 MLD and these levels are being maintained, and will be augmented incrementally.

Further, to keep up with the increased demand during the summer months, it has been planned to enhance city supply gradually, and maintain the same.

2.3.4 Chennai water supply augmentation

PROJECT - I:

As announced by the state government of Tamilmnadu in the Budget Speech of 2001-2002, the Chennai Water Supply Augmentation Project-I for the drawl, treatment, conveyance and distribution of 180 MLD water from the Veeranam Lake to Chennai city was administratively approved by Government, MA&WS Department. This has been taken up for implementation by the Chennai Metropolitan Water Supply & Sewerage Board.

PROJECT - II:

This proposal is aimed at tapping sources of water proximate to Chennai city. The Project consists of the Construction of 4 new Reservoirs at Thirukkandalam, Zamin Korattur, Thiruneermalai and Pallikaranai and 4 Check dams at rivers Koratalaiyar, Adyar, Cooum and Palar and envisages the deepening and desilting of Madhavaram, Retteri, Korattur and Ambattur lakes. An administrative approval was accorded by Government for implementing this Project at an estimated cost of Rs. 493 Crores.

2.3.5 Measures for Augmenting Chennai city

1. Water supply from other sources:-

For a permanent solution to the recurring water problem in Chennai City, the feasibility reports on the possible tapping of water from the River Cauvery at MetturDam, Pallipalayam and Hogenekkal are under the consideration of the Government. A proposal for tapping water from Neyveli Acquifer and to link with the Chennai Water Supply Augumentation Project – I is also under examination.

2. Construction of a 50 mld tertiary treated reverse osmosis plant (TT/RO PLANT).

It is proposed to put up a 50 MLD Tertiary Treated/Reverse Osmosis Plant at Kodungaiyur to treat the secondary treated sewage available in the existing Sewerage Treatment Plant at Kodungaiyur and supply this to the industries in the Manali area to meet their growing water demands.

3. Desalination, reverse osmosis plant

Metro Water would consciously pursue the policy of conversion of saline/brackish water along the coast and other locations in the Chennai Metropolitan area. Poor quality water in these locations would be utilised as a resource and would be converted into potable water.

At present Chennai city has 5 Reverse Osmosis plants located at Nochikuppam, Kasimedu, Kasimedukuppam, Ayothiakuppam, and Velacherry, contributing to the local needs of specific areas suffering from water-stress in times of shortage. 10 more plants of higher capacities were installed so as to resource at least 100mld from poor quality water through desalination/reverse osmosis should be installed on a Build Own Operate & Transfer (BOOT) basis.

These plants would be located along the coast; in peripheral areas and other areas like Alandur, Pallavaram, Tambaram, Ambattur, Avadi and Madhavaram.

4. Proposed 530 mld water treatment: plant at Chembarambakkam

In order to treat additional water to be drawn from Andhra Pradesh, an additional treatment capacity of 530 MLD is proposed to be constructed at Chembarambakkam with assistance from the French Government The Budget Estimate for the year 2002-2003 was Rs.87.00 crores. Tenders received for this have been evaluated and the work is to be awarded.

5. Second Chennai project

The Second Chennai Project, taken up in 1996 at a cost of Rs.778.9 Crores is in an advanced stage of implementation. In order to ensure equitable distribution of water in Chennai city, 7 new water distribution stations have been contemplated of which 6 have been commissioned. Work on the transmission mains is almost complete.

6. Twinning consultancy

1. Metro Water has entered into a Twinning arrangement with a well run water utility viz. M/s.Generale deseaux of France in order to improve the performance and operational efficiency of Chennai Metro Water and based on the suggestion of the World Bank. The consultancy works have been taken up at a cost of Rs.26.5 crores

2. Proposals have been formulated for the refurbishment of the Kilpauk Water Treatment Plant.

3. Information system and Technology planning (ISTP) is also to be taken up as a Pilot Project to improve Metro water functioning in billing and collection, financial accounting and consumer service monitoring.

2.3.6 Water conservation measures

1. Leak detection and rectification works

The Board is carrying out a well conceived "Leak Detection and Rectification programme" to reduce the losses in the distribution system. Works are in progress in about 65% of the distribution system where all house service connections are being replaced by MDPE pipes. In addition, the choked up water mains are also in the process of being replaced. The works are proceeding on schedule and to be completed by June 2002.

2. Chennai city River Conservation Project

The Chennai City River Conservation Project continues to be implemented, and is proceeding on schedule. The long term objective of the project is to holistically improve the water ways and disposal networks.

Moreover, the capacity of the existing sewer system has become grossly inadequate and is in need of major improvements if the discharge of untreated and partially treated sewage into the City Water ways is to be prevented.

This comprises of "Interception, Diversion and Treatment of Sewage" in the city and enhancing the capacity of the existing Sewage Treatment Plants. The works are planned to be executed in 16 packages.

2.4 Findings from Case Study

1. Traditional system of water supply was efficient to fulfill the water requirement. Filling up of Eris for housing and other development of city was an un-thoughtful idea.
2. This is a development without consideration for resources for infrastructure. Water is the one of the primary needs and its reqirement considerations were ignored.
3. A bigger percentage of Chennai city's total expenditure is just for drinking water. In other Indian cities there is a problem of irregular tariff collection, but in this city people have to pay water apart from the tariff imposed.
4. Water supply has posed a new economy in the city.
5. Poor personal suffer a lot for water.
6. Projects of rain water harvesting are going on but it requires active public participation.

Chapter 3: Study area Profile

Investigator has taken Indore city as study area. The city is a commercial capital of Madhya Pradesh and is one of the mega cities of India. It is known for the rule and glory of Holkar kingdom. Present city is an important industrial, trade and commerce, and educational centre. It is a bigger city than the State capital in terms of area, population and infrastructure. The study area profile includes, the physical features, the historical background, population changes and its growth trend, age-sex-structure, family structure, emigrational trend, literacy trends, labor force, occupational pattern, etc. An analysis of these factors in relation to city functions will help in assessment of various city needs in respect of housing, infrastructure, commerce and industries, amenities, recreation, etc.

3.1 Location

Indore City is located in the center of Indore District. It is a divisional Head Quarter, is situated almost centrally on the fertile Malwa plateau with its cardinal points 22° 43' N latitude and 76° 42' E longitudes with an altitude of 18 5' above the mean sea level. It is well connected to whole country with rail, road and air. The location of Indore is presented in fig. 3.1.

3.2 Physical features

Indore is located in Malwa plateau region and occupies relatively plain plateau having a very gentle slope towards North. The hinterland of this city is also flat but intermixed with some Hillocks like Bijasan, Gadha Tekri, Bhuri Tekri, Deoguradia and depression at Sirpur and Bilaoli tanks. There are no physical constrains except Pipliyapala tank on South-West limit or condition of the growth of the city.

3.3 Historical background

The present city is about 400 year's old settlement. Till the end of the 15th century its original nucleus was a riverside village, which occupied the bank of river Saraswati. This area is now known as a Juni Indore at present. The village grew as a halting place for the pilgrimage traveling from Mahakaal at Ujjain on river Sipra to Omkareshwar on the river Narmada and onwards to Mahankaaleswar.

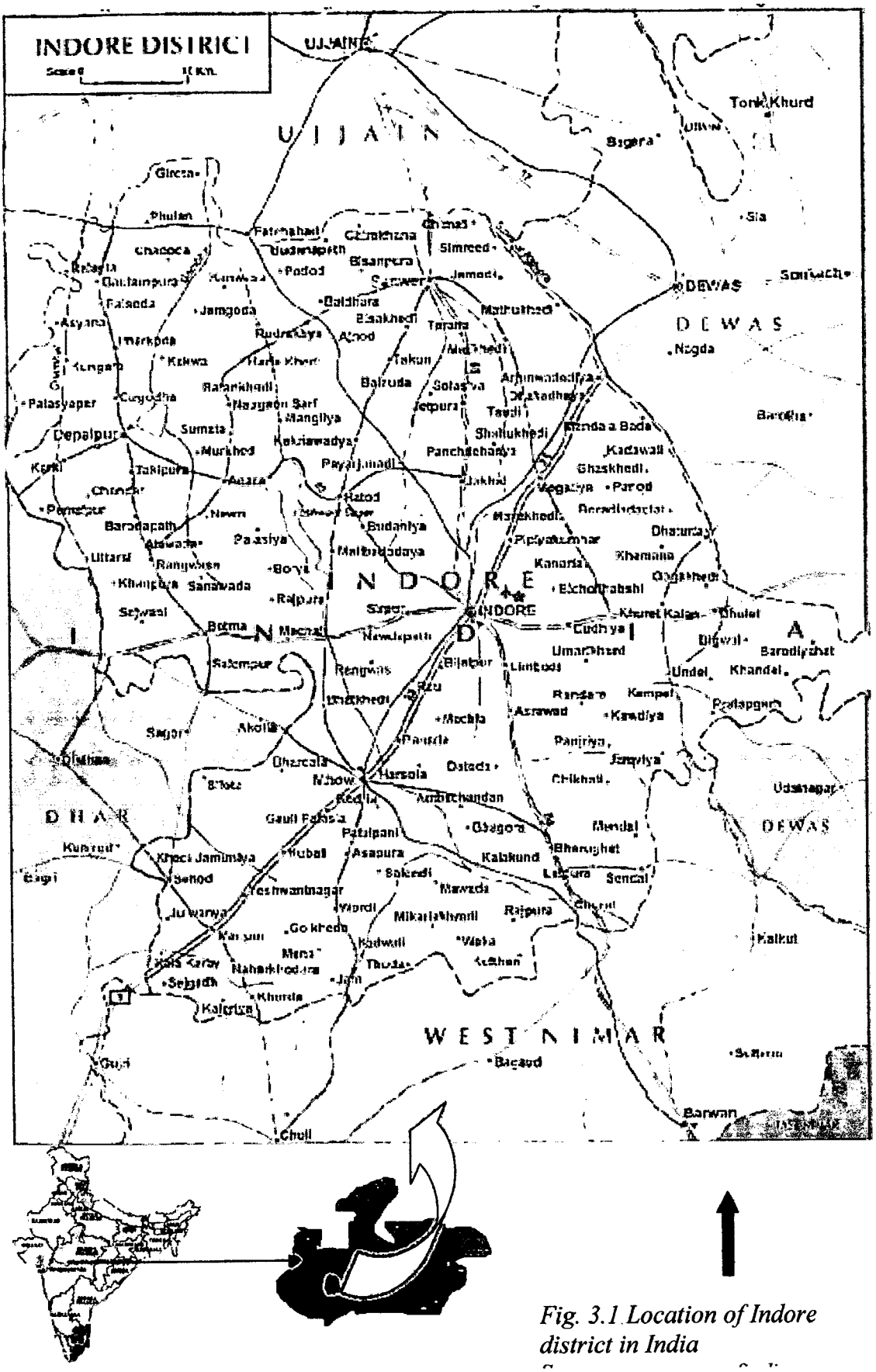


Fig. 3.1 Location of Indore district in India

Indore city was on the routes of the Marathas of Deccan on their way to North India. Their army transit camps here attracted local zamindars, which were drawn by the promise of lucrative trade, settled in the village on the confluence of the river khan and Saraswati Rivers. The present city is known as the heritage of the Holkar's state capital. The foundation of this commercial centre was in 1715.

The capital was previously at Maheshwar, on the banks of river Narmada Fig. 3.2 shows a scene of Maheshwar. Indore is located at the mid of two famous pilgrim places Ujjjain and Omkareswar. Pilgrims used to travel via Indore in course of their pilgrimage. The location of Indore is very important in whole India.

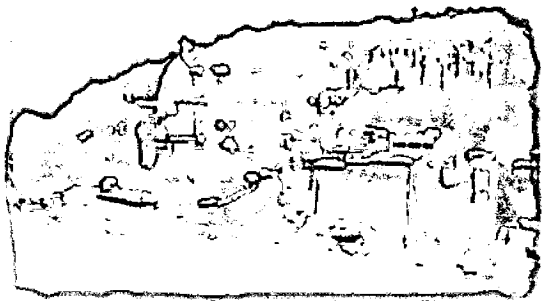


Fig. 3.2 Ghats of Maheshwar: Early capital of Holkar Kings

It is located approximately in the centre of the country and could have been connected to all the important, big and metropolitan areas easily. The location had a big potential for business and industrial activities. Holkars were attracted to this location and shifted their capital in Indore.

Military and commercial development was in progress during Holkar's period. It got an administrative importance with declaration of Indore Province by Maratha's as the capital was shifted from Maheshwar to Indore and served as transit camp for Marathas in their route to North. Establishment of Holkars capital at Indore provided new forces for the development of the city in the view of the defense needs.

3.4 Urbanization trends

Nearly 28 per cent of the county's population lives in urban centers. Census 2001 showed that the population was 285 million. The rate of growth in Indore is very high in the state of Madhya Pradesh. Table no.3.1 presents a comparison of urban population in India, Madhya Pradesh and Indore district.

Table 3.1: Urban Population at the National, State and District Levels

S.No	Attributes (Figures in Lacs) .	India	State (M.P)	Indore District
1	Total Population	10,270	603	26
2	Urban Population	2,854	161	18
3	Rural Population	74,166	443	7
	% Urban Population	27.78	26.6	71.5

Source: Census of India, 2001 and census of Madhya Pradesh, 2001

Indore district is one of the most urbanized districts of the state. Census 2001 shows that Indore district covers 4.28 per cent of the State population while the urban population of the district constitutes 11.48 per cent of the total urban population of the State.

The growth of the city has been pushed by the rapid population growth in the area. The urban population of the district increased from 38.82 per cent in 1911 to 69.6 per cent in 1991.

The total population of Indore district is 25.85 lacs. In 1971, the percentage of urban population in the district was 62 per cent while in the year 2001; it has increased to 71.5 per cent, showing an average rise of 4.2 per cent in the four decades from 1971 to 2001. Fig 3.3 presents the urbanization rates in Indore district.

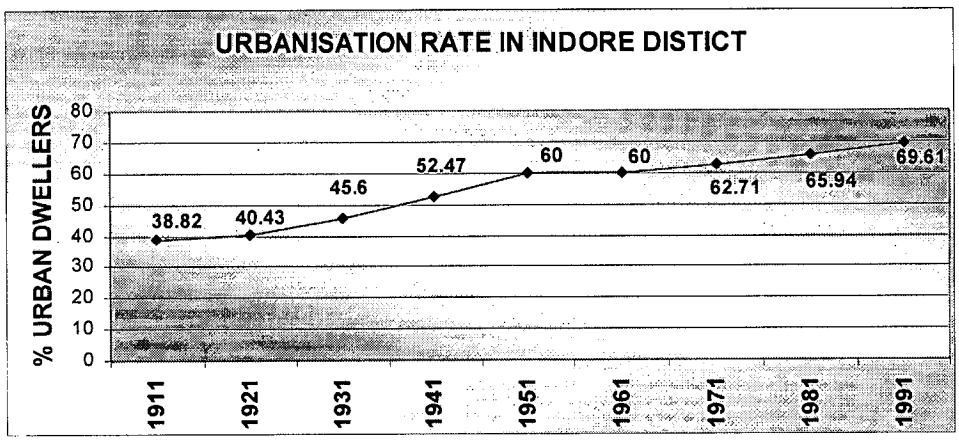


Fig: 3.3 Urbanization trends in Indore

Indore City population accounts for approximately 87per cent of the total urban population in the district, rising from 10.25 lacs in 1971 to 15.97 lacs in 2001. Population of Indore Urban Agglomeration is 16.39 lacs.

3.5 Demographic Profile

3.5.1 Population of Indore city area

Indore city is often referred to as 'Modern City' with a history of 400 years. Indore City has the largest population among the cities in the State and shows a consistent decadal population growth rate of around 33 per cent. Indore being a commercial city is growing at a rapid pace and is likely to continue to witness increasing urbanization in and around it. Increase in population is mainly due to increase in migration not only from within the state, but also from neighboring seven states. It may be necessary to canalize the growth into other neighboring cities and sub-cities to maintain the quality of life in the larger metropolis. The area of the city increased considerably from 55.8 sq km in 1960 to 130.17 sq km in 1991, complementing the rapid population growth in the city. The city has a population density of 12272 persons per sq.km.

3.5.2 Population growth

Numerous factors contributed to the population increase of the city, some of which are immigration, high birth rate, changing socio-economic amenities and factors like reorganization of territorial boundaries. While the factors responsible for decline in population of the city could be the natural calamities like war, plague, famine, etc. Government policies to encourage industrialization of back-ward districts, provided impetus for industrial growth in Dewas, Ujjain and Dhar which is likely to check abnormal influx of population in Indore. The planning area of the city is increasing by years but the district area is constant, this accounts to the equalizing of the growth rate of the city and the district from 1991. The decadal growth rates of the city, district and state are given in Table 3.2. Fig 3.4 presents the graphical presentation of decadal growth rate.

Table 3.2: Decadal Population growth in Indore city, Indore district and M.P.

Year	Indore pop	Growth rate, Indore	Growth rate, Indore Dist.	Growth rate, MP.
1911	54,142	-80.64	-9.82	15.3
1921	1,05,317	94.51	24.45	-1.38
1931	1,42,524	35.33	12.36	11.39
1941	2,03,695	42.92	19.34	12.34
1951	3,10,859	52.61	32.23	8.67
1961	3,94,941	27.05	25.38	24.17
1971	5,72,622	45.19	36.03	28.67
1981	8,29,327	44.82	37.49	25.27
1991	10,91,618	31.62	30.26	26.84
2001	15,42,618	41.31	40.81	31.59

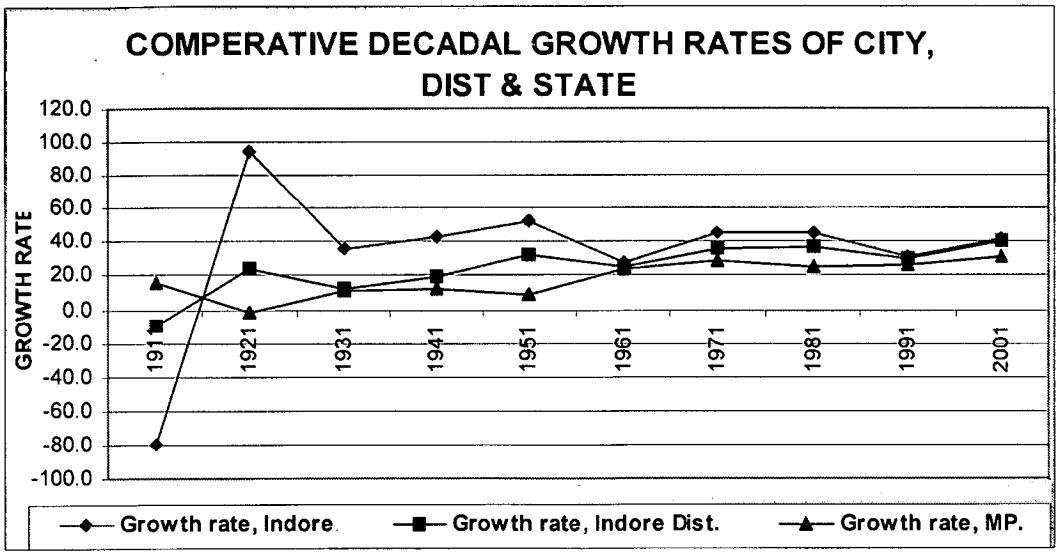


Fig: 3.4 Decadal Population growths in Indore city, Indore district and M.P.

This table and graph illustrate that there is a decrease in decadal growth rate from year 1901 to 1911 when the population decreased by 45 per cent. At this time people suffered on account of epidemics. There was a sudden increase of population by 95 per cent by the decade 1911-21. The growth pattern has been almost normal since 1931. There is again a decrease observed in the decadal growth rate during 1951-61, this is due to the distribution of surplus rural work force in the three districts, Ujjain, Devas and Indore. The percentage increase of population in 1981, over population of 1971 was 53.80 per cent and the population growth from 1981 to 1991 was observed as 34.50 per cent and from 1991 to 2001 it was found 47.90 per cent. These figures show that increase in population from 1991-2001 was tremendous. The high rate of growth of population during this period is mainly attributed to the rapid industrial and commercial development in Indore planning area.

It has been observed from the decadal growth that the city has become a class I city in the year - 1921 and a mega city in the year – 1991. The basic reason for such a growth could be due to the growth of trade and economic condition. Growth of population in the city is presented in fig.3.5.

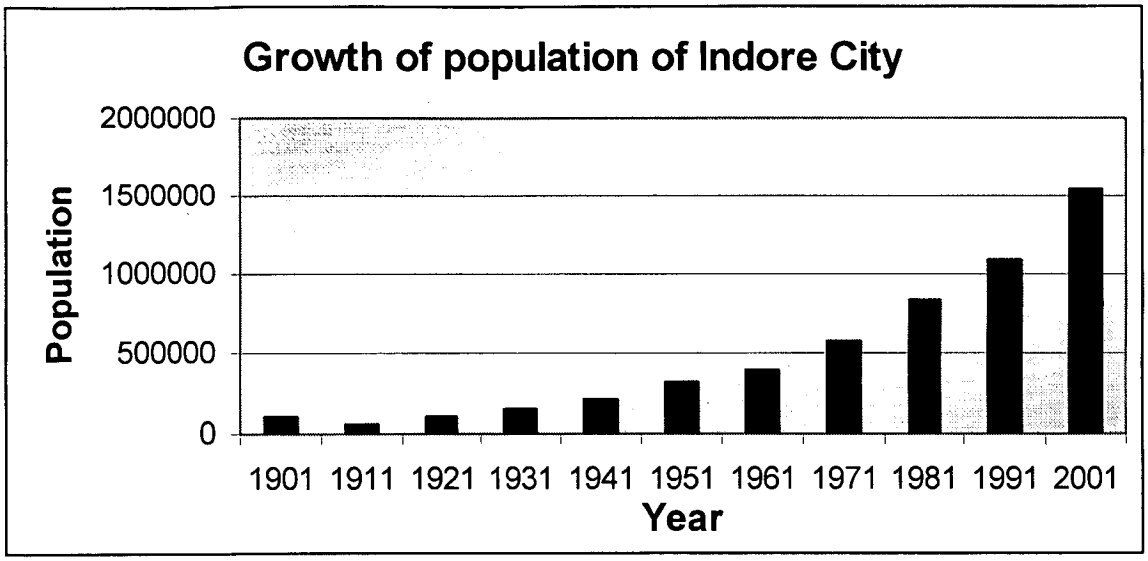


Fig:3.5 Growth of population in Indore city

Growth trends

The growth trends can be understood by the birth rate, death rate and rates of immigration and out migration. Table 3.3 and Figure 3.6 present the birth and death rates of Indore city, Indore district and Madhya Pradesh.

Table 3.3 Decadal Birth and Death Rates

S. no		Birth Rate	Death Rate
1	Madhya Pradesh	31.2	10.2
2	Indore District	10.02	4.67
3	Indore City	10.6	5.21

Source: Census of Madhya Pradesh 2001

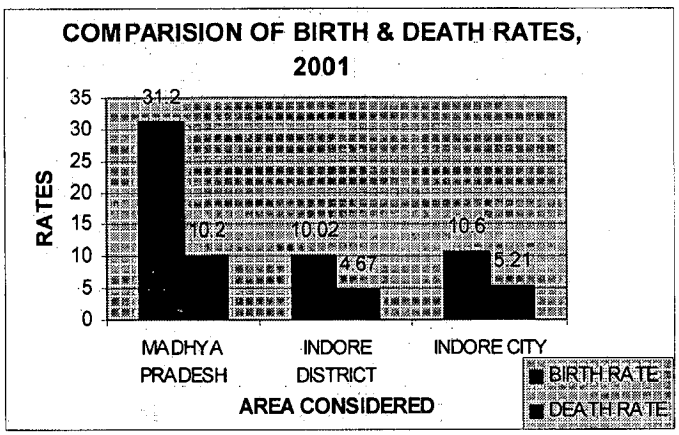


Fig: 3.6 Comparison of birth rate and death rate
Source: Census of Madhya Pradesh 2001

Migration

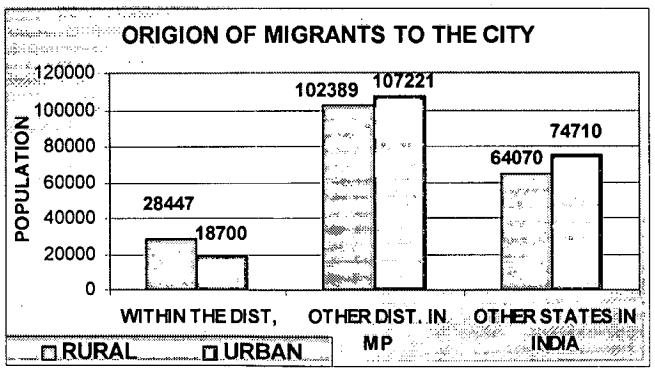
The data on birth and death rates depict the natural increase in population. The migration could also be assessed by deducting natural increase from the total increase in the population. Fig 3.7 (a) and (b) give details about the migrants in terms of origin of migrants, period of their stay in Indore, migrants from within Madhya Pradesh and from other states. There are four kinds of migrants in Indore city:

Permanent migrants: These people have shifted to Indore permanently.

Regular seasonal migrants: These people come from the rural and tribal areas. These are not able to secure income the years from their rural based economy. They come to Indore every year and usually spend 8 months in a year and work on construction sites.

Seasonal distress migrants: These are the people, who are able to make their livelihood out of their rural economy, but are sometime struck by environmental failure or natural calamity which leaves them without sufficient income.

Nomadic population: Some people who come here, because of their specific occupation do not settle in one place and they travel from one place to other within the city and from city to city.



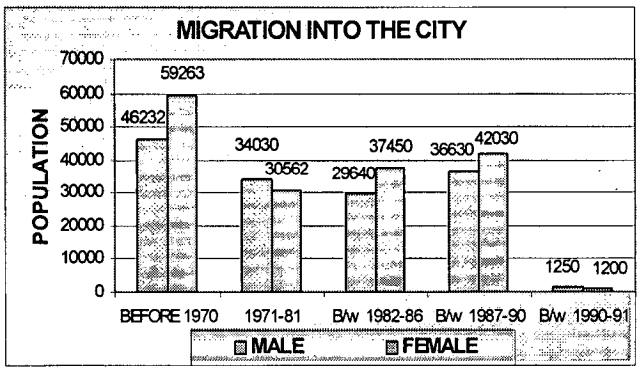
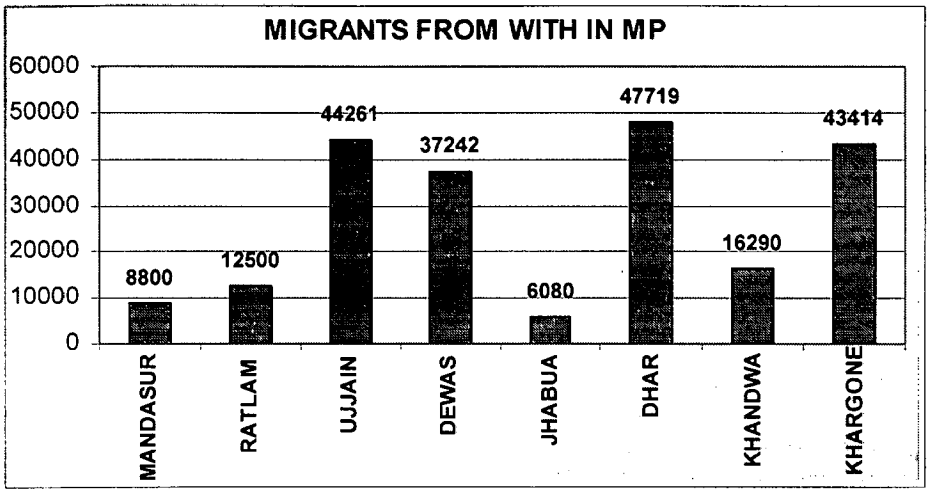
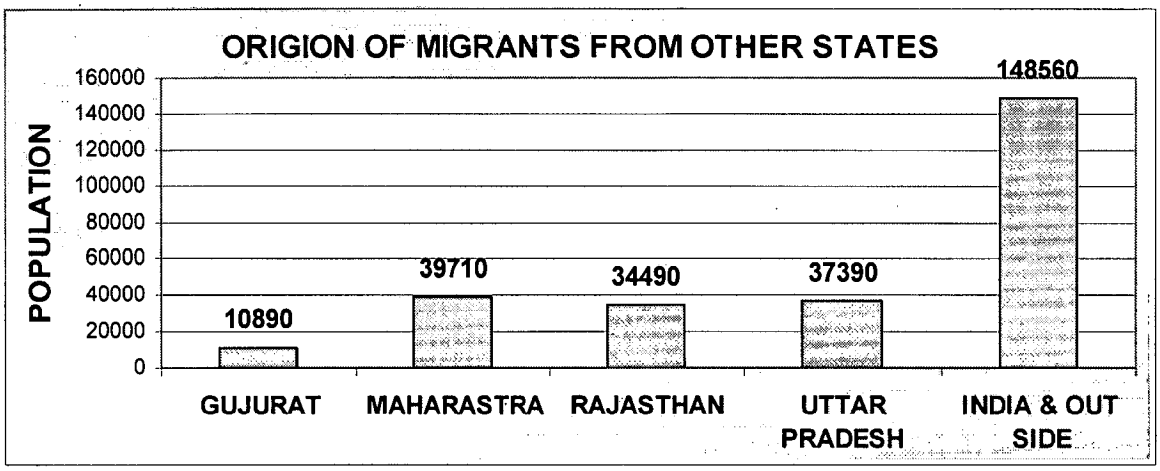
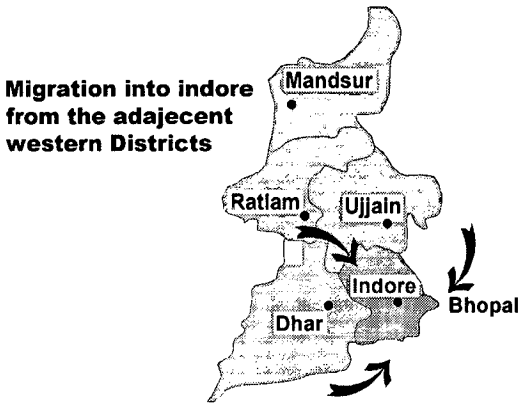


Fig: 3.7(a) Migration trends in Indore
Source: Census of Madhya Pradesh 2001







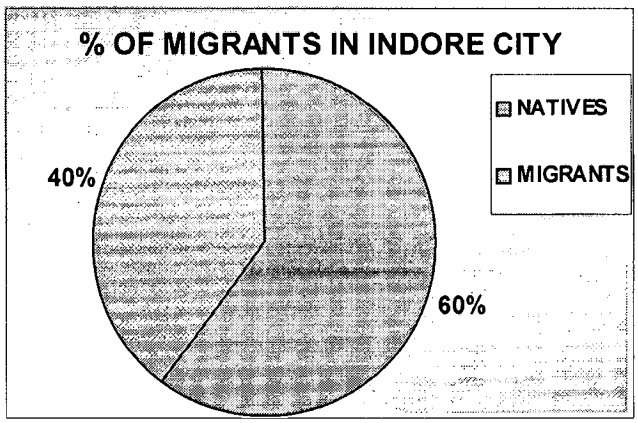


Fig: 3.7(b) Migration trends in Indore
Source: Census of Madhya Pradesh 2001

The pie graph reveals that 40.7 per cent of total population has migrated to city. In other words 2 out of every 5 persons are migrants. A negligible percentage of immigration is from same district. Nearly half of the immigration is from the outside the state.

3.5.3 Population Density

The rate of urbanization is very high in Indore. Population density has been increased with the time. The planning boundary of the city has been changing from time to time; this is one of the reasons which are balancing the density with the rapid population growth.

Migration in the city increased the population, and the density. Social polarization is also one of the reasons for densification. Indore has a large numbers of slums, with high density of population; it is a hurdle in stepping forward to the better living conditions of these areas.
Table 3.4 and Figure 3.8 presents a comparison of densities in Madhya Pradesh, Indore District and Indore city .

Table 3.4 Comparative population density 2001

S. No		Population(2001)	Area in ha	Density
1	**Madhya Pradesh**	60,385,118	790767	76
2	**Indore district**	2465827	16517	149
3	**Indore mc**	**1474968**	**13017**	113

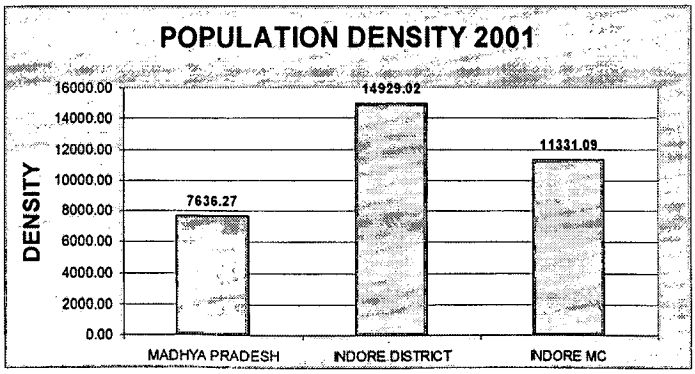


Fig. 3.8 Comparative population density 2001

Source: Census of India 2001

This table reveals that Indore district has maximum density followed by Indore Municipal Corporation and the State; this means that the other town and villages around Indore Municipal

Corporation are also highly populated. Population density in Indore Municipal Corporation is presented in figure 3.9.

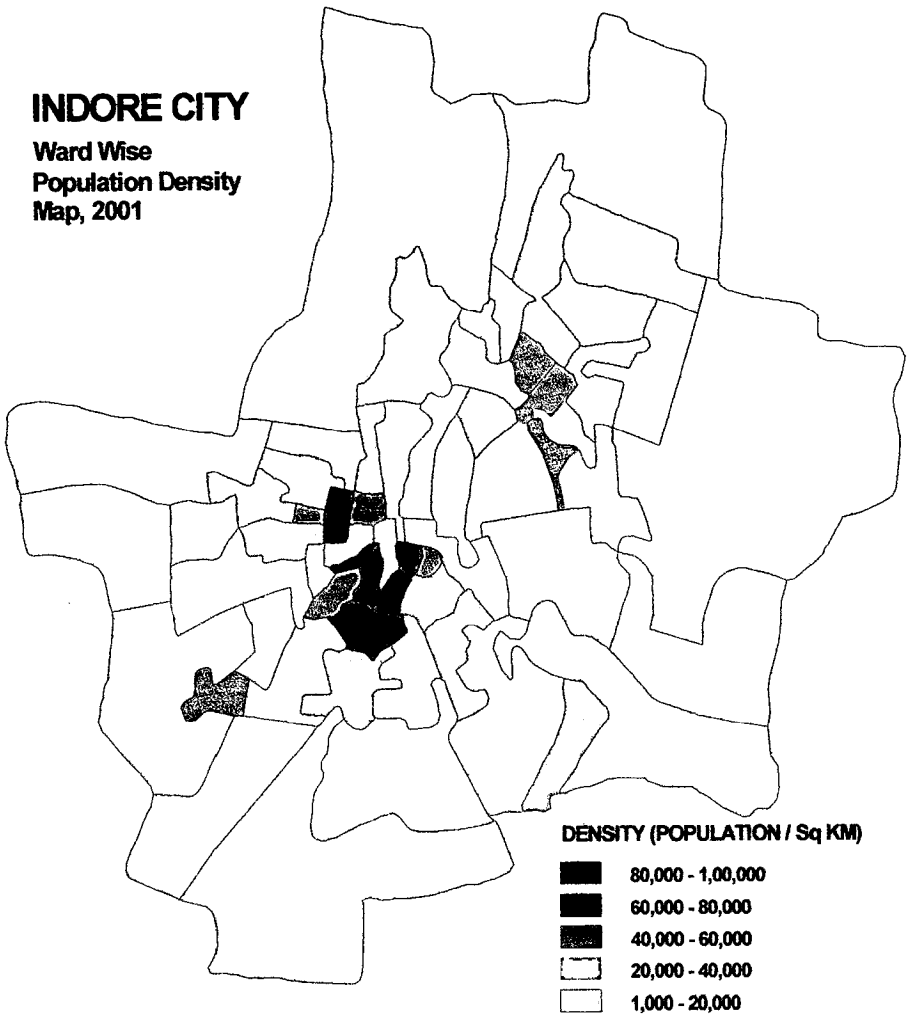


Fig. 3.9 ward wise population density in Indore Municipal Corporation

The khan and Saraswati Rivers flow very haphazardly, spreading their tributaries all through the city this resulted in the formation of settlement clusters all over the city.

Large numbers of the central wards are comparatively less populated being a commercial use. Similarly the outskirts of the city are less populated as there are urban villages and some of them are imposed industrial land use.

3.5.4 Household size

The decadal household size according to the census of India was 5.5 in 1971, 4.7 in 1981, 4.5 in 1991 and 4.73 in 2001. This has been presented in fig. 3.10

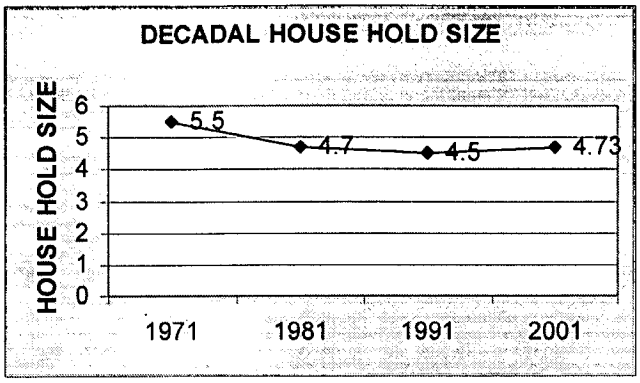


Fig. 3.10 Decadal average household size
Source: census of India

The decadal trend of the house hold trend is not uniform, it is changing. From the graph it is observed that the size is increasing from 1991 to 2001, where a general expectation would be decrease in size

3.5.5 Sex Ratio

Sex ratio is the number of females per every thousand males. This ratio helps in determining the balance of the population of a certain place. The decadal sex ratio has been presented in Table 3.5 and Figure 3.11.

Table 3.5 Decadal comparison of sex ratio in urban areas

S. No.	YEAR	1911	1921	1931	1941	1951	1961	1971	1981	1991	2001
1	MP UBAN AREA	913	878	872	882	907	856	868	893	912	919
2	INDORE DIST. URBAN AREA	891	848	740	767	856	848	857	886	906	911
3	INDORE CIY	754	735	731	766	854	851	865	889	900	904

Source: census of India

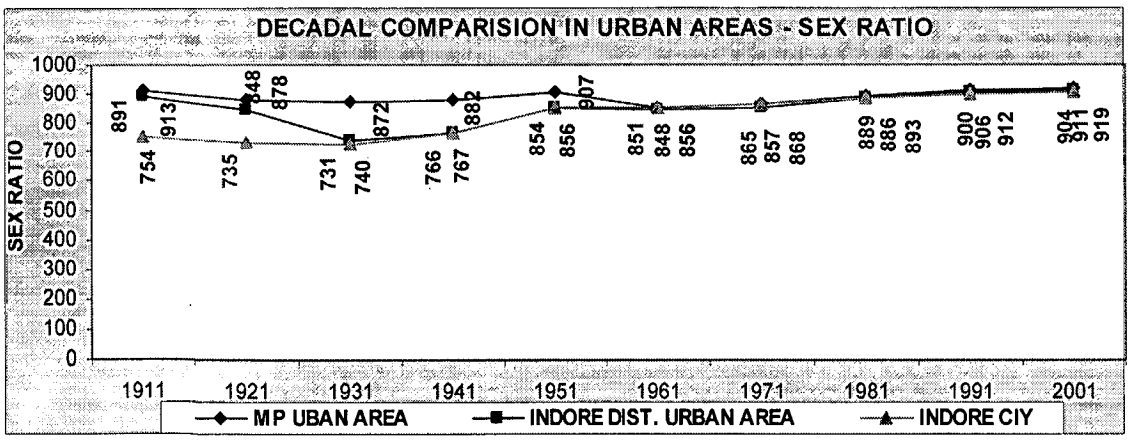


Fig. 3.11 Decadal comparison of sex ratio in urban areas (Source: census of India)

This data shows that there was a variation of the ratio between the urban areas of Madhya Pradesh, Indore district and Indore city up to the decade 1951 and then slowly the ratio got into a similar trend and is continuing so far increasing decanally. It can be observed that the ratio of the city is always less than the other two. The ratio of the district and the city were getting closer in the map from 1931, this could be because of the growth of the city physically. From 1961 all the three ratios are in the similar levels, growing decanally. Increase in female population from 906 in 1991 to 911 in 2001 could be a reason for migration of working male population to the city is increasing.

Ward wise sex ratio in the Indore Municipal Corporation is presented in Figure 3.12. This figure reveals that:

- A large proportion of immigrants constitute of males.
- There has been a sexually selective morality. The reason for such a scenario could be racial influences, the climatic and physical conditions and social customs, etc.
- Plague and influenza are known to take away more females than males as has been exhibited in 1921.
- Though Indore is the trade and commerce capital of the state which can absorb more workers, its sex ratio falls under the range 900-950.

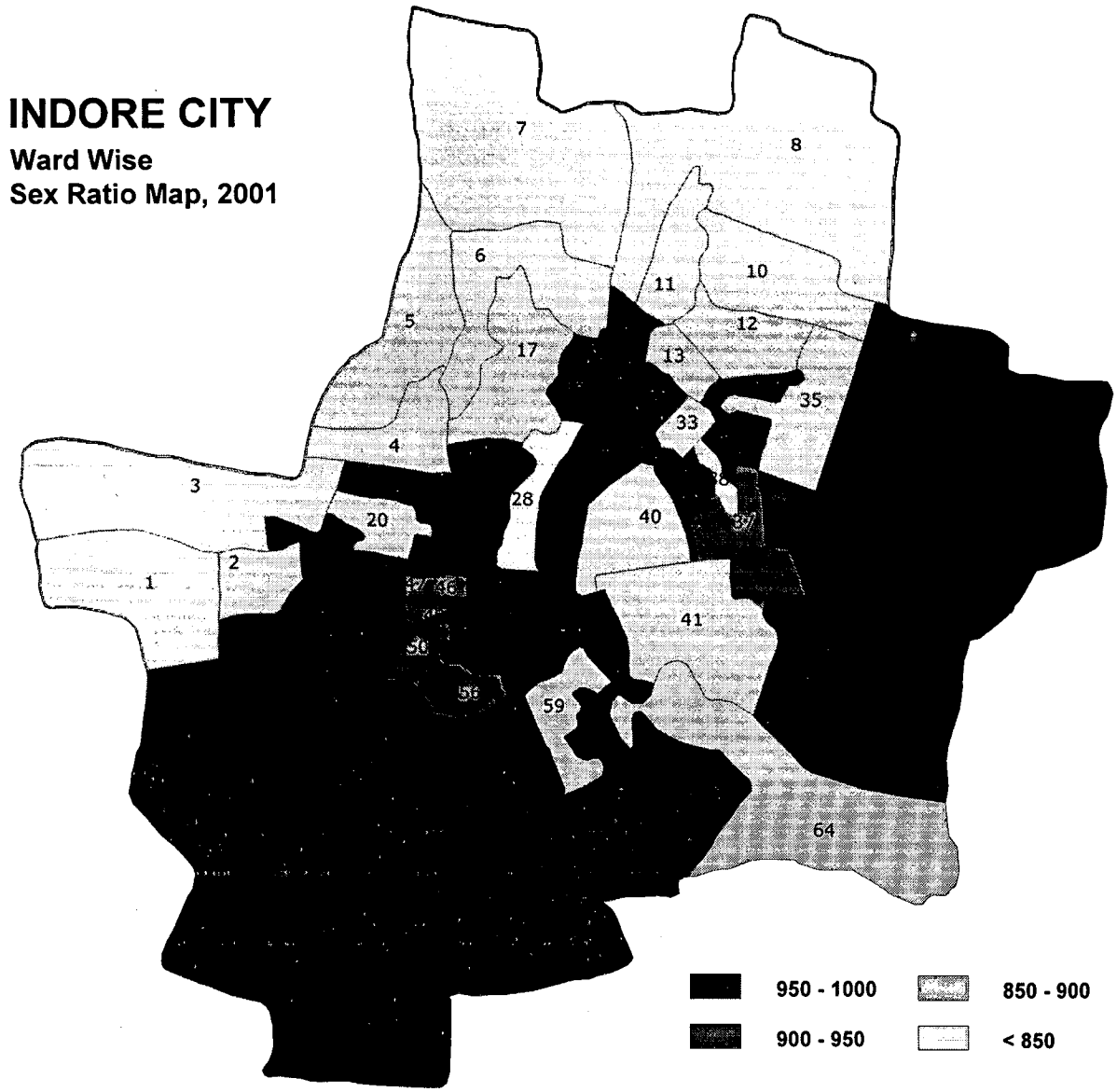


Fig. 3.12 Sex ratio in Indore Municipal Corporation area

Source: census of India

3.5.6 Literacy

Literacy influences other attributes of population such as fertility, mortality and morbidity, occupations etc. The trends in literacy are considered as an index of the pace at which the socio-economic transformation of a society is taking place.

The literacy rate in Indore municipal area in 1991 was higher than the average all-India literacy levels. Figures for Indore City are noteworthy with regard to the literacy rates.

As Indore is the trade and commerce capital of the state Madhya Pradesh, there is a lot of in migration into the city. The people who have migrated to an urban place will tend to have an overall development in the life style. This change of life style is incorporated by education, thereby increasing the literacy of the city. The decadal literacy rate has been presented in Figure. 3.13.

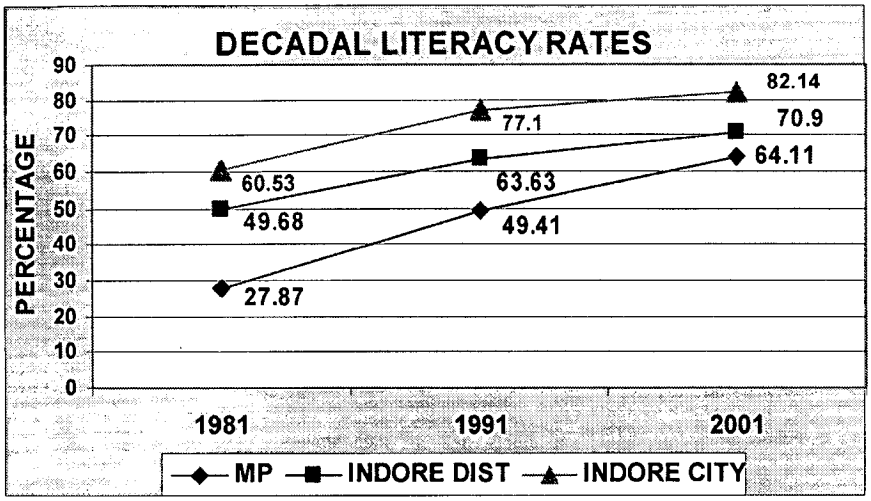


Fig. 3.13 Decadal literacy rates

Source: census of India

The literacy rate of Indore is the highest in Madhya Pradesh followed by Bhopal. The reason for this could be migration. There is a marked difference between male and female literacy rates.

Although female literacy is lower compared to male literacy, the improvement from 68.4 % in 1991 to 74.6% in 2001 is quite impressive, resulting in a decrease of the gap between male literacy and female literacy. Figure 3.14 presents a comparison between male and female literacy rates. Figure 3.15 presents a comparison of literacy rates in Madhya Pradesh, Indore District and Indore City.

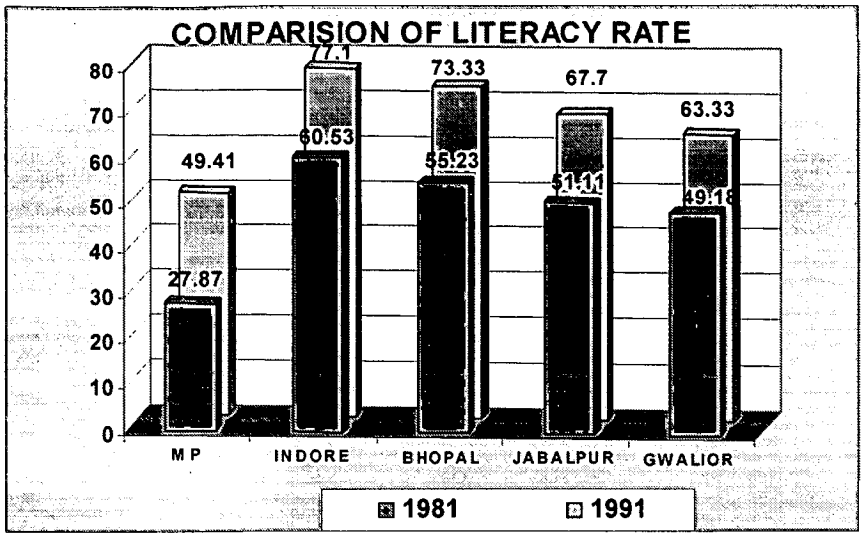


Fig.3.14 Comparison of male female literacy rates

Source: census of India

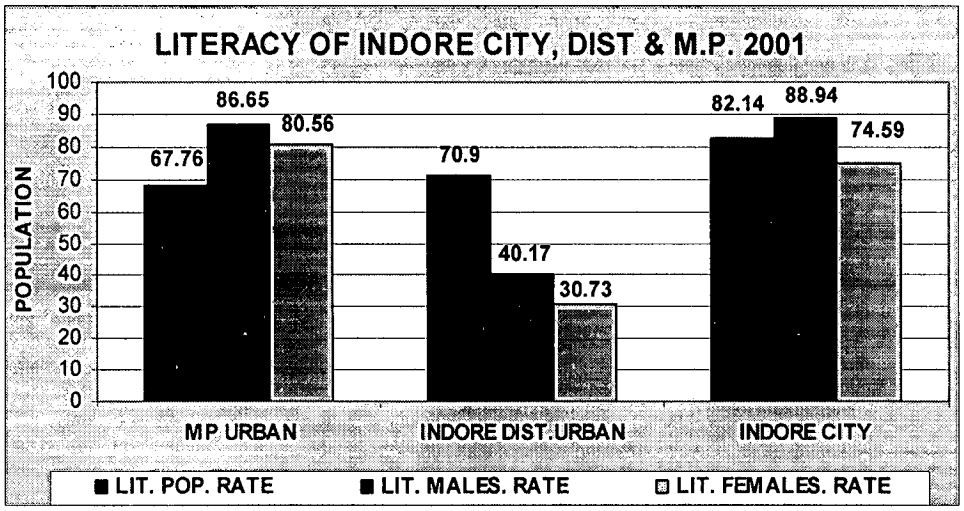


Fig.3.15 Comparison of literacy rates in M.P., Indore district and Indore city

Source: census of India

Ward wise literacy rates have been presented in figure 3.16.

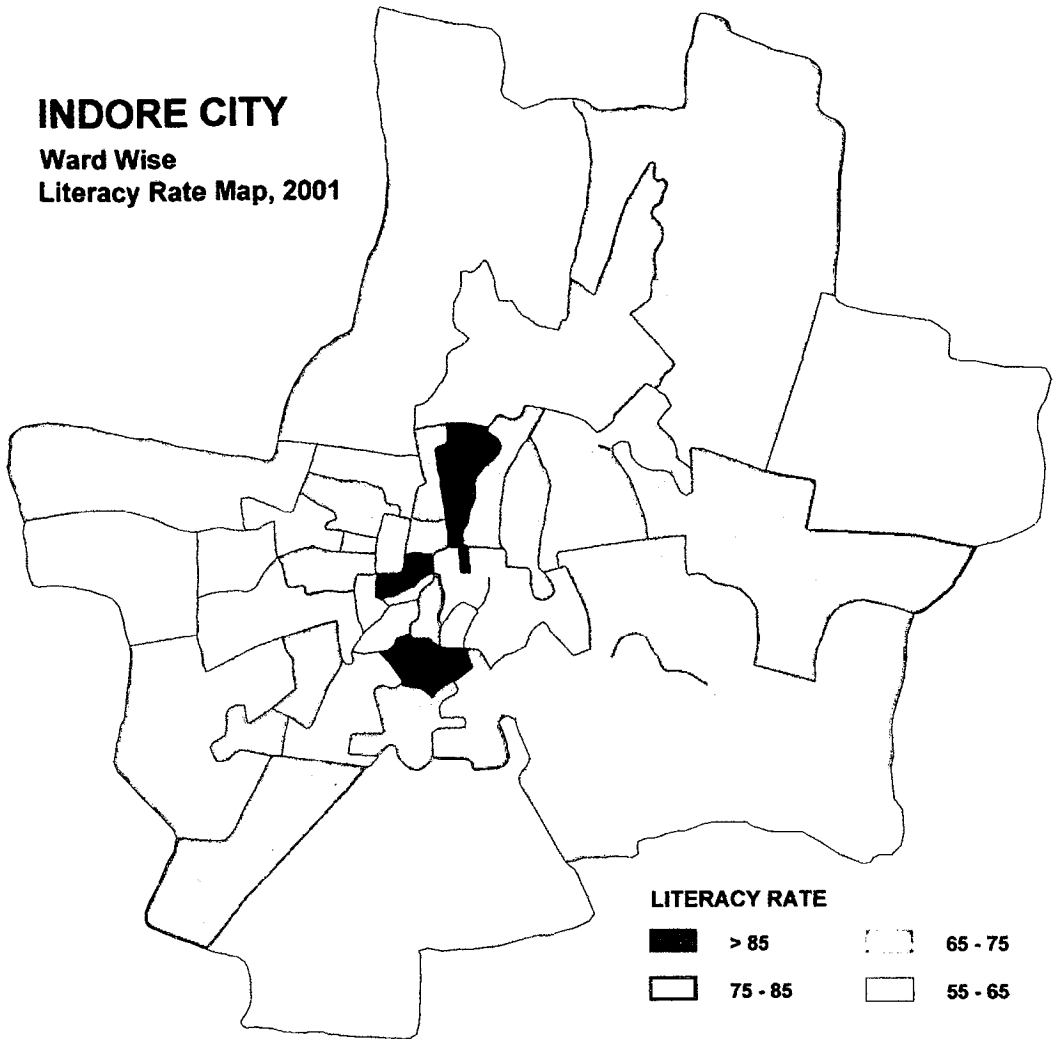


Fig.3.16 Ward wise literacy rates (percentage) in Indore city

Source: census of India

The rate of literacy in peripheral areas is less, as these are urban villages. The highest rates are observed in the Rajwada, Bada Sarafa and Hemu Kalani Nagar which are the earliest colonies. The inner area is having more rates due to the earlier settlement. The south-west part of the city is also having higher literacy rate due to the presence of Rau settlement (Rau is an industrial area).

3.6 Socio-economic characteristics

3.6.1 Religion and Caste

Indore and its adjacent its adjacent districts have a predominance of Hindu religion. Sikh, Christian and Jain are mostly urban communities, while Hindus and Muslims show greater tendency for

urban areas. A Comparison of religion in Indore district and M.P. has been given Table 3.9 and Figure 3.17.

Table 3.6 Comparison of religions in Indore district and M.P. (1991)

s. no.	Religion	Indore city	%	Indore dist	%	Madhya Pradesh	%	India	%
1	Hindu	8,87,729	80.04	10,12,741	79.46	1,24,80,376	81.36	16,47,50,096	76.39
2	Muslim	1,44,624	13.04	1,78,466	14.00	20,96,822	13.67	3,60,32,362	16.71
3	Christian	7,050	0.63	9,548	0.75	1,59,094	1.04	61,55,023	2.85
4	Sikh	15,046	1.35	16,230	1.27	1,18,444	0.77	37,86,314	1.76
5	Buddhist	4,522	0.41	4,771	0.37	79,026	0.52	22,60,016	1.05
6	Jain	38,257	3.45	40,508	3.18	3,62,275	2.36	23,54,988	1.09
7	Other	442	0.04	525	0.04	3,914	0.03	2,87,723	0.13
8	Not stated	11,386	1.04	11,729	0.93	38,886	0.25	38,886	0.02
	total	76,703	100	83,311	100	121,826	100		100

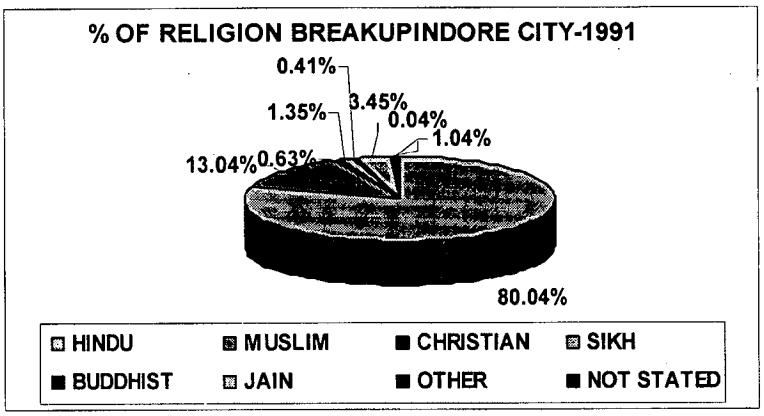


Fig.3.17 Religions in the city

Source: census of India

According to 1921 census the Hindu religion in Indore was divided into 740 casts and sub-casts. Population of Indore has a large proportion of Marathi Brahmins today; this is the result of the in-migration during the rule of Holkar. They were said as "the brains". This could be a reason for high literacy rate in Indore compared to the other states in the state.

Sikh, Christian and Jain are mostly urban communities, while Hindus and Muslims also show a greater concentration in Mhow, which is a cantonment. Jains on the contrary show greater concentration in Depalpur. Table 3.7 presents the decadal trends in religion.

Table 3.7 Decadal break up of religions in Indore City (%)

S. no.	Religion	1971 (series 1)	1981 (series 2)	1991 (series 3)
1	Hindu	81.00	80.77	80.04
2	Muslim	12.50	12.69	13.04
3	Christian	0.57	0.48	0.63
4	Sikh	1.48	1.53	1.35
5	Buddhist	0.19	0.20	0.41
6	Jain	4.23	4.33	3.45
7	other	0.03	0.00	0.04
8	not stated	0.00	0.00	1.04

Population of Indore was given a caste breakup of certain important sections; Brahmins, Bania, Rajput, Khatni, Balai, etc. few tribes are Bhil, Kir, Dhangar, etc.

Indore has a large amalgamation of people from various regions belonging to various regions; this mixture gave rise to the formation of new samitis and samajas, which take care of these communities.

Brahmins – Rambagh Basti

Gujarati – Wallabh Nagar

Jains – Cloth market, Marothia bazar; Lokmanya Nagar, Gomatgiri.

Maharashtrians – Lokmanya Nagar, Vasu Deobagh Nagar, Vaishali Nagar, Rajendra Nagar, Sainath Colony, Tilak Nagar

Sindhis – Bhanwar Kuan Road, Jai Rampur, Lal-bagh road

Muslim abadi – Bombay bazaar & Badwali Chowk (Old Indore) Chandan Nagar, Khajarana, Azad Nagar (New Indore)

Punjabi – Vishnu Puri, Kathi Wala Tank, Pratap Nagar (since 1955).

Goldsmith – Champawar, Daulat Ganj, Lohar Patti.

Present scenario

Maharashtrians – 15%
Gujaraties – 7-8%
Jains – 20%
Punjabi – 7-8%
Sindhi – 4-5%
Muslims – 10-15%
Others – 30%

The 1961 census recorded 78 dialects or languages spoken as mother-tongue in Indore District. Most common among them are Hindi (61.9%), Malwi (13.6%), Marathi (8.3%), Urdu (8.0%), Sindhi (3.2%), Gujarati (1.4%), and Punjabi (1.3%).

2.6.4 Employment

There is a general tendency to be engaged in occupation after the age of 20, but still the other factors like child labor affect this tendency. Fig 3.18 presents a break-up of working population under and above the age of 20.

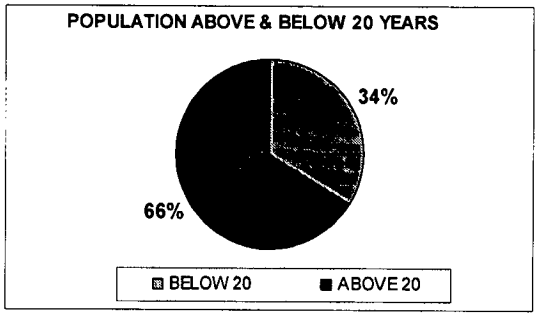


Fig. 3.18 Working Population above and below the age of 20

Fig. 3.19 presents the break-up of employment in various sectors. Fig. 3.20 presents the employment status of the city. Figure 3.21presents the ward wise employment in the city.

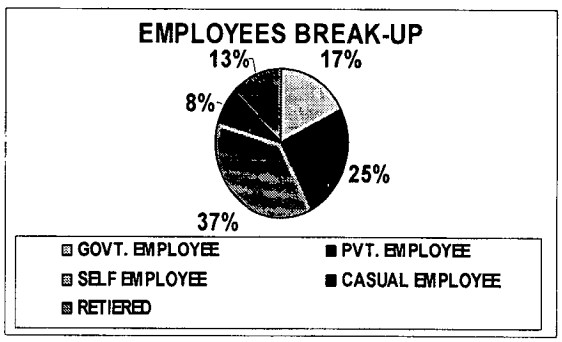


Fig.3.19 Employees Break-up

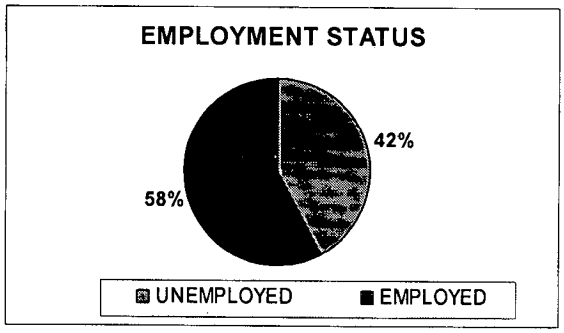


Fig. 3.20 Employment status

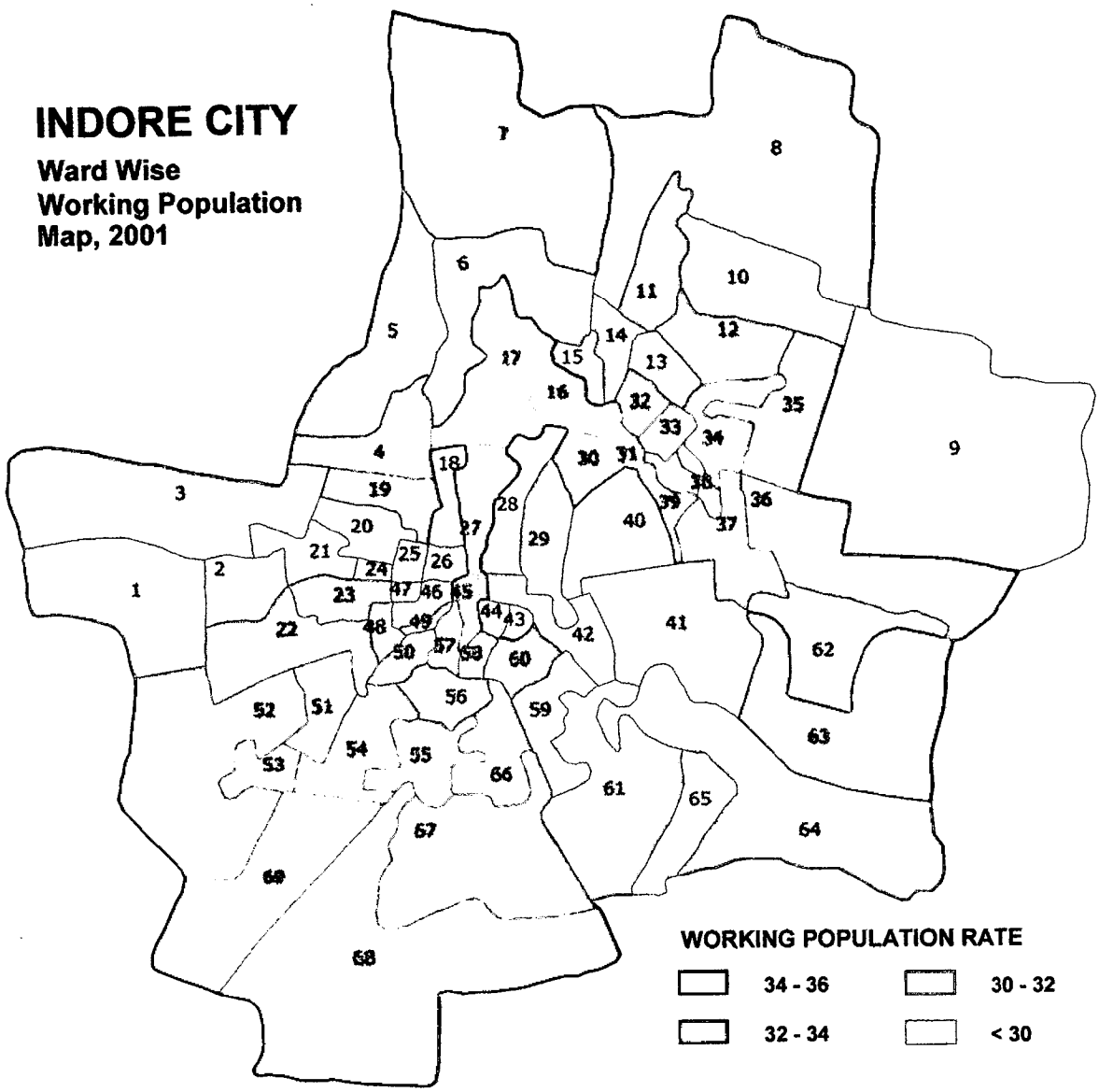


Fig. 3.21: Ward wise working population

Few peripheral wards - niranjanpur (7),rajendra prasad nagar (69) and tirupati colony (63) - are having more percentage of working population due to the presence of industries.

The central area being the commercial hub of the city, which is the trade and commerce capital of the state, has maximum capacity of absorbing employees. These wards have more percentage of working population such as Rajwada, Shivaji Nagar, Rustam Ka Bagicha, Jagjeevan Ram Nagar - wcich constitute to the commercial usage of land.

Silnath Camp, Bhagirath Pura, Shastri Nagar Jawahar Marg - these areas have both informal commerce and trade centers.

3.7 Institutional Structure in the city

3.7.1 Indore Development Authority (IDA)

Until 1973, the city had a 'City Improvement Trust', to assist the Indore body in its development activities. In 1973 the improvement trust was converted to Indore Development Authority (IDA) under the Madhya Pradesh Town and Country Planning Act 1973. Primarily, IDA develops new residential areas. During the early stages of development of such areas, IDA is responsible for developing basic infrastructure. Once a sizable number of plots are sold, the area is formally transferred to IMC, which is then responsible for maintenance of the infrastructure in the area.

Apart from developing residential areas, IDA has taken up a number of development schemes like construction of some major roads, traffic squares, Krishnapura Lake, Meghdoot Garden, etc.

3.7.2 Madhya Pradesh State Electricity Board (MPSEB)

MBSEB is monopoly state institution responsible for power generation, transmission and distribution in the state.

3.7.3 Madhya Pradesh Housing Board (MPHB)

MPHB functions as per the Madhya Pradesh development act of 1972, for development of housing in the city.

3.7.4 Madhya Pradesh Town and country Planning (TNCP)

TNCP department in Indore was established under MPTNCP Act of 1973. the main function of TNCP is to prepare master plans and give permissions in accordance with the master plan. Development planning committees are formed under 17-A (1) Provision of MPTNCP Act. These committees comprise of elected representatives, senior officials and government representatives.

3.7.5 Madhya Pradesh Pollution Control Board (MPPCB)

MPPCB monitors air quality, water quality and noise levels at various sampling points distributed throughout the city. It is also mandated to monitor industries and enforce pollution control measures. MPPCB is the nodal agency appointed to implement the 'National River Conservation Plan'.

3.7.6 Indore Development Fund Ltd. (IDFL)

A limited company, Indore development fund ltd., has been formed to mobilize funds for repair and construction of roads in the city. The company is fully owned by IMC.

3.7.8 Regulatory and Development Bodies

The Public Health Engineering Department (PHED), a State Government body, is charged with a number of responsibilities in water supply and sanitation. It is a state level body; presently the staff is deputed to Indore to oversee the Narmada water project.

3.8 Water Supply in Indore and Problem Identification

The old township was dependent for water supply on the tanks of Pipliya, Sirpur and Limbodi. Apart from these a number of open wells were situated in the city. Water supply of city was mainly dependent on the Bilaoli tank up to the later half of the twenties of nineteenth century. In the course of its development planning, the drainage of the city was provided by two small rivers, Khan and Saraswati. A sustainable planning requires full and judicious exploitation of locally available resources.

The existing water bodies in IMC area are Yashwant Sagar, Sirpur Talab, Pipliya Pala Tank and tributaries of Khan and Saraswati. The outer sources are five rivers namely Gambhir, 22 km away, Chambal , 43 km away, both flowing from South to North West of Indore, Kalisindh, 64 kms from Indore and Narmada River 70 km south of Indore. There is another small river namely river Khan, which passes through the city and flows from South to North meeting river Kshipra near Ujjain.

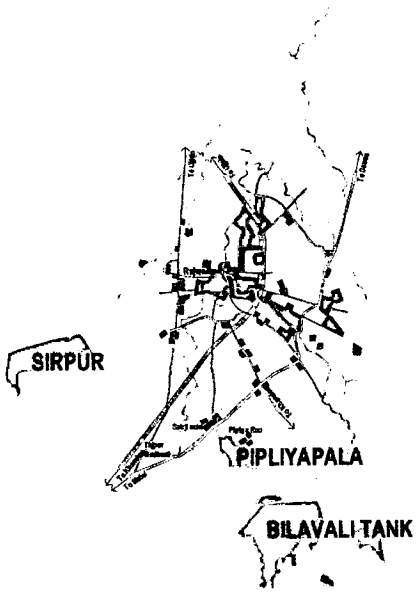


Fig. 322 Water resources in Indore (1920)

The old capital of Holkar was on the bank of River Narmada, where the water was ample, but still in the new capital, i.e. in Indore the local resources were these three lakes and two seasonal rivers Khan and Saraswati. The drainage of the city was provided by the internal water body, and water supply was done from the external sources, i.e., the contaminated part was in the city while the fresh water bodies were out side. Instead of this they could have taken use of the seasonal rivers for drinking water supply. Figure 3.22 presents the water sources in 1920.

In the third decade of nineteenth century, the city with a population of about 1.25 lakh suffered a severe spell of water scarcity and a new water supply system was executed in 1939 based on supply from Yeshwant Sagar. This Yeshwant Sagar scheme was designed for an ultimate population of 2.34 lakh and the total supply of the scheme was 7 mgd & was enhanced from 7 mgd to 8.5 mgd. In the middle of the sixth decade of nineteenth century, the approximate population of the city was about 4.10 lakh and the total water supply with all the existing water supply schemes of that period was-

Yeshwant Sagar	-	7.00 mgd (Average of the year)
Bilaoli and Sirpur tank	-	3.5 mgd
Tube wells	-	1.5 mgd
		12 mgd (54 mld)

Indore had population of about 5.72 lacs in 1970. Even then the two available water systems, Yashwant Sagar and Bilavali Tank were unable to fulfill the growing needs of city. Again there was a greater demand in comparison with available water. The city started facing drinking water scarcity after facing the acute draught problem during 1965-66. Subsequently Narmada water supply system was introduced. The city has been facing severe water supply crisis since the year 1971 because of population explosion and due to this problem drinking water supply became the prime concern of city planners and Narmada project came into existence. The division of sources of water after the introduction of Narmada project is presented in Table 3.8.

Table: 3.8 Sources of Water Supply in Indore City (2001)

Sr. no.	Sources of water supply	Installed capacity (MLD)	Water Supplied (MLD)
1	Narmada River	186	144
2	Yashwant Sagar	18	18
3	Bilaoli Tank	9	9
4	Well and Tube well	9	9
	Total	222	180

. *Source: Narmada Project, Water works Department. IMC. 2001*

Quality of water supplied through Narmada Water Supply Network was monitored for the past five years and the following observations are made:

- There has 76 per cent of total water supplied to the city is from the Narmada water supply network.
- Contamination of consumer points of all sources ranges from 11.02 to 16.36 per cent, which signifies a situation that demands serious concern, i.e., regular maintenance and repair of water supply lines wells, tube wells and hand pumps.
- Higher contamination level of wells, tube wells and hand pumps is quite natural as 60 per cent of the city area lacks sewerage and proper drainage services and having septic tank or other alternative arrangements resulting seepage, leakage and water logging.

3.8.1 Narmada water supply project, Indore (phase – I& II)

This was the first water supply project in the country where the water has to be lifted to a height of 550 m. through steep hills and mountainous terrain. The Narmada was tapped by establishing an intake well at Jalud, situated 5 km away from Mandaleshwar. It offers 65000 sq. km. for collection of unfiltered or raw water. A hilly region between the city and river and its height of 1800 ft. was the existing challenge of its horizontal distance. The strong will of the people bat the efforts of engineers and expert who undertook this unique project one of its own kinds in whole of Asia. A 12000mm dia pipe line having capacity of 4crore gallons per day was laid in the first phase to transport the water across this distance. An equal length of pipe of 600 mm dia was laid, which could carry 1crore gallons of water per day, in the second phase, in 1999.

This water is collected in the pumping centers and then supplied in the city through pipe lines. Over the years, it has been observed that there has been steady increase in both Indore Municipal Corporation area and population covered by piped water supply. On the other hand, there is a steady decline in per capita per day supply (lpcd) of water, which has decreased from 129 lpcd in the year 1997 to 116 lpcd in the year 2000.

The city is almost dependent on water from a distant source and supply from this scheme also seems to be very expensive. The scheme was designed to serve population of 12 lakh and the present population is 16 lakh. Same river waters are also bone of contention between several States and the development of river valley projects may, in future, jeopardize the total available quantum of water for urban use.

3.8.2 Cost analysis

Cost analysis of the Narmada Project shows that the total annual expenditure, excluding electricity charges are of about Rs. 33.00 crore per year. Cost of per unit of water supply is app. Rs. 9.50/kl in ideal conditions which comes around Rs. 15.53/ kl including unaccounted and non revenue water and losses due to illegal connections, and actually it is even greater after adding the interest of loan repayment. While the citizens pay Rs. 2/kl. The other tariffs have been discussed below.

- Water tariff (metered)

1.	Domestic	Rs. 2.00/kl
2.	Commercial	Rs.10.50/kl
3.	Industrial	Rs.22.00/kl
4.	Other inst./Govt off.	Rs.10.00/kl

- Water rate unmetered — Rs. 60.00/kl month for ½" conn.
- Water tax ,if any imposed — 10% on net property tax

The existing tariff is too low and requires revision on priority basis. There is very less percentage of metering. As per the primary survey carried out, 90 percent of the households pay Rs. 60/- per month for water. So they pay just for 30 units as per the rate decided by PHED, but the overhead tank capacity is above 4 kilolitre in 60 per cent of the households.

3.9 Issues

- Indore is facing rapid population growth, and the population is going to increase tremendously by the end of 2031.
- There is water scarcity at present; also the resources have not been utilized in a planned way.
- The basic problem is with the population growth.
- If the same rates of migration and birth are continued, then probably Narmada River Water will also not be sufficient to fulfill the requirements.
- Water has given rise to socio- economic development, and water scarcity can just stop all the activities of development.

Chapter 4: Assessing the Present Status of Development

A comprehensive survey was carried in the study area was carried out to assess the socio-economic, infrastructure and physical conditions. Investigator has presented the results of field survey in two parts, i.e. the primary data from the household survey and vsual observation and general discussions with the local people. Annexure 1 and 2 presents the schedule for survey.

Income is taken as a base for analysis of all the parameters, as it is the most important parameter, which decides the functions of the system. Income increases purchasing power of the people of the system increases, which leads to increase in standard of living, investment in higher education, good health, owning vehicles, household appliances, etc... As a social point of view in the Indian society, higher income makes higher social status of the people in the system. In economic view, income of a system increases the higher capital formation, which leads to higher investment, which leads to higher production, which leads to higher trade and commercial activities, which leads to higher income, which leads to higher saving, which leads to higher capital formation, which leads to higher investment, through which the cyclic process continues. In the present investigation having the importance of income in mind, the Investigator considers income as dependent (y) variable, and rest of the variables as independent, (x_1, x_2, ...x_n) variables for analysis. The Investigator looked at the range of income of the households and grouped the households under five categories such as, annual income less than Rs 1,00,000/- , Rs. 1,00,000-2,00,000, Rs. 200000-300000, Rs 300000-400000, and above Rs. 400000, and the households falling under each category of income is grouped accordingly, and are presented in Table no. 4.1. This table illustrates that there are about one-fourth (23 %) of the households of the surveyed households in the system are confined in the lowest income group category, i.e, the annual income group belong to less than Rs. 100000/- , and about half (48%) of them confined in the next higher category, about one fifth (19%) in the next higher category, and rest are scattered in other two categories. It is also observed that number of households' availability in different income group categories is decreasing along with increase in income from the second category onwards ,which shows that most of the households belong to second category i.e. annual income Rs. 100000/- to Rs. 200000/-.

Table 4.1: Number of Households of different income groups in Indore

S. No.	annual income	nu. Of households	%
1	<100000	23	23%
2	100001-200000	48	48%
3	200001-300000	19	19%
4	300001-400000	6	6%
5	>400000	4	4%
	total	100	100%

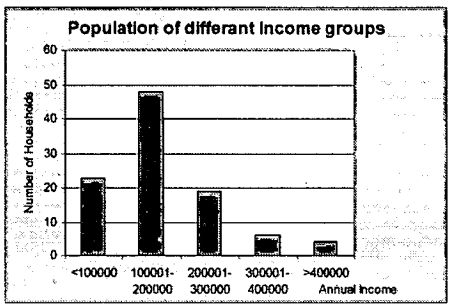


Fig. 4.1 Number of Households of different income groups in Indore City

Highest income group consists of people having annual income of more than Rs. 400000/- per year. There are four households coming under this category, of which two are the joint families while the other two are nuclear families. It has been further observed that in houses where the ladies are working has higher income. However the percentage of such houses is also less.

4.1 Demographic Characteristics

4.1.1 Family Size and type

Indore is an important city in Madhya Pradesh for education, commerce, sports, health and medical facilities, industries and administration, so being highly urbanized it has adopted culture of smaller family size and nuclear families. Smaller family size is good from population control point of view, but the increasing number of nuclear families has increased the housing requirements and extra burden over resources. In Joint families brothers and parents live together, share the same house, same kitchen and hence all the expenses are shared, so the requirements are naturally reduced, it is good for the better utilization of land and housing. This investigation has been done for assessing the water requirement. The water requirement of the same number people living in joint family and same house is always less than the requirement of the same people living in nuclear family and different house.

Taking example of a person, he has his wife, two sons and daughters-in-law, and four grandchildren in his family. He had built a house over a plot of 2400 sq. ft. with an overhead tank of 3000 liters and a 4000 liters tank for collection of piped water. Now his family is separated. Both the sons and father live in different houses. Elder son is living in a house of 1500 sq.ft., and younger son lives in a multistory apartment in a flat of 1200 sq.ft.. Table 4.3 presents an estimate

of the previous and present requirements and expenditure of the same family. Joint family system is good from the cultural point of view also. Children get good care of grandparents, even if their parents are working. The traditions and culture is also transferred to younger generations. Nuclear family does not get such advantages. When people get job at different places, then there is no other option than the nuclear family, but same joint family separated and living in the same city definitely increases load over resources. The market is also increased to fulfill the requirements, as the number of nuclear families is increasing, but in overall perspective it is against the development of economy.

Table 4.2: Estimate of the expenditure of a joint family, after and before separation

Sr. no		Commodity	Requirement of joint family (X)	Present Requirement			Total
				Father(Y1)	Elder brother (Y2)	Younger Brother (Y3)	
1		Land	2400 sq. ft	2400 sq. ft	1500 sq. ft	1200 sq. ft	5100 sq. ft
2		Water	7000 liters	3500sq. ft.	3500 liters	2000 liters	9000 litres
3. Monthly Expenditure	1	House rent	0	0	0	Rs. 2000/-	Rs. 2000/-
	2	Water bill	Rs. 120/-	Rs. 60/-	Rs. 60/-	Rs. 60/-	Rs. 60/-
	3	Electric bill	Rs. 600/-	Rs. 400/-	Rs. 450/-	Rs. 350/-	Rs. 1200/-
	4	Servants' pay	Rs. 500/-	Rs. 300/-	Rs. 300/-	Rs. 200/-	Rs. 800/-
	5	Milk bill	Rs. 1400/-	Rs. 450/-	Rs. 900/-	Rs. 900/-	Rs 2250/-
	6	Veg. /fruits	Rs. 1000/-	Rs. 450/-	Rs. 600/-	Rs. 500/-	Rs. 1550/-
	7	School fees	Rs. 5000/-	0	Rs. 3000/-	Rs. 2000/-	Rs. 5000/-
	8	Crèche free	0	0	0	Rs 500/-	Rs. 500/-
	9	Conveyance	Rs. 2000/-	Rs. 250/-	Rs. 1500/-	Rs 1000/-	Rs. 2750/-
	10	Phone	Rs. 1000/-	Rs. 1000/-	Rs. 1200/-	Rs. 1000/-	Rs. 3200/-
	11	Food & gas	Rs. 3000/-	Rs. 900/-	Rs. 1500/-	Rs. 1200/-	Rs. 3600/-
	12	Extra	Rs. 2000/-	Rs. 300/-	Rs. 500/-	Rs. 500/-	Rs. 1300/-
		Total	Rs. 16620/-	Rs. 4110	Rs. 10010/-	Rs. 10210/-	Rs. 24330/-
4.Appliances	1	Fridge	1	1	1	1	3
	2	T.V.	1	1	1	1	3
	3	Computer	0	0	1	1	2
	4	Fans	5	5	5	4	14
	5	Coolers	3	1	1	1	3
	6	Wash. Ma.	1	1	1	0	2
	7	Automobiles	5	1	3	2	6

The table shows noticeable difference between the two. The previous expenditure was Rs. 16620/-, while the present expenditure is Rs. 24330/-, whereas the land requirement increase from 2400 sq. ft to 5100 sq. ft.

This person belongs to income category of Rs. 300000-400000/-., and the table shows that all the requirements are drastically increased. This rule implies to the people of all the income group categories. It is a point of concern that joint families are splitting although the people have their jobs in the same city.

Looking at the number of households in the family, the largest family in the surveyed households is found in the highest income group, and it's a joint family. Joint family culture has been vanishing in Indore city. This survey reveals that about one third of the households (31%) are living in joint families. Most of the Sindhi, Bohra and Punjabi families are joint families. Most of them have joint business, shops or industries. The income level of these communities is also high. The number of children per family is limited till 3 in 90% of the surveyed households. The number of people living in the family in different income groups has been presented in table no 4.2.

Table 4.3: Number of members in the family

S. No.	annual income	1-3	%	4 - 6	%	7- 9	%	>9	%	Total
1	<100000	4	25	14	18.92	5	71.43	0	0.00	23
2	100001-200000	8	50	39	52.70	1	14.29	0	0.00	48
3	200001-300000	3	18.75	15	20.27	1	14.29	0	0.00	19
4	300001-400000	1	6.25	5	6.76	0	0.00	0	0.00	6
5	>400000	0	0	1	1.35	0	0.00	3	100.00	4
	total	16	100	74	100.00	7	100.00	3	100.00	100

This table illustrates that about three fourth (74%) of the households have family size 4-6.
Other category is the family size of 1-3, 16 percent households come under this category. This shows that single child culture has been adopted by these families. It has been already mentioned that number of children per capita is limited to 3. The bigger family sizes, i.e., 7-9 and >9 present the joint families and constitute 10 percent of the number of the households.

4.1.2 Sex Ratio and condition of women

The condition of women is comparatively good in Indore city. The number of females per thousand males has been increasing. Since the family size is being reduced. Unlike other states of North India there are no cases of female feticide in Indore. Indore people give importance to girl

child and put stress on their education. The city is 100% literate and well educated also. According to census 2001 there are 900 females against 1000 males, but the survey done over 100 households' shows 293 females against 288 males. Table 4.4 and Figure 4.2 present the number of males and females in different income groups.

Table 4.4: Number of males and females in different income groups in Indore

S. No.	annual income	nu. Of households	male (x1)	%	female (x2)	%	total
1	<100000	23	58	20.14%	48	16.38%	112
2	100001-200000	48	101	35.08%	114	38.91%	215
3	200001-300000	19	44	15.27%	44	15.02%	88
4	300001-400000	6	74	25.69%	75	25.6%	149
5	>400000	4	11	3.82%	12	4.1%	23
	total	100	288	100%	293	100%	587

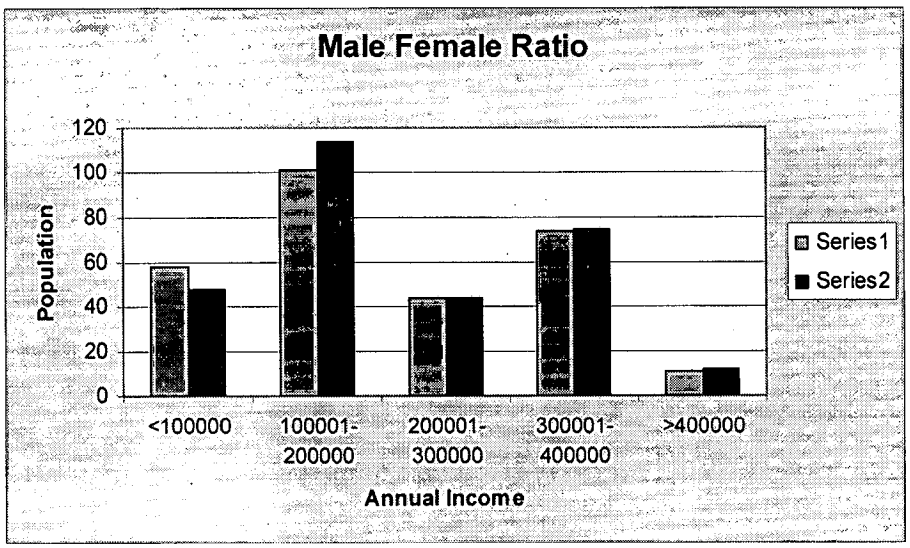


Fig. 4.2 Number of Males and Females indifferent income groups

This table reveals that the sex ratio is greater than one. The maximum number of females against males is found in the second income group, i.e., 114 female against 101 males. These families are square families with two or three girl children. It is noticeable that female students score high at school level and since 10 years they have maintained well position in the merit list of State and Central Board of Middle and High School Education.

The less female ratio in the census indicates difficult housing situation prevailing in the city. The migrant worker has a tendency to leave his family behind unless he is hopeful of obtaining a house within his rent paying capacity. Table 4.5 shows the percentage of working ladies.

Table 4.5: Number of households with working women

S. No.	annual income	nu. Of households	working ladies	%
1	<100000	23	2	8.69%
2	100001-200000	48	5	10.41%
3	200001-300000	19	12	41%
4	300001-400000	6	5	83%
5	>400000	4	3	75%
	total	100	27	100%

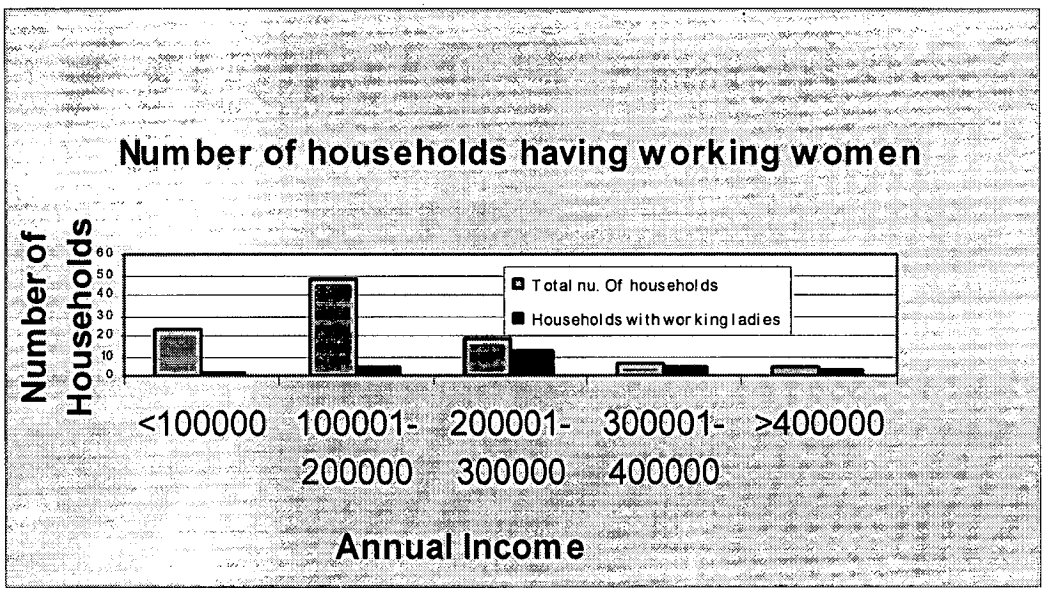


Fig. 4.3 Number of households having working women

Five ladies out of six households are engaged in economic activities in the fourth income group (300001-400000). While in the lowest income group only 2 ladies out of 23 households are engaged in economic activities. According Urban Environment Report, Indore the employment rate in females is just 33%. Figure 4.4 presents graph showing households with working women. Female population in Indore city is well educated but their role in economic activities is comparatively less. There is safe environment for women in Indore. These females are housewives and have major role in the culture and civilization of the city. The native business families and Sindhi, Punjabi, Muslim and Bohra families in Indore have greater percentage of joint families and housewives.

Less rate of employment in women is a point of concern, but on the other hand these ladies give attention to kids, and their education, this is probably the reason for controlled and well mannered youth of city.

4.3 Social Characteristics

Religion, Caste system and languages play major role in the social characteristics. Socially, Indore has been the unique city in the State. As Indore is situated in Malwa region the native people are Hindi speaking only. Later in 1818, Holkars came in the city; they brought their soldier staffs of Marathas and other communities and official staff of Brahmins, their generations have been living in the city since that time and still Maharashtrians community stands second in majority followed by Sindhi and Sikh communities.

Holkars encouraged trade and commercial activities in the city. These efforts attracted other neighboring States' people, and they have also become domicile of the city. Industrial and religious activities were the other reasons for attraction, and people have migrated in the city. Today, social fabric of Indore consists of Maharashtrian, Gujrati, Marwadi, Sindhi, Punjabi, Sikh, Bangoli, Bohra, Muslim and Christian and South Indian communities. The survey done over 100 households has covered the people speaking five languages only yet there are all the above mentioned communities existing in the city. Table 4.6 and Figure 4.6 show the number of people speaking different languages in different income groups.

Table 4.6: Number of households speaking different languages

S. No.	Annual income	Hindi	%	Marathi	%	Punjabi	%	Sindhi	%	Urdu	%	Total
1	<100000	18	28.13	3	15.00	0	0.00	0	0.00	2	66.67	23
2	100001-200000	33	51.56	11	55.00	2	28.57	2	33.33	0	0.00	48
3	200001-300000	10	15.63	4	20.00	2	28.57	2	33.33	1	33.33	19
4	300001-400000	1	1.56	1	5.00	2	28.57	2	33.33	0	0.00	6
5	>400000	2	3.13	1	5.00	1	14.29	0	0.00	0	0.00	4
	total	64	100.00	20	100.00	7	100.00	6	100.00	3	100.00	100

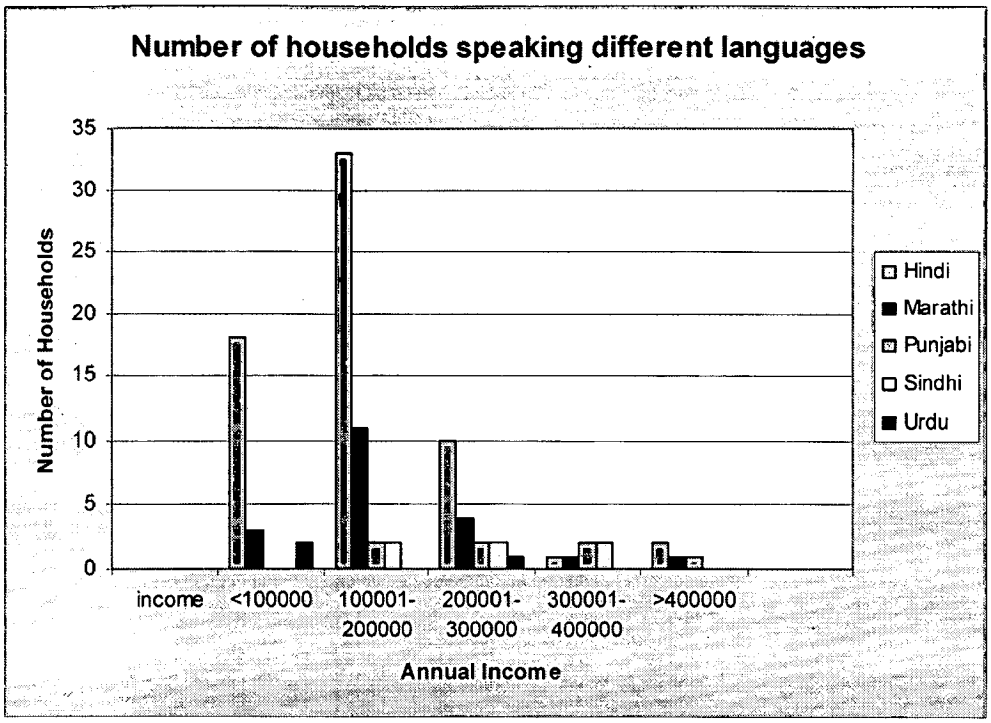


Fig. 4.4 Number of households speaking different languages

This table illustrates that about two third (64%) of the households speak Hindi language, followed by Marathi at one fifth of the households, and next are scattered over other languages, such as, Punjabi, Sindhi, and Urdu speaking communities. It is understood from the table that more than one third of the city's population (36%) migrated from the other states to this city, and are living together.

4.2.1 Religion

The main religion in Indore is Hindu; other religions are Islam, Christian, Persian, Bohra, Sikh etc. There are social groups and institutions of all these communities. City's system supports and encourages religious activities of the same. The festivals and religious activities go year around in the city. The festivals which are socially celebrated are Holi, Ganesh Puja, Durga Puja, Dashera, Janamashtami, Id and Christmas etc. The interesting thing is that, these festivals have been culturally accepted by all the communities. For example, Navaratri is a main festival of Gujrat, but its celebration is done jointly by all the communities. This festival comes in the month of September or October and whole city is decorated by frills and lighting and beautiful statues of Goddess. These statues are made by Bangali artists. Young girls and boys dance Dandiya and Garba and perform worship of goddess.

Another example is Ganesh sthapana. This festival is mainly a Maharashtrian festival. It is celebrated in August or September, and for eleven days. This festival has become a part of whole city's culture. Just like Navaratri, it is celebrated at social level and by all the societies of the city. Other religious festivals like Lohri (Punjabi), Id, Christmas are also now culturally accepted by all the communities.

The city is very peaceful. It has recordable history of peace and rate of crime and riots is very less as compared to other metropolitan cities of India. All the communities work for welfare of the city. Religious activities are not the only feature for unity in diversity, these communities run educational institutions, cultural societies, hospitals and banks. Examples are Holkar college (Maharashriyan), Gujrati Samaj vidhyalaya (Gujrati), Christian Hospital (Christian), Islamiya Karimiya College (Muslim), Khalsa University (Sikh), Bank of Rajasthan , South Indian Cultural Association (SICA) school etc.

This culture of unity in diversity imparts major role in the economic and commercial activities also in the city. City is a big centre of collection and distribution of various commodities. Large mandies dealing in various commodities such as grain, cotton, cloth, hardware, glassware, timber vegetable and fruit where wholesale transaction take place with the joint efforts of all these communities.

4.2.3Caste

The caste system in Indore is same like whole India. The division of caste was done according to the occupation of the people. Brahmin, Vaishya, Kshatriya and Shudra are the four castes. The teaching class and people engaged in religious activities were categorized as Brahmins, Business and merchant class was categorized as Vaishyas, the rulers and soldiers and defense staff was categorized as Kshatriyas while the people serving all these categories were known as Shudra. Previously this differentiation was done according to the occupation of the people, but later castism played created disputes in the people. Now the society has been developed in such a way that caste differences do not matter much for the concerned occupation. All have adopted the occupation of their own interest and choice. Castes are referred only for the marriage purposes. Somewhere occupation of the people has also remained similar, that too in case of Brahmins and Vaishyas. Still Brahmins have their own importance in religious activities. Indore from its historical perspective has remained a castle of Jamindars and a village of Brahmins. The Brahmins

are in majority in the city. Business class still have majority of vaishyas. The caste structure of the surveyed households has been presented in Table 4.7..

Table 4.7: Population of different castes in Indore

S. No.	Annual income	Brahmin	%	Vaishya	%	Kshariya	%	OBC, SC/ST	%	Total
1	<100000	15	34.09	2	7.14	1	5.88	5	45.45	23
2	100001-200000	18	40.91	13	46.43	14	82.35	3	27.27	48
3	200001-300000	9	20.45	7	25.00	0	0.00	3	27.27	19
4	300001-400000	1	2.27	4	14.29	1	5.88	0	0.00	6
5	>400000	1	2.27	2	7.14	1	5.88	0	0.00	4
	total	44	100.00	28	100.00	17	100.00	11	100.00	100

This table explains that about half (44%) of the households belong to Brahmin community. Followed by Vaishyas just above one fourth (28%), Kshatriya about one fifth (17%), and the rest are confined among OBC/ SC/ ST categories. It clearly shows that society is dominated by the Brahmin traditionally, but the domination is not obscured in practice due to social transformation occurred in the city.

4.3 Economic Characteristics

Infrastructure and services like education, health, communication, administration, etc., play vital role in economic development. Indore is a commercial capital of the State and has very big market for retail and wholesale of almost all the commodities. Previously, Indore was known for cotton industries and for these cotton industries the housing and road networks were set up. At present there are numerous other commercial activities taking place. The income of people is increased and hence the culture of software parks, shopping malls, multiplexes, etc., has come in the city. This has opened way to a lot of income earning opportunities in the city. The census 1991 indicated that in Indore District, there were close to 6.3 lacs workers. Indore city accounts for nearly two thirds of the total employment in the district.

Traditionally, different professions in Indore involve, real state business, construction industry, journalism, arts, medicine, hospitality, teaching, computer job work, printing, small scale industries and household industries, food processing units like oil refineries, sugar and floor mills,

etc., and sale and exchange of different commodities like cloth, garments, footwear, hosiery, cosmetics, jewelry, utensils, furniture, grains, dry fruits, oil, sugar, hardware, stationeries, etc..

The composition of different occupations plays important role in the calculation of requirement of the infrastructure. Water, Electricity, Roads, modes of transportation all are dependent variables for easygoing integration of these occupations' system. Different commercial set-ups require a definite set of amenities and infrastructure. Although Indore has good history of city planning, now the commercial activities are taking different shape.

4.3.1 Industrial centre

City is an important industrial centre in the State. Expanding flatted industries and industrial development in the region has also given this city a status of an industrial centre. There is large number of manufacturing establishments, producing goods like cloth, iron and steel, chemical, wood products, building material, transport equipment, automobile parts, automobiles, television, electrical appliances, leather footwear. paper, alcohol, medicines, sugar, oil, etc. Multinational companies like Eicher, Bajaj, Kinetic Honda, Tata, Crompton etc are confined in the Pithampur and Sanver Road, and all the staff resides in Indore. This staff consists of skilled and unskilled manpower from all over the country.

4.3.2 Transport Centre

Transportation is also a good source of employment in Indore city. The modes of local transport are auto-rickshaws, tempo, and minibuses. There is a market of private bus services for State and interstate transport also. Transportation sector has employed a number of people in operation and maintenance of public and private vehicles, auto garages, dealership of automobile parts, petrol pumps, traffic management and construction, operation and maintenance of roads, traffic islands, flyovers and bridges etc.. Activities in transport, storage and transshipment centers have sprung up along National Highway just outside the municipal limits. The State's first dry ports near Pithampur and air cargo terminal have also come up in the region signifying the importance as regional centre of Trade and Commerce.

4.3.3 Administrative Centre

The city contains Regional offices of various business establishments, banks and public sector undertakings. State government offices like town and country planning office, high court, police headquarters, etc. are confined in the city.

4.3.4 Educational Centre

Indore has been a big education centre since 1960. Devi Ahilya Vishvavidhyalaya, one of the known universities is an identity of Indore. Apart from this the Govindram Seksariya Institute of Technology and Science (Indore) has played very important role in the industrial development of the state. Decade of 1991-2001 has witnessed the emergence of many technical schools, engineering, management, and catering and fashion institutes. The culture of education has been turned into the market and apart from the schools and colleges there is a big market for coaching classes for preparation of competitive exams like GRE, TOEFL, CAT, PET, PMT, MCA, IIT-JEE, UPSC etc.. The 50 per cent of the students reading in all these institutes are the migrated, that too not only from the State but from the whole nation. Hence, a greater proportion of the migrated population consists of the students. Students for higher education and competitive exams are also coming in the mass quantities in the city.

4.3.5 Medical centre

Increasing medical facilities have encouraged many doctors and other medical staff, pharmacists as well as pathological laboratories to get settled in the city. Indore provides better and cheaper medical services and hence the people from all over the State take advantage of these facilities. The number of households engaged in different professions has been presented in table no 4.7.

This table explains that the employment rate is highest in the private sector. About two fifth of the households (39%) are engaged in private jobs. More than one fifth (22%) households are employed in government, while other group which is also about one fifth (19 %) of the population is engaged in their own business. Real estate and construction industry provide employment to 6 per cent of the households (labor class is not included) and 6 per cent of the households is having their own shops. Senior citizens of the city who are living alone, are dependent over pension and house rents, and have 4 percent share. Rest are scattered over in other occupations like teaching (2%), agriculture (2%) etc.

Table No. 4.8: Number of members engaged in different professions in different income groups

S. No.	Annual income	agriculture	%	govt. job	%	non govt job	%	teaching	%	own shop	%	own business	%	construction	%	%	Total
1	<100000	1	50	3	13.64	16	41.03	0	0.00	1	16.67	0	0.00	0	0.00	50.00	23
3	100001-200000	0	0	14	63.64	18	46.15	2	100	4	66.67	9	47.37	0	0.00	25.00	48
4	200000-300000	1	50	3	13.64	5	12.82	0	0.00	0	0.00	5	26.32	3	50.00	25.00	19
5	300000-400000	0	0	1	4.55	0	0.00	0	0.00	0	0.00	4	21.05	2	33.33	0.00	6
6	>400000	0	0	1	4.55	0	0.00	0	0.00	1	16.67	1	5.26	1	16.67	0.00	4
7	total	2	100	22	100	39	100	2	100	6	100.00	19	100.00	6	100.00	100.00	100

Table 4.9: Year of Construction

S. No.	annual income	before 1960	%	1960-80	%	1980-2000	%	after 2000	%	Total
1	<100000	2	33.33%	5	31.25%	11	20%	5	23.842	22
2	100001-200000	3	50%	4	25.00%	31	55%	10	49.304	48
3	200001-300000	1	17%	5	31.25%	8	14.28%	5	19.622	19
4	300001-400000	0	0%	2	12.50%	3	5.35%	1	6.1785	6
5	>400000	0	0%	0	0.00%	3	5.35%	1	4.0535	4
total		6	100%	16	100%	56	100%	22	100%	100
		6%		16%		56%		22%		100%

Many poor personals from the rural and tribal areas, which are not able to secure livelihoods, migrate to Indore every year to Indore and work for periods of 8 months to work on construction sites. Migration has given rise to housing requirement, hence housing and construction industries are blooming in the city.

4.4 Housing

Housing requirement is increasing and consequently the other related fields like water supply, its distribution network, sewage system, solid waste disposal system, and electricity and telephone lines have also increased with the same pace.

Housing is a prime determinate of the water requirement and water conservation. The year of construction, type of housing, (i.e., detached, semi detached, apartment, row housing etc.), area under each house, area of roof are such determinates. The increase in housing requirement can be assessed by the frequency of construction of houses with respect to time. Increasing number of housing requirement has given flux to construction industry.

Method of rain harvesting system is dependent over type and area of roof and housing. Table no. 4.9 presents the year of construction of houses.

This table shows that in 1960 there were very few houses in Indore. Only 6 per cent of the households built their houses before 1960. Next period, i.e., 1960-80 witnessed the construction of 16 per cent houses. More then half houses i.e. 56 per cent have been built in the period of 1980-2000, followed by houses built after 2000, i.e. 22 per cent. Migration only is not the reason for increase in housing requirement. Other reason behind this is the breaking-up of the joint family culture. This brake up has definitely put extra pressure on the infrastructure. The trend of changing family patterns and land requirements has already been discussed. The number of houses has been increased; the marginal open spaces around built-up area have been reduced.

Many places in Indore have reported about the depletion of ground water level. This happened because the surface area is paved by concrete and then percolation of rain water does not take place, and rain water does not reach till the ground. Population is increasing day by day and hence apartment and row housing is preferred instead of detached houses.

Detached houses have some marginal open spaces around the house. Maximum number of floors in detached and semidetached houses is 3; hence the occupancy in such houses is minimum. The marginal open space is a mean for percolation of water. As the water requirement is increasing, the resources are also needed to be increased; ground water level depletion shall be given great concern. Rain water harvesting is the best solution to overcome the problem of ground water

depletion. The factors influencing the potential of rain water harvesting site depends on a number of factors. The most important out of them are the climatic conditions and the characteristics of the catchments area.

Catchment area characteristics determine the quantity of runoff. Runoff depends upon the area and type of the catchment over which it falls as well as the surface features. All calculations relating to the performance of rainwater catchment system involve the use of runoff coefficient to account for losses due to spillage, leakage, infiltration, catchment surface wetting and evaporation, which will contribute to reduce the amount of runoff. The data regarding type of housing is required for determining the density of people, water requirement and the quantity of harvested rain water per person. There is a term called Runoff coefficient of catchment surfaces. This coefficient is a ratio of the volume of water that runs off a surface to the volume of rainfall that falls on the surface.

Based on these factors the water harvesting potential of a site could be estimated using the formula given below

~~Water harvesting Potential= Rainfall (mm) X Area of catchment X Runoff coefficient~~

All the houses in survey are having R.C.C. flat roof. The value of this coefficient is 0.6 to 0.8 for flat concrete roof. Greater the roof area more is amount of rain water harvested. Table no.11 and 12 present the plot area and the covered built-up area for the surveyed households. One can consider the roof as a tank to collect the water. In case of detached houses quantity of rain water collected over per person will always be greater than the apartment. The types of houses in various income groups are presented in Table No. 4.10.

Table 4.10: Type of housing

S. No.	annual income	detached houses	%	semidetached houses	%	apartment	%	row housing	%
1	<100000	6	20.69%	7	22.58	6	30%	4	18.18
2	100001-200000	8	28%	19	61.12%	9	50%	12	54.54
3	200001-300000	10	38%	3	9.67%	2	11.11%	4	18.18
4	300001-400000	2	7%	1	3.23%	1	5.55%	2	9.09
5	>400000	3	10%	1	3.23%	0	0	0	0
	total	29	100%	31	100%	18	100%	22	100%

This table illustrates that more than one fifth of the houses (29%) are detached and about one third are semidetached (31%). Apartment houses' percentage is 18 per cent while there are 22 per cent

households living in row housing. This is positive point in the economic design of rain water harvesting system, as only less than one fifth houses are apartment type.

Housing density

This can be determined by the occupancy of the people. The easiest method of finding the density is to find out the two variables, i.e., the population and the area of house and open spaces around the house. The sum of house area and the open space around it gives the plot area. Table no. 4.11 illustrates various sizes of plots owned by households of different income groups. These are categorized into four categories, i.e., plot area less than 1500 sq. ft., 1500-3000 sq. ft, 3000-4500 sq. ft and plots having area more than 4500.

Table 4.11: Area under each house: Plot area

S. No.	annual income	<1500 sq.ft	%	1500-3000	%	3000-4500	%	>4500	%	Total
1	≤100000	17	26.1538	6	13.9535	0	0	0	0	23
2	100001-200000	28	43.0769	14	32.5581	2	33.333	4	40	48
3	200001-300000	7	10.7692	7	16.2791	2	33.333	3	30	19
4	300001-400000	11	16.9231	15	34.8837	1	16.667	2	20	6
5	>400000	2	3.07692	1	2.32558	1	16.667	1	10	4
	total	65	100	43	100	6	100	10	100	100

This table reveals that about two third of the households (65%) live in area less than 1500 sq. ft. and less than half (43%) of the households live in the plot sizes between 1500-3000 sq.ft., and rest are scattered over in other bigger size plots (3000-4500 sq. ft. and >4500 sq. ft.).

Land prices are increasing and the city is increasing in area to meet with the housing requirement. Previously the plots were divided under the category of H.I.G., M.I.G. and L.I.G. The area under H.I.G. house was maximum, L.I.G. had minimum and M.I.G. was in mid of these two. Nowadays this concept has gone. Economic status and the plot area are not dependent over each other. Housing market has been increased and fashion of smaller, manageable and architecturally beautiful houses has been come into the existence. People still do not prefer to live in apartment; instead they go for row housing. Fig. 4.5 and 4.6 present the housing types of same income group. The status of people is same, but the area of plot and time of construction is different. Fig. 4.5 shows a view of housing in Saket Nagar, which was built in year 1970. It is one of the colonies of prestigious people in Indore, and Fig. 4.6 is a photograph of row housing

near Aranya housing. This housing is recently built in year 2005. The income level of both the colonies is same. Only there is a difference of plot size and location. Fashion of contemporary, small manageable and beautiful houses has attracted the senior citizens living in the big houses (plot area greater than 2400sq.ft) to sell their big houses and to get a smaller house in exchange of it.

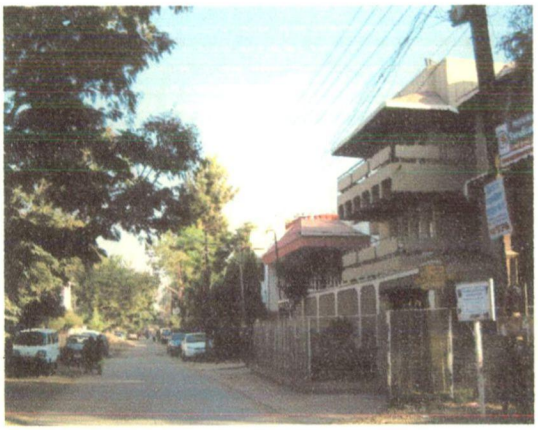


Fig 4.5 Saket Nagar; an old HIG colony

Fig. 4.5 Row housing near Aranya Nagar (2005)

Fig 4.6 Ravindra Nagar, bungalows converted into flats

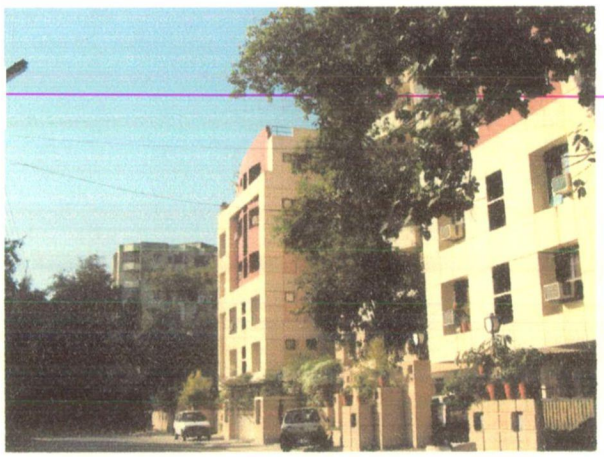


Fig 4.7 Old Palasia, a bungalow converted into flats

The colonies which are in the heart of the city and have better living conditions, proximity of market and better infrastructure, like Ravindra Nagar, Saket, Chandralok, M.I.G. are the colonies with bigger plot sizes (plot area greater than 2400sq.ft). The out migration in Indore is also becoming popular. Younger generation belonging to these colonies is attracted towards the bigger metropolitan cities of India or abroad for better education and employment. The chances of their return are usually very less. Some cases are there of such families who have only two or three girl children. When the girls are got married, the bigger plots remain of no use for the parents and finally the house is sold. The land prices in these areas have been constantly

increased. Than the builders purchase their house, and reconstruct it in the form of flat system. Wherever the building height is restricted they go for G+1 or G+2 structures and make 6-8 flats with the better facilities and aesthetics. The house owner is given one or two flats free in return of the land and house. People prefer this for economic advantages and safety. Fig. 34 shows such a scene of Ravindra Nagar. These plots were owned by higher income grouped people. Now there are 8 smaller but well facilitated houses are built in the same area which was owned by a single owner. Fig. 35 shows Apollo Enclave, previously it was a single bungalow and family of 6 members with two residing servants was living here, now there are 48 flats and 200 people are residing over the same.

Housing market has been increased on one side but at the same time the open spaces are highly reduced. Increasing housing density results in reduced built up area per-capita. Table no. 4.12 presents the roof area of houses of the households of different income groups. This table is on an assumption that roof area is equal to the built-up area.

Table No.4.12: Roof Area

S. No.	Annual income	Roof Area in sq. ft								
		400-800	%	800-1200	%	1200-1600	%	>1600	%	Total
1	<100000	9	25.714	11	21.1538	3	15.7895	0	0	23
2	100001-200000	18	51.429	20	38.4615	5	26.3158	5	38.462	48
3	200001-300000	3	8.5714	8	15.3846	4	20.1	4	30.7	19
4	300001-400000	1	2.8	1	1.9	1	5.2%	3	27.27	6
5	>400000	2	5.7143	0	0	1	5.26316	1	7.6923	4
	total	33	100	40	100	12	100	11	100	100

This table shows that two fifth, i.e. 40 per cent households belonging to the second income group i.e., Rs. 100000-200000/- per year have roof area in the range of 800-1200 sq.ft. One third, i.e. 33 per cent households has roof area of 400-800 sq.ft. More than one tenth (12%) households have houses have roof area of 1200-1600 sq. ft., and another set of more than one tenth (11%) households have houses of highest built- up area, i.e., more than 1600 sq. ft. This depicts that roof area is increasing with the increase of income group.

4.5 Water Supply

4.5.1 Sources of Water Supply

The main sources of water in Indore are Narmada, and Yashwant Sagar and piped supply is dependent over the same. Other sources include Bilaoli Tank, wells and tube wells (with power pumps). The sources of water supply in the city are presented in table 30. There are the four categories regarding water supply, first category shows water supply only with Narmada, second is the combination of Narmada and Bore well, the next is water supply through own bore well and fourth is the community water supply. In the last catagory, communities collect the Narmada water and ground water and supply to the community premises, Table 4.13 presents the sources of water supply in the surveyed houses.

Table 4.13: Present Sources of Water Supply in Indore city (secondary sources)

Sr. no.	Sources of water supply	Installed capacity (MLD)	%	Water Supplied (MLD)	%
1	Narmada River	186	83.78%	144	80%
2	Yashwant Sagar	18	8.11%	18	10%
3	Bilaoli Tank	9	4.05%	9	5%
4	Well and Tube well	9	4.05%	9	5%
	Total	222	100.0%	180	100%

Source: Narmada Project, Water works Department. IMC. 2001

This table reveals that the installed capacity of whole system is 222 MLD, and the water supplied is just 180 MLD, i.e., only 81% is supplied of the total installed capacity. The rest quantity of water, i.e., 19 per cent is kept extra. Though the installed capacity of Narmada water supply system is 186 MLD, only 77.40 per cent of the installed capacity is supplied by leaving the gap of 22.60 per cent.

There is very much difference in installed capacity of the sources, water supplied and water received in the residential areas. The piped water supply is not regular, so people rely on ground water sources too. The wells and tube well presented in Table 4.13 present are the government wells. Apart from this, there are many private wells also functioning in the area. Table 4.14 presents the sources of water supply in the surveyed area.

Table 4.14 : Sources of Water Supply in the surveyed area

S. No.	annual income	Narmada	Narmada and Tube well	Bore well	Total
1	<100000	11	7	5	23
2	100001-200000	25	10	13	48
3	200001-300000	8	8	3	19
4	300001-400000	3	2	1	6
5	>400000	2	1	1	4
	total	49	28	23	100

This table reveals that half of the surveyed households (49%) are totally dependent over Narmada water, whereas Table 4.13 presented that 80 percent of the government water supply is through Narmada River. The rest of the households depend on either bore wells or tube wells along with Narmada River water for their survival. Households have reported that piped water comes alternate day that too at very low pressure. Some times water is not even supplied because of the leakage and repairing works of the pipelines.

Summers time is more difficult, as sometimes water is supplied once in three or four days. Piped water supply remains no more reliable. Narmada water supply seems to be insufficient to fulfill the water needs of people and during summer seasons extreme shortage is faced as the city is increasing in size. Hence some households have dug bore wells in their house premises. Bore wells are more in case of apartment and row housing.

It was found during survey that the quality and taste of Narmada water is better than the ground water, hence people use Narmada water for drinking purpose and ground water for other uses.

It is also found that 22 per cent households are totally dependent over ground water. These households are located in Sainath colony, Samvid Nagar, Sudama Nagar, Khatiwala tank, Ashish Nagar, MOG lines, Manbhavan Nagar, Brijeshwari NX, Nanda Nagar, Ganeshpuri, Vijay Nagar, Ashish Vihar NX, Suraj Nagar, Sarvasampanna Nagar, Narayan Bagh, Indrapuri, Nemi Nagar Jain Colony and Manoramaganj. Brijeshwari NX is the only new colony neither in these, rest all are neither newly built nor in the outskirts of the city. Sudama Nagar is unauthorized colony, so piped water supply is still not connected. Rest of the colonies have been provided piped water supply but the pressure is too low. Ground water is depleting at the same time, so restoration of ground water need the utmost concern.

4.5.2 Water Tariff

Water tariff is an important aspect of water supply scheme. Earlier water availability was assured free of cost but with increasing pressure of population and consumerism; supply and demand mechanism has started playing a significant role in water pricing. Water-pricing should adequately

cater to developing proper economic value for water so as to discourage wastage and encourage optimal use. The principle of tariff is based in paying in proportion to the cost of water use. There are three main roles of tariff; viz

1. It influences resources allocation and frugal use of resources.
2. If the tariff charges are deviated from cost of production the income distribution will be affected.
3. The tariff will raise financial revenue to cover capital cost and operation and maintenance cost

The ideal tariff must be financially viable, fair from consumer point of view, enforceable and may be linked to other charges, and affordable.

Looking at the pricing system in Indore, the tariff is not based upon the cost of water supply. The capital investment and production cost of potable water do not meet with the total tariff collected. Total expenditure incurred in completing phase I and II of Narmada project was Rs. 5200 lac in which 70% was loan and 30% grant in aid. Indore Municipal Corporation produces 180 MLD of water. The production costs in different major heads are shown in table no. 4.15.

Table 4.15: Production Cost of water of IMC

S. No.	Major Sub Head	Production cost in Rs.		Cost per MLD/day	
		Annual Cost (in lac)	%	Cost in Rs.	%
1	Repairs and chemicals	1187.86	30.72%	1808.08	30.72%
2	Salary and wages	821.77	21.25%	1250.79	21.25%
3	Power (Electricity and diesel)	1821.17	47.25%	2771.95	47.10%
4	Sinking fund	36.10	0.93%	54.94	0.93%
	Total	3866.90	100%	5885.68	100%

Source: A report from Narmada project 2001

It is important to note that the electricity charges alone accounted for about half (47.2%) of total production, followed by repair and chemical charges for about one third (30.72%) and just above one fifth (21.25%) over the salaries and wages, while one per cent is spent over sinking fund.

The cost recovery can be done only with the tariff. The number of connections and tariff charged over them gives an idea about the amount which can be collected from the public. Table no 4.16 presents the tariff collected from different places.

Table 4.16: Category of water connection and tariff of IMC

S. No.	Category of Connection	Nos	Tariff
1	Domestic	115450	Rs. 2.0/KL, Rs. 60.0/month on flat rate
2	Commercial	745	Rs. 10.50/KL, Rs. 150.0/month on flat rate
3	Industrial	1057	Rs. 22.0/KL, Rs. 300.0/month on flat rate
4	Free connection for freedom fighters	16	Nil
5	Stand Post	7263	Nil

Source: A report from Narmada project 2001

This table shows that the maximum number of connections (115450) is in the domestic water supply, followed by the stand posts (7245), industrial (1057), commercial (745) and free connections respectively.

Indore Municipal Corporation expected Rs. 1900 lacs as the income from water distribution, in the year 2000-01, whereas the actual income was Rs. 657.47 lacs, i.e., 34.60 per cent of budgeted income. As per the problems discussed about piped water supply, many people do not deposit water tariff. Table no. 4.17 describes the tariff given by the people from different income groups.

Table 4.17: Monthly tariff (survey data)

S. No.	annual income	**Rs 60**	**%**	**60-120**	**%**	**>120**	**%**	Total
1	<100000	18	21.69	3	25.00	1	50.00	22
2	100001-200000	43	51.81	5	41.67	0	0.00	48
3	200001-300000	14	16.87	2	16.67	1	50.00	16
4	300001-400000	5	6.02	1	8.33	0	0.00	6
5	>400000	3	3.61	1	8.33	0	0.00	4
	total	83	100.00	12	100.00	2	100.00	97

This table reveals the 97 per cent households deposit water bills, of which 83 per cent households fill just Rs. 60/- per month for water bill. Just above one tenth (12%) of the households have more than one water connection and 2 per cent of the households had more than 2 connections.

4.5.3 Pattern of use of water

The pattern of use of water can be assessed by the habits of people, types of use, storage capacity, and type of supply of water. For example more water is consumed when it is directly collected from the tap, and less water is consumed from stored water. Use of household appliances also play important role in water consumption. Dish washer, vacume cleaner, number of taps in the house, building systems (dual flushing system, auto flush, bath tub, spray tap, shower heads etc.) affect water consumption. For example, Washing machine requires definite amount of water, whereas manually washing requirement depends upon the habit of people, it might be less than or greater than the quantity of water requirement in washing machine for same purpose. It is very difficult to get the quantity of water required by each member of the family, because all have different habits. Therefore investigator, inquired about the water storage capacity in each house. Generally people store water for two days. The piped water is first collected in the tank on ground floor and then it is raised in overhead tank. Somewhere where the piped water is not available, still ground water tanks are constructed, because the ground water is also stored in the ground floor tanks. Electric supply is also irregular in Indore, hence in case of power cut the overhead tanks could not be filled, and the ground floor tank water only could be used. There are few cases (4%) where the ground water is directly raised in the overhead tanks. Table 4.18 shows the information regarding the collection tank and overhead tank capacity.

Table 4.18: Capacity of collection tank (lit)

S. No.	annual income	<2000	%	2000-4000	%	>4000	%	Total
1	<100000	15	38.46	5	19.23	3	9.09	23
2	100001-200000	19	48.72	10	38.46	17	51.52	46
3	200001-300000	5	12.82	8	30.77	6	18.18	19
4	300001-400000	0	0.00	1	3.85	5	15.15	6
5	>400000	0	0.00	2	7.69	2	6.06	4
	total	39	100.00	26	100.00	33	100.00	98

Note: one house in group 2 does not have tank

This table reveals that the water requirement of second income group is the maximum, while the housing density of this income group was also the highest (discussion in housing). There are 17 tanks having capacity more than 4000 lit. in the same income group. About two fifth of the households (39%) have collection tanks of capacity less than 2000 lit.

Overhead tank is the other mode of water storage. Table 4.19 presents the sizes of overhead tanks in various income groups.

Table 4.19: Capacity of overhead tank (lit)

S. No.	annual income	<2000	%	2000-4000	%	4000<	%	Total
1	<100000	19	46.34	3	10.71	2	6.45	23
2	100001-200000	17	41.46	12	42.86	18	58.06	48
3	200001-300000	5	12.20	9	32.14	5	16.13	19
4	300001-400000	0	0.00	1	3.57	5	16.13	6
5	>400000	0	0.00	3	10.71	1	3.23	4
	total	41	100.00	28	100.00	31	100.00	100

This table reveals that just above two fifth of the households (41%) have overhead tanks of capacity less than 2000 lit. , more than one fourth (28%) of the households have overhead tank of 2000-4000 liters and about one third (31%) have tanks of capacity more than 4000 liters.

4.6 Rain Water Harvesting

Collection tank and overhead tanks are built for storage of one or one and half day's water needs. The households, who are fully dependent over ground water, must take efforts to protect the depletion of ground water. Rain Water harvesting is such a measure. Investigator has noted the houses where the rainwater harvesting has been done. As this is the only measure to raise the ground water table, it needs a strong attention. It has been found during the survey that the Indore Municipal Corporation has adopted this technique for government buildings, public parks and stadium. The department has successfully implemented rain water harvesting techniques and the summery is given in Table 4.20.

Table 4.20: Status of Rain Water Harvesting (secondary source)

S. No.	Building	Number
1	School Buildings	7
2	IMC and other Municipal Buildings	19
3	Government Buildings	5
4	Residential Buildings	3000
5	Public places and gardens	138
6	Historical Buildings	1

The above table explains that the efforts have been done at public level, and at private level 3000 households have also participated in this. Table 4.21 presents the status of rain water harvesting in the residential buildings of various income groups.

Table 4.21: Status of Rain Water Harvesting in the surveyed area (primary survey data)

S. No.	annual income	yes	%	no				
				don't intend to do	%	intend to do	%	total
1	<100000	9	30	9	25.71	5	19.23	23
2	100001-200000	17	56.67	18	51.43	13	50.00	48
3	200001-300000	3	10	7	8.57	9	15.38	19
4	300001-400000	1	3.33	3	8.57	2	7.69	6
5	>400000	0	0	2	5.71	2	7.69	4
	Total	30	100	35	100.00	26	100.00	100

This table reveals that about one third of the households, i.e. 30 per cent have adopted rain water harvesting techniques in their houses. Out of remaining 70 percent, 35 percent do not intend to adopt it, 26 per cent intend to adopt it while rest 9 percent do not have any opinion regarding this. Many people denied because they live in apartment and personally can not invest in such activities, but a solution to this is community level participation. All the households were questioned that whether they will take part in community level participation. These details are given in Table 4.22.

Table 4.22: Agreement in community level participation

S. No.	annual income	yes	%	no	%	Total
1	<100000	19	23.75	4	20.00	23
2	100001-200000	39	48.75	9	45.00	48
3	200001-300000	16	20.00	3	15.00	19
4	300001-400000	4	5.00	2	10.00	6
5	>400000	2	2.50	2	10.00	4
	total	80	100.00	20	100.00	100

It is clear from this table that 80 percent households are agreed to take part in community level participation, while 20 percent are not in favor of the same. Investigator recommends that if some public awareness campaign will be run, then the public participation will be definitely increased.

4.7 Services

4.7.1 Drainage

The next part of survey gives the data required for design for rain water harvesting. Even if the public is taking part in this program, it is necessary to know about the environmental conditions. If there is leakage in drainage lines, it will contaminate the ground water. These places are detected, so as first the repair could be done and other precautionary measures can be taken.

Table no 4.23 presents the type of drainage facility available.

Table 4.23: Type of drainage facility

S. No.	annual income	Septic tank	Sewer	No facility	
1	<100000	4	18	1	23
2	100001-200000	5	43	0	48
3	200001-300000	4	14	1	19
4	300001-400000	1	5	0	6
5	>400000	1	3	0	4
	total	15	83	2	100

This table illustrates that 83 percent of the households have been provided with a sewage system, 15 per cent are having septic tank and in two cases there is no facilities. These two are the cases of Nanda Nagar and Suraj Nagar.

Table 4.24 illustrates the problems pertaining to leakage, during dry and rainy seasons.

Table 4.24: Problems in drainage system

S. No.	annual income	overflow	%	clogging	%	bad odor		no problem	Total
1	<100000	3	30	3	50	1	33.333	16	23
2	100001-200000	3	30	2	33.333	1	33.333	42	48
3	200001-300000	4	40	1	16.667	1	33.333	13	19
4	300001-400000	0	0	0	0	0	0	6	6
5	>400000	0	0	0	0	0	0	4	4
	total	10	100	6	100	3	100	81	100

This table shows that 10 per cent of the households face the problem of overflow of drains, 6 percent face the problem of clogging while 3 per cent of cases have problem of bad odor.

4.7.2 Solid waste management

The job of solid waste collection is in the hands of municipalities and some private agencies in the city. Table 4.25 gives details of solid waste collection agencies. Some areas do not have waste disposal facilities. The solid waste is either burnt or thrown out and dumped in these areas.

Table 4.25: Solid waste collection system

S. No.	annual income	IMC	%	Private agency	%	N.G.O.	%	No facility	%	Total
1	<100000	14	21.88	4	17.39	0	0	5	38.46	23
2	100001-200000	34	53.13	9	39.13	0	0	5	38.46	48
3	200001-300000	10	15.63	7	30.43	0	0	2	15.38	19
4	300001-400000	3	4.69	3	13.04	0	0	0	0.00	6
5	>400000	3	4.69	0	0.00	0	0	1	7.69	4
	total	64	100.00	23	100.00	0	0	13	100.00	100

This table reveals that more than three fifth of the households get service of municipality for solid waste collection, and about one fourth of the households dispose their waste by the service of some private agencies, while more than one tenth people do not have any facility for the same. Indore is a megalopolis and it does not have proper disposal system.

4.8 Environmental Conditions

4.8.1 Water Quality

The main sources of water are Narmada and ground water. The quality of piped water is dependent upon the condition of pipelines, and the working of treatment plant. Whereas the ground water quality may be affected by the amount of salts and alkalis in the soil. The quality of water is classified in the three categories, good, average and bad. The survey data has been described in Table 4.26.

Table 4.26 Water quality

S. No.	annual income	Good	%	Average	%	Bad	%	Total
1	<100000	22	25.88	1	6.67	0	0.00	23
2	100001-200000	43	50.59	5	33.33	0	0.00	48
3	200001-300000	13	15.29	6	40.00	0	0.00	19
4	300001-400000	5	5.88	1	6.67	0	0.00	6
5	>400000	2	2.35	2	13.33	0	0.00	4
	total	85	100.00	15	100.00	0	0.00	100

4.8.1 Air quality

Air quality is a dependent function of number of motor driven vehicles, transportation network, and smoke producing industries. However the industrial area is zoned in a separate area in the city, the major pollutants are dust and smoke produced by vehicles. Air quality is described in table 4.27.

Table 4.27 Air quality

S. No.	annual income	Good	%	Average	%	Bad	%	Total
1	<100000	15	39.47	7	12.07	1	25.00	23
2	100001-200000	17	44.74	30	51.72	1	25.00	48
3	200001-300000	4	10.53	13	22.41	2	50.00	19
4	300001-400000	1	2.63	5	8.62	0	0.00	6
5	>400000	1	2.63	3	5.17	0	0.00	4
	total	38	100.00	58	100.00	4	100.00	100

This table reveals that about three fifth (58%) of the study area is having average air quality, while about two fifth (38%) of the area is having good air quality, while 4 percent of the area is having bad air quality. This means there is considerable amount of air pollution.

4.8.2 Noise pollution

Noise pollution is a consequence of frequency of motor driven vehicles on the road, and location of crèche, playschools, commercial and industrial areas. Noise pollution has been classified in three categories, high, low and no problem areas. Table 4.28 presents level of noise pollution.

Table 4.28 Noise pollution

S. No.	annual income	High	%	low	%	No problem	%	Total
1	<100000	1	25.00	4	28.57	18	21.95	23
2	100001-200000	0	0.00	9	64.29	39	47.56	48
3	200001-300000	3	75.00	1	7.14	15	18.29	19
4	300001-400000	0	0.00	0	0.00	6	7.32	6
5	>400000	0	0.00	0	0.00	4	4.88	4
	total	4	100.00	14	100.00	82	100.00	100

Table reveals that noise pollution is high only in 4 percent locations, while more than one tenth of the locations have moderate level of nose pollution, and more than four fifth areas are free from noise pollution.

4.8.3 Land Quality

Land quality is affected by solid waste disposal. Land quality is graded according to vegetation, and cleanliness in the area. It has been categorized into three groups, i.e., good, moderate and low. Land quality has been described in table 4.29.

Table 4.29: Land quality

S. No.	annual income	Good	%	Average	%	Bad	%	Total
1	<100000	11	18.97	11	28.21	1	33.33	70.171
2	100001-200000	31	53.45	16	41.03	1	33.33	142.47
3	200001-300000	10	17.24	8	20.51	1	33.33	56.754
4	300001-400000	4	6.90	2	5.13	0	0.00	18.025
5	>400000	2	3.45	2	5.13	0	0.00	12.576
	total	58	100.00	39	100.00	3	100.00	300

This table presents that about three fifth of the locations are having good land quality, about two fifth of the locations had moderate quality of land and 3 per cent of the locations are with bad land quality.

Chapter 5: Observations

This section is based over the observations. Investigator first studied the political and administrative history of the city, before the site visit. The local people were interviewed about the existing drinking water supply conditions, and based on the discussions with local people, especially the senior citizens, and retired staff of Indore Municipal Corporation, following analysis has been drawn out.

5.1 Pattern of historical growth of the city

Indore got importance due to a historical junction of Pilgrimage and Military route.

The central spine connecting administrative center and military center formed as place for commercial activities. There was a residential area of Britishers in the city and after its development, the commercial development took place and the central core area has been restricted which leads to the shifting of central spine from Subhash marg to MG road. Residential areas grew up parallel to central spine. Structural form along the central spine can be characterized by commercial activities housed in 3 or 4 storey buildings along the spine and roads parallel to spine and on grid roads with low rise residential development

behind the commercial roads by means of narrow lanes. A schematic sketch over the map of core is presented in fig. 5.2 to elaborate this.

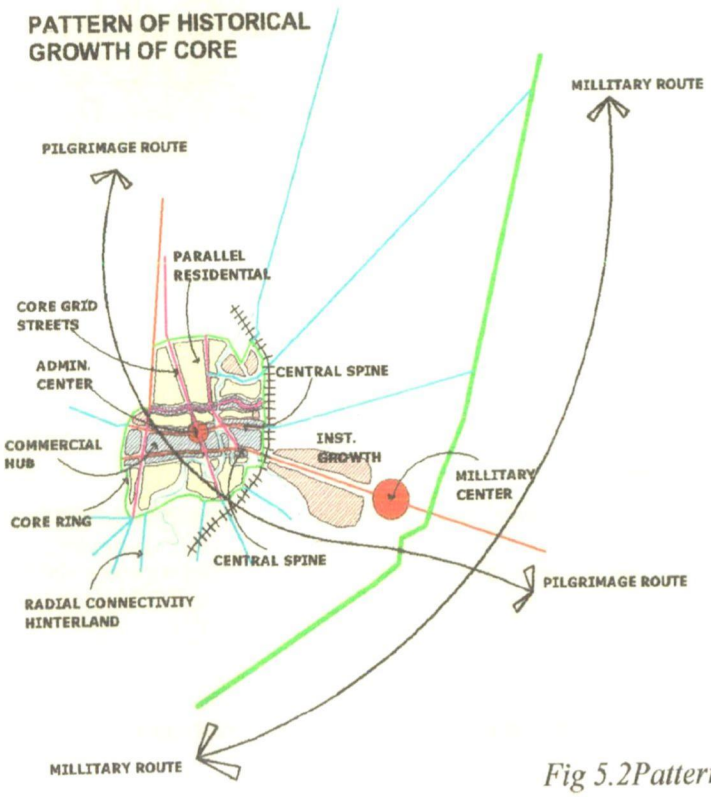


Fig 5.2Pattern of growth of core

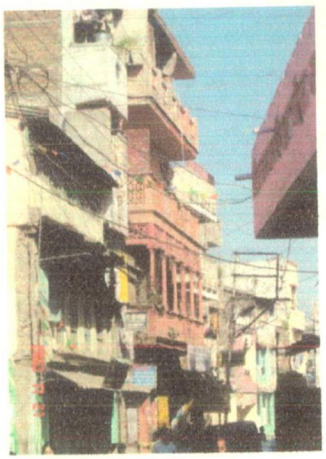
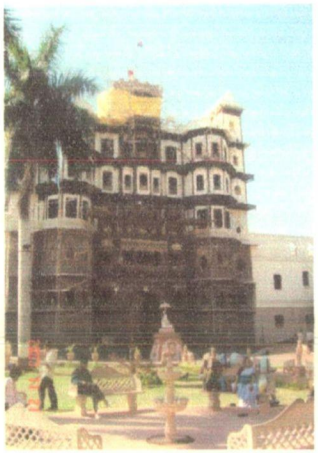


Fig 5.1Congested Core Area,

5.1.1 Core Area

Indore is known as commercial capital of the state. The place where, commercial activities originated lies in the present core of the city. As it has been already discussed in (chapter 2, study area profile) that Indore was the halting place for pilgrims who traveled from Ujjain, to Omkareshwar, the Holkar kings constructed pavilions for pilgrims to take rest. These pavilions are known as Chhatari in local language and are the heritage of the city. One heritage site contains a number of pavilions and known as Chhatribagh. Other sites for these are Krishnapura Chatri, and Bolia Sarkar Chatri, and these were constructed in the axis with the office building of kings, known as Rajwada. Today Rajwada is a centre of main market of Indore. Fig. 5.3 presents Rajwada.



This historical office of the Holkar Kingdom is built in a mixture of Maratha, Mughal and French style. It is a seven storied building (only facade remains). The lower three floors are made of stone and the upper floors are made of wood, which made it very vulnerable to destruction by fire. It is now used for art exhibitions and classical music concerts. This building is one of the heritage sites of Indore, and well landscaped, with plants and water fountains in, and outside it.

Fig.5.3 Rajwada: from outside

Fig.5.4 Rajwada: interior

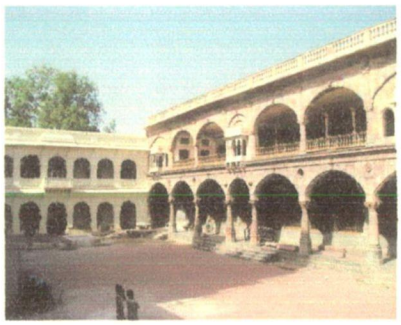


Fig. 5.5 Rajwada: central courtyard

Fig. 5.6 Other buildings around Rajwada

Figures 5.4 and 5.5 show view of interiors of Rajwada. The buildings around Rajwada have been given the similar architectural character (material and texture and color) of Rajwada. The figures 5.6 show the other buildings around Rajwada.

Fig. 5.6 Picture gallery of the buildings around Rajwada

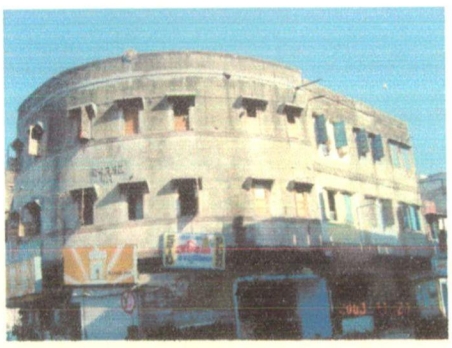


Fig 5.7 Core area of the city: A corner building with mixed land use. Ground floor for shops and first and second floor for residential use

The core area of the city (as presented in fig. 5.6, 5.7) is of mixed land use. The lower floors are utilized for commercial activities while the upper floors are used for residential purpose. It is the densest area in the city. Figures 5.8 and 5.9 give an idea of the density of the core area.

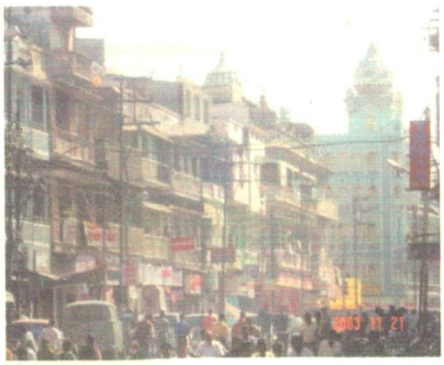


Fig 5.8 Core area of the city:
View to an ancient Gurudwara

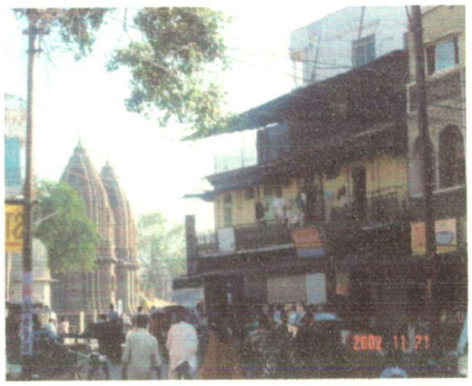


Fig 5.9 Core area of the city:
View to Krishnapura Chhatri

The market around Rajwada is a market of garments, cloth, cosmetics (Ada Bazar), foot wears (Yashwant road), books (Khajuri Bazar), hosiery, dry fruits (Bohra bazar), utensils and crockery, and gold and jewelry.

Gold and Jewelry market is known as Sarafa, and it is very famous for its fast food joints, and known for local taste of Indore. These joints are kept open for whole night, and are always crowded. The daily turn over by business of one food joint (90-100 sq.ft) is about Rs 50,000/- . These would have been located here with keeping the point of safety of the gold and jewelry from theft.

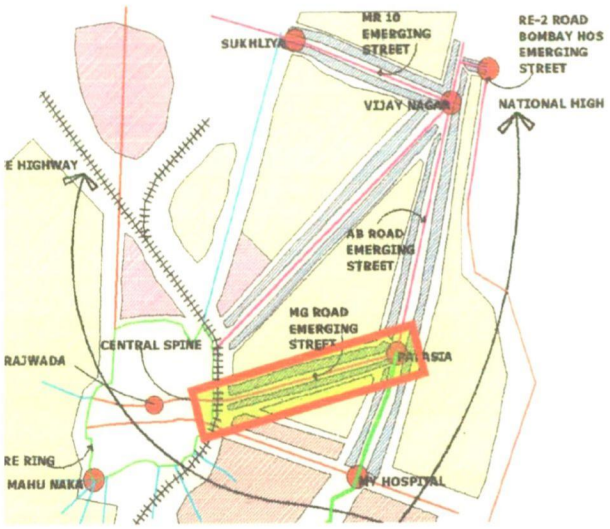
This area is supplied water from Narmada, and water scarcity in this area is a very common problem. The buildings in this area are dense and they have common water connection.

As the floor area ratio here is high, the marginal open space is also less, and because of this the space for water storage is less. Summer season is very difficult, as the water supply becomes very irregular. Even if the water comes, it comes at very low pressure. The residential use is on the upper floor, so lifting water till the upper floors take a lot of time and labor of the people. Fig. 5.7 shows a typical building with mixed land use.

Being a heritage site, this area requires water for maintenance of Rajwada building and garden. Sarafa food joints also consume a lot of water.

5.2 M.G. Road

This is the adjoining road to the railway station and bus stand. This road has been playing an important role in depicting the image of the city since last 80 years as it was planed to put good impression of the city for a new visitor. The prestigious buildings of the Holkars period are placed along Mahatma Gandhi road.



5.10 A part of M. G. Road containing a series of ortant buildings from Core area of the city to Palasia

Fig 5.10 presents map showing a part of M. G. Road containing a series of important buildings from Core area of the city to Palasia. High court, Hukumchand Ghanta Ghar, High court, Santosh Kutir and some more royal bungalows of the Holkar Period are enhancing the aesthetic character of the city and are such buildings. A huge vista is formed by the facades of these buildings.

M.G. road is the main road of Indore, containing the important shops, showrooms, mall, traffic island and bungalows. This was containing only the royal bungalows, but these have been converted into showrooms and malls. Figures 5.17 to 5.28 present a panorama of the buildings confined on M.G. Road.

A temple of Lord Ganesha, famous for the great size of its idol, known as Bada Ganapati is located at the West side end of M.G. Road. This idol is 28 feet high (see fig.5.11).

A series of shops is there from Bada Ganapati to Rajwada. A famous books market known as Khajuri Bazar is located here. Krishnapura Chatri, is the next important building, at M.G. Road. This was a halting place for pilgrims, and was built on the bank the banks of Khan River. Fig. 5.12 and fig 5.13 present the pictures of this pavilion.

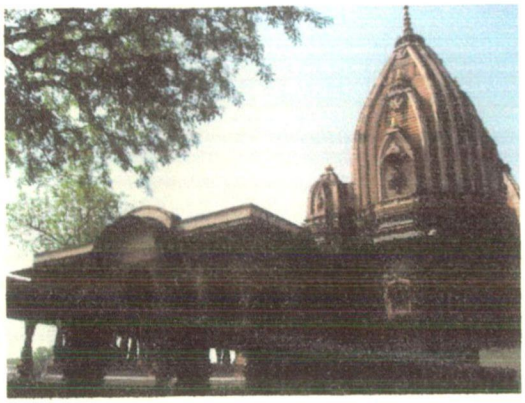


Fig. 5.12 Krisnapura Chhatri,

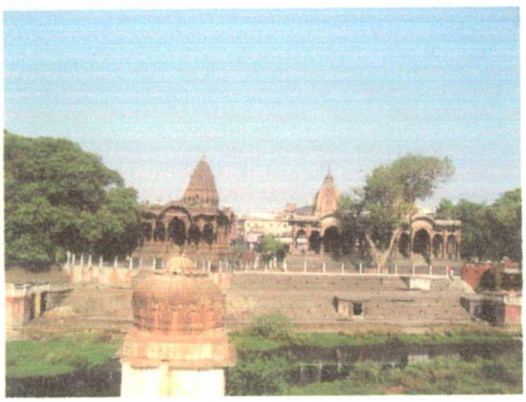


Fig. 5.13 Krisnapura Chhatri,

Fig. 5.14 Krisnapura Chhatri,

Krishnapura Chhatri, was built on the banks of river, but now the river water is highly contaminated, because the sewage is directly disposed into it. Fig 48 shows a view of the steps of Krishnapura Ghat, and polluted water. The next monument at M.G. Road is Bolia Sarkar Chhatri (fig. 5.14).

Fig. 5.15 Bolia Sarkar Chhatri, facade

Fig. 5.16 A Gurudwara in Sikh Mohalla, M.G. Road

Fig. 5.17 Gandhi Hall; an exhibition pavilion on M.G. Road

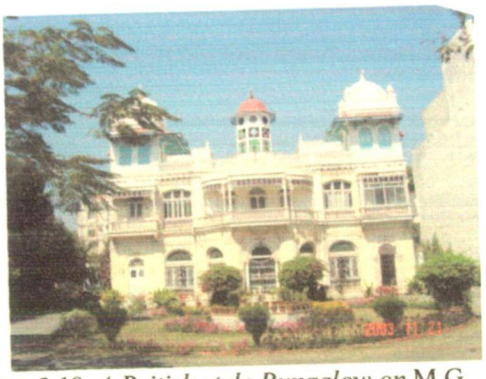


Fig. 5.18 A British style Bungalow on M.G. Road

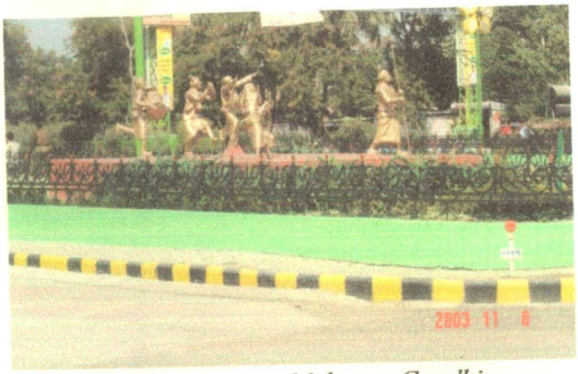


Fig. 5.19 Sculptures at Mahatma Gandhi Square

Fig. 5.20: M.G. Road

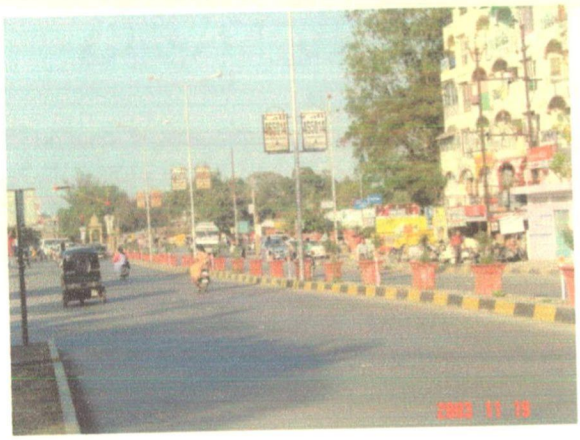


Fig.5.21: M.G. Road

Fig.5.22: M.G. Road

Fig.5.23: City centre at M.G. Road

Some of the snaps of M.G. Road. , the prestigious buildings and showrooms are shown. Fig. 5.22 shows a view of a beautiful bungalow, which front side, has been occupied by informal shops.

ig. 5.24 Treasure Island, a Mall at .G. Road

Fig. 5.25 Indraprastha Tower,M.G. Road

Fig. 5.26 lHukumchand Tower,M.G. Road

The land use of buildings on M.G. roads is changed from residential to commercial, and without any consideration of water. City center contains about 400 offices, and 3000 employees in the area of 4000 sq.m. There are some training centers also in these buildings, where hundreds of students visit daily. The drinking water is scarce; most of the employees and students bring drinking water from their home.

The most problematic area is the water shortage for other uses, which results in unhygienic conditions in public toilets. This naturally effects the work environment in offices. All the commercial buildings on M.G. road face the similar problems.

5.3 Housing in the city

Fig. 5.27 Saket Nagar

Figure 5.27 shows Saket Nagar, a low rise, and detached housing. Water supply, sewage, solid waste management and maintenance are in the hands of IMC. The households are well educated and mostly industrialists and businessmen. Income level varies from Rs. 400000/- and above per anum. Water Scarcity is faced during summer seasons only. People are ready to adopt rain water harvesting.

Figure 5.28 is a photograph showing a view of row housing in Vijay Nagar. Water supply, sewage, solid waste management and maintenance is in the

hands of IMC. The households are well educated and mostly industrialists and businessmen. Income level varies from Rs. 300000/- and above per anum. Narmada water (piped water) comes very irregularly, and they rely over ground water. People are ready to adopt rain water harvesting.

Fig. 5.28 Vijay Nagar

Figure 5.29 Ravindra Nagar, detached housing. It has considerable amount of rented houses, hence density is high. Roads are fully paved; here also water scarcity is faced in summer. People are social and take part in community activities, and can also afford rain water harvesting at personal level.

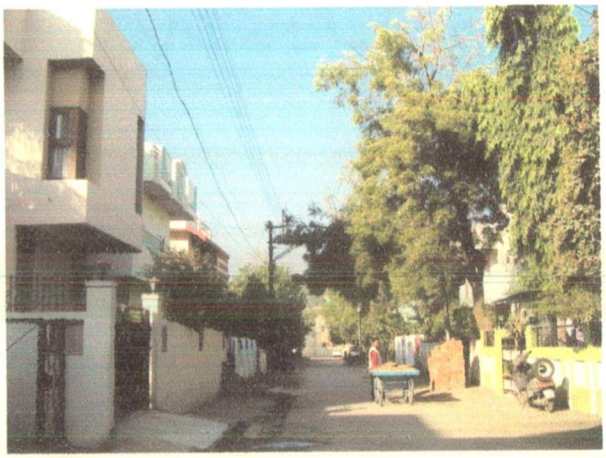


Fig. 5.29 Ravindra Nagar

Fig.5.30 : An apartment housing inOld Palasia Area

Fig 5.30 presents a new type of multistory housing in Old Palasia area, and an example of changing architectural style and choice of people. Households here are migrated people from other states, and also from the same district. There was a bungalow at this place, now the people density is drastically changed.

g. 5.31 Shalimar Housing

Figure 5.31 presents Shalimar Housing; it is a newly built (2002) housing at highest scale. People living here reported that they get Narmada River water only for drinking purpose. Rest of the requirements is fulfilled by ground water. Already ground water is depleting and definitely the ground water will remain of no more use, if they do not go for ground water recharging.

Aranya housing (designed by great architect, B.V. Doshi) as shown in figure 5.32 has poor infrastructure services. This area has not been connected with Narmada water. Somewhere, problem of overflow of sewage water is faced, and the ground water will be definitely contaminated.

Fig. 5.32 Aranya Housing

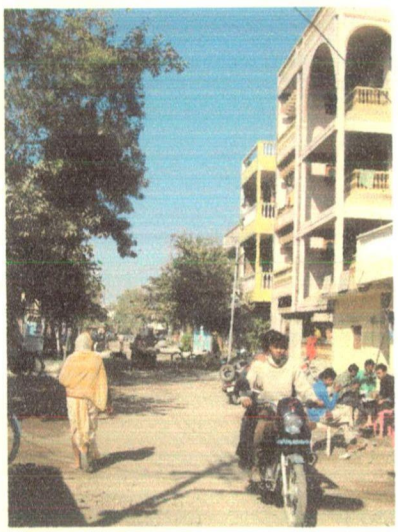


Fig. 5.33 Nanda Nagar

Nanda Nagar, which was housing designed for mill workers, now has become their own property. The old type of houses are demolished, and rebuilt in the form of multistoried structures. Rental housing is common here. Houses are generally taken on rent by the migrants from the district, who are engaged in small clerical jobs, shops, floor mills, etc. Some of them are motor mechanics, vendors; scrap sellers, etc. Figure 5.33 presents a street of Nanda Nagar.

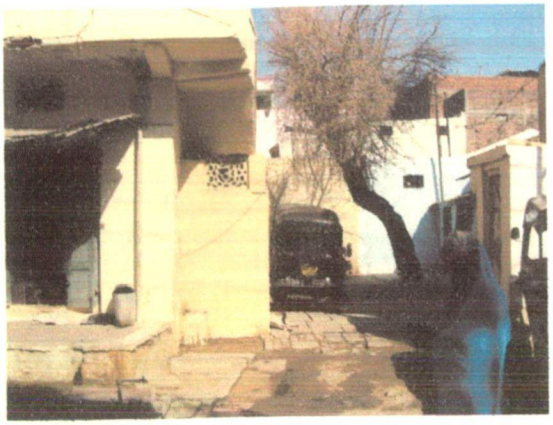


Figure 5.34 presents encroachment in Nanda Nagar. This was a housing meant for low income group. Now there is hardly any open space left in this area. One connection of piped water supply in this area is shared by 5-6 houses, and hence the summer season is very difficult.

Fig. 5.34 A water connection in Nanda Nagar.

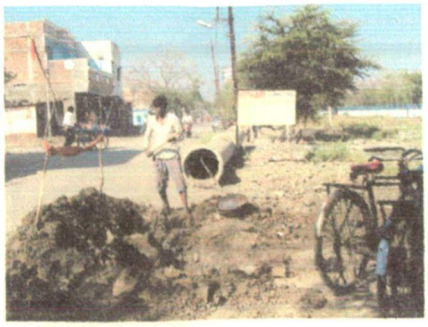
Figure 5.35 shows a public water tap in Nanda Nagar. , which can hardly accommodate a bucket under it, apart from this, drainage can not take place. This stagnant water raises mosquitoes, and when comes on road, it makes road, wet and muddy. Roads are paved, the pavement is damaged and actually no percolation takes place.

Fig. 5.35: A public tap in Nanda Nagar

Fig. 5.36 A Street of Nanda Nagar

Road sections are not designed. Previously there were bituminous roads, but because of black cotton soil, problems of cracks and holes in roads were always faced. As soon as it rained, the holes were filled with water and again damaged the roads. Then they started paving with RCC, and these are also not having rain water drainage facilities. Gutters are absolutely absent.

Fig 5.36 shows such a street, there is hardly any space left for rain water percolation. The road level has come close to plinth level, and in some cases it is above plinth level also, in rainy season, rain water will definitely come into the rooms.



5.37: Water pipeline under construction

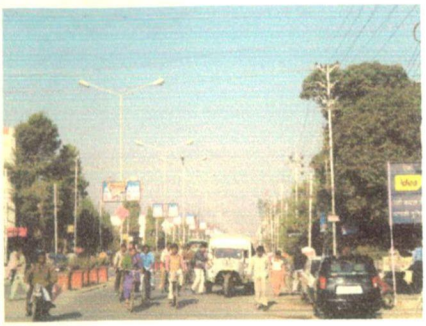


Fig 5.38: Patnipura Main road

'ig 5.39: Ill design of road in Nanda Nagar

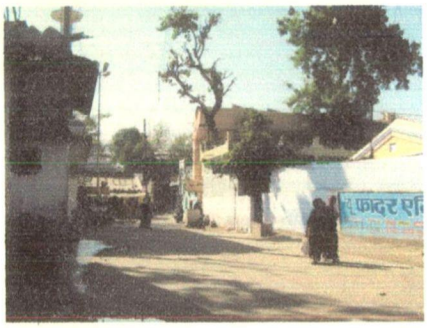


Fig 5.40: Poor condition of road in Patnipura

The housing for mills (Bhandari Mill, Malwa Mill, Swadeshi Mill, Kulkarni Bhatta, and Kalyan Mill) was confined in Nanda Nagar, PardeshiPura, Patnipura and although mills are no more, but this area is known as Mill Area. The population of this area is now increased. This area was located in North Side of the city. Now Indore development authority has developed new colonies and next generation of this area only have been expanded in this area.

Aranya housing, is also one of the colony of this expanded city area. Infrastructure of this area is not developed well yet. Figure 5.37 presents work of Narmada pipe line construction (investigator took this snap in December 2005).

The main roads which are aliened with HIG housing of the mills are also not designed properly. Now the road level has come a feet above the plinth, as a thick slab of RCC is laid over the road. Fig. 5.39 shows a view of Patnipura Main Road.

Road separators are covered with huge earthen pots; these pots will neither contribute anything to rain water percolation, nor impart anything to environment, and instead, will be damaged by air pollution of vehicles. Figure 74 present an ill design of RCC road under construction in Nanda Nagar. Figure 5.40 presents poor condition of roads in Patnipura.

5.4 Summer Season

M. P. is facing problem of electricity shortage after separation of Chhattisgarh. Daily 2 hours load shading is conducted in Indore. As the piped water comes from greater distance, electricity shortage obstructs the regular supply of water. Water supply is irregular when it rains lightly, and

also at the time of electricity shortage. Water is supplied for one hour in two days, and sometimes even once in three days, that two at very low pressure.

The areas which are being developed are not yet connected with piped water supply. Some of them which are connected, especially in the extension of mill area, share ½ inch connection with 4 to 5 houses.

Fig. 5.41 water scarcity

People, who can not afford expense of ground water boring, have to depend upon the mobile water supply, and it creates a lot of mess. Figure 5.41 presents a scene of tanker water supply. People are filling water through a pipe coming from tanker. They have to spend two hours daily just for water.

Generally women and kids have to be involved in such activities. The area like Manavata Nagar, where piped water supply is highly irregular, people have to bring water from 2 km.

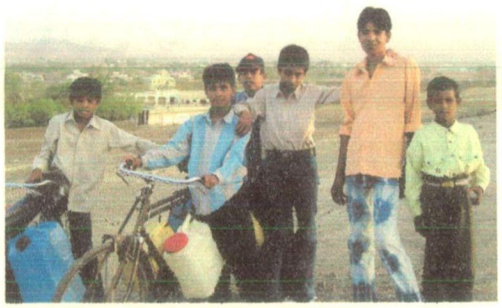


Fig. 5.42 shows kids of Manavata Nagar, (this colony is at some elevation) who bring water in plastic cans on bicycles from 2 km distance and on such a high terrain.

Fig. 5.42 A scene of Manavata Nagar in summer season (may 2005)

5.5 Water Bodies in Indore

The existing water bodies in Indore are Yashwant Sagar, Sirpur Talab, Pipliya Pala Tank and tributaries of Khan and Saraswati. Efficient use of water has not been done. Natural conditions only are not responsible, but there is some lacuna in planning and people's habit too.

Figure 5.43 shows a view of Yashawant Sagar, It has considerable amount of Water. This water is clean.

Fig. 5.43 Yashwant Sagar

Fig. 5.44 shows a view of Bilaoli Filter Tank. This is Narmada River water. This water is purified here before supplying to city.

Fig. 5.44 Bilaoli Filter Tank

Fig. 5.45 Pipliyapala

Pipliyapala is a name of place. There were a number of trees in this area and a water body in the shape of Peepel leaf. When Bilaoli was built, this area was used to store the overflowed water of Bilaoli filter plant. Nowadays there is scarce water in Bilaoli, and it hardly overflows, so Pipliyapala Lake is drying. Fig 5.45 presents a view of Pipliyapala Lake.

Fig. 5.46 Pipliyapala Lake

Other dying water bodies in city are Khan and Saraswati River and their tributaries. Indore was a river side village, and route for pilgrims, so this activity gave rise to religious activities in Indore. Holkar built a series of monuments and temples along the rivers.

Many of them still exist and are in good condition too. People also visit these places, but the only and very negative point is that, that rivers are badly contaminated by direct disposal of sewage water in it.

Fig. 5.47 Lal Bagh Palace

Figure5.47 shows Lal Bagh Palaces. It was built for Maharaja Tukoji Rao Holkar. Lal Bagh Palace is constructed on the bank of Saraswati river, having total site of 28 hectares, The interior is lavishly decorated in the style of Versailles Palace, The gates to the grand site are replica of the gates of Buckingham palace (London), about twice their size, were molded in cast iron.

Fig. 5.48 Bamboo Grove behing Lal Bagh Palace

Figure 5.48 shows the beautiful bamboo groves behind Lal Bagh Palace and along River Saraswati. Palace was built away from city in this quet place. Still the one can have felt the taste of luxury of Holkar kings by visiting the palace. Its east side windows open towards river and rest three side towards beautiful English gardens. Now river water is polluted.

Next important building along river is Hanuman Mandir at Navalakha. Navalakha is a Hindi word and means nine lakhs. There were nine lakh trees in this area, but now the they are cut. This place contains cluster of three important venues, i.e., city zoo, Hanuman Mandir and a Dargah.

Fig. 5.49 Ghats of Hanuman Mandir.

Figure 5.49 shows ghats of Hanuman Mandir. This was the trend of use, temple like auspicious place was built along beautiful river, and people would have taken holy bath over here. They maintained the temple well, but could not preserve the river. Now nobody can sit on the holy steps of this Ghat.

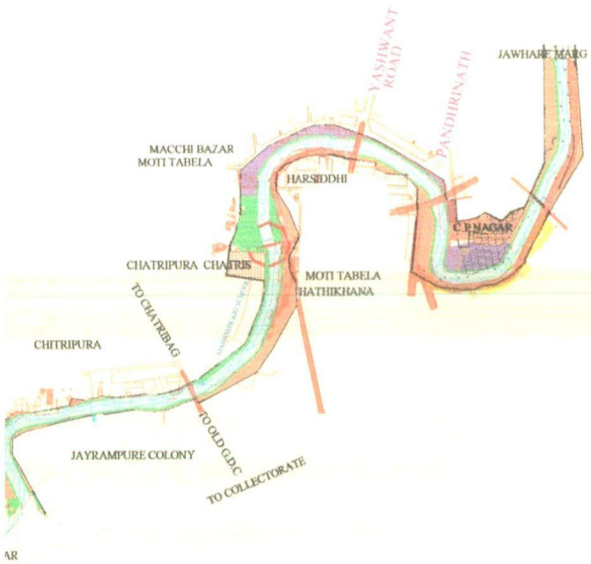


Fig 5.50 a part of Saraswati passing through Juni Indore

One more important temple complex along river is Pandhri Nath and Harsiddhi temple near the core of present city (near Rajwada). This area comes under old Indore which is known as Juni Indore today. This only was the river side village. Fig 5.50 presents a part map of river passing though Juni Indore.

Figure 5.51 shows temple Pandharinath and figure 5.52 shows Harsiddhi Temple. Next figures, i.e. fig 5.53, 5.54 and 5.55 show the present condition of this patch of river.

Fig. 5.51 Pandharinath Temple

Fig. 5.52 Harsiddhi Temple

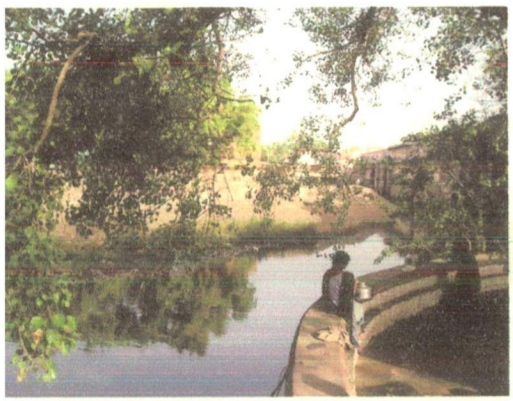


Fig. 5.53 A patch of river in front of Harsiddhi Temple

Fig. 5.54 Slums have been developed along the river. The waste of fish market is dumped here, it is highly unhygienic a

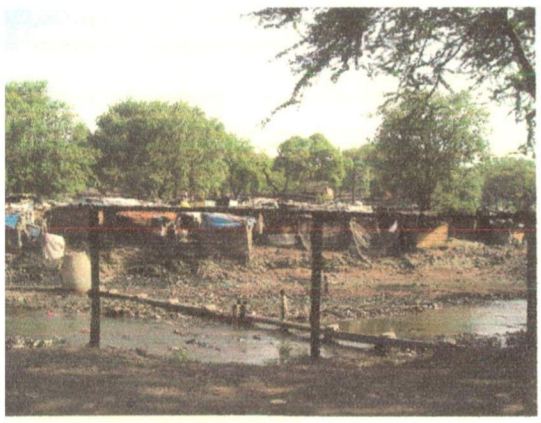


Fig.5.55 A patch of river, fish market and slum lie along it

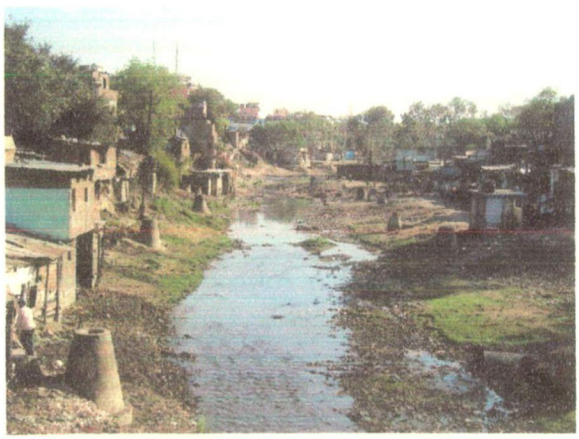


Fig. 5.56 Slums along River Khan near Pandharinath temple.

There are two crematoriums, one at Rambagh and one at Juni Indore, on the banks of river, and still used.

There are two crematoriums, one at Rambagh and one at Juni Indore, on the banks of river, and still used. These pictures show that early settlement was planned, as a part of river is crosses through the old settlement, i.e. Juni Indore, the cultural and religious life of people can be identified looking at this scenario. When the village was turned into city, the river was polluted. Previously the population was less and there were ample sources of water, and now population is increased, and the sources remained of no use. If the sewage water would have been disposed in river after some treatment then the river could have been protected. As this is a seasonal river, it could have used as a storage of rain water too.

5.5 Narmada Project

Water comes to city through a 70 km long rout and steep terrains of Vindhyanchal series of mountains. City has been expanded tremendously, the local sources would not have been sufficient, even if they were preserved well. Narmada was the closest water source, from Indore. Narmada is also assumed as life giving river to Indore. Following figures present the journey of water from Jalud (a pump station at Narmada) to Indore. Narmada water is taken from a intake well situated at Jalud. Raw water is pumped here. There are 9 vertical turbine pumps of 324 MLD total capacities. This pump is shown in fig. 95.

1 NO. – 50 MLD – 675 HP, 4 Nos. - 45 MLD - 550 HP, 2 NO. –25 MLD – 300 HP ,2 Nos. – 22.5 MLD - 275 HP
NORMAL OPERATION : 232 MLD

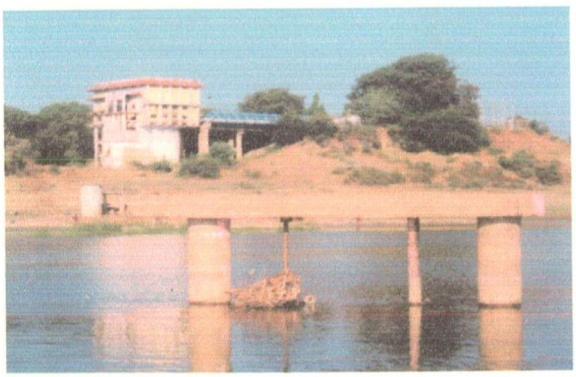


Fig. 5.57 Intake site at Jalud

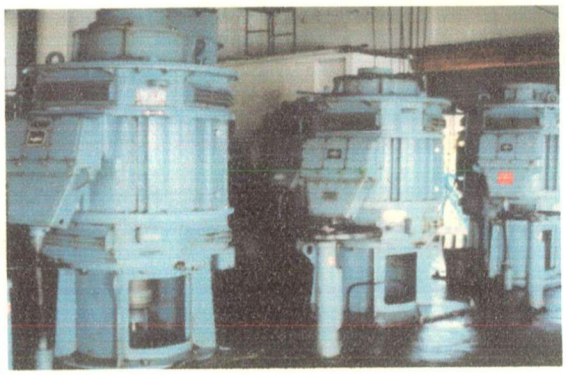
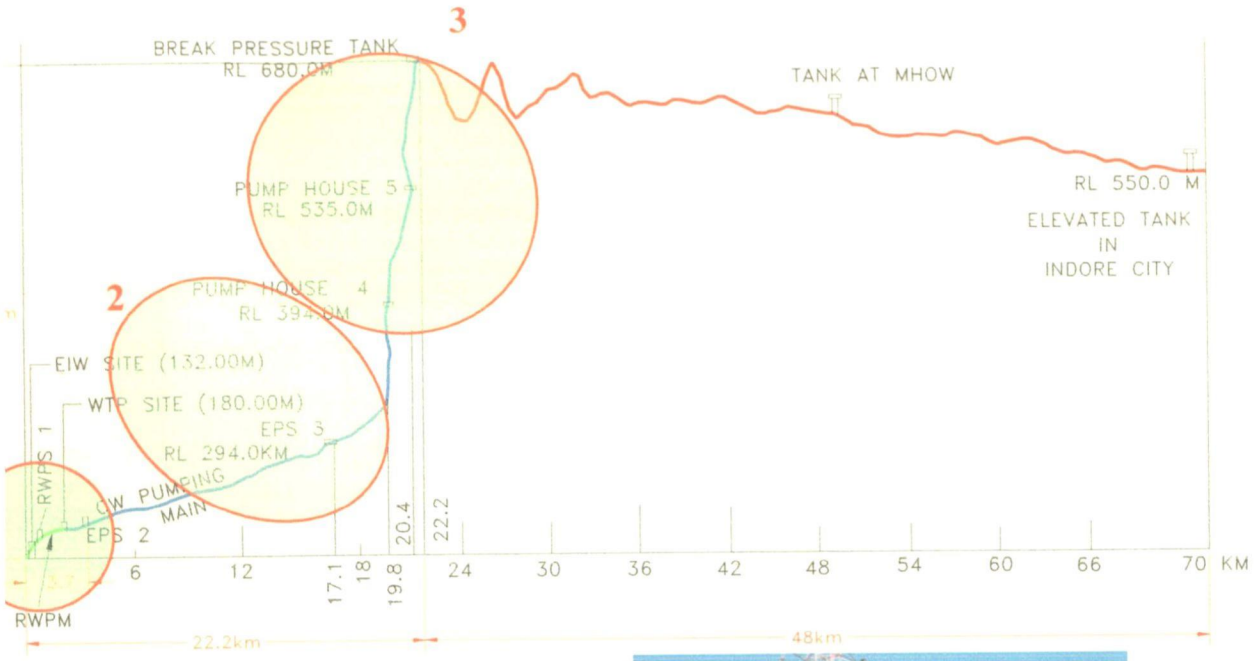
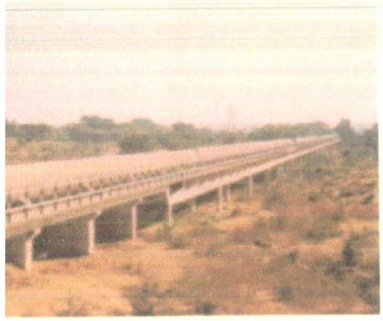


Fig. 5.58 Raw water pumps at Jalud

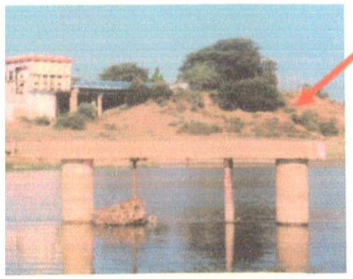
Figure 5.59 shows a schematic diagram of the project. Figure 5.59 to 5.61 Photographs at each pumping station are given.

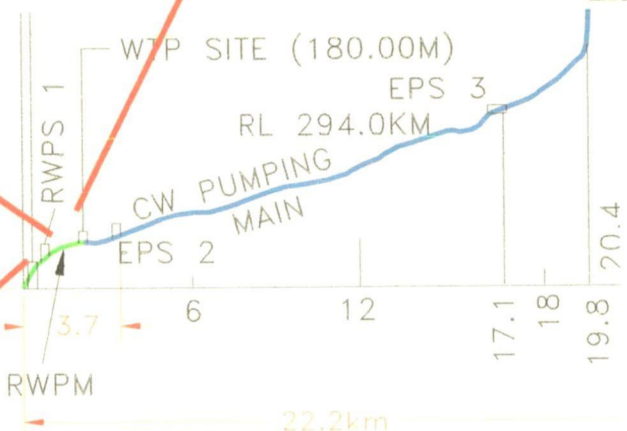




Electrical substation

ater pipe





The level from where, water is taken

Fig. 5.59Detail at 1

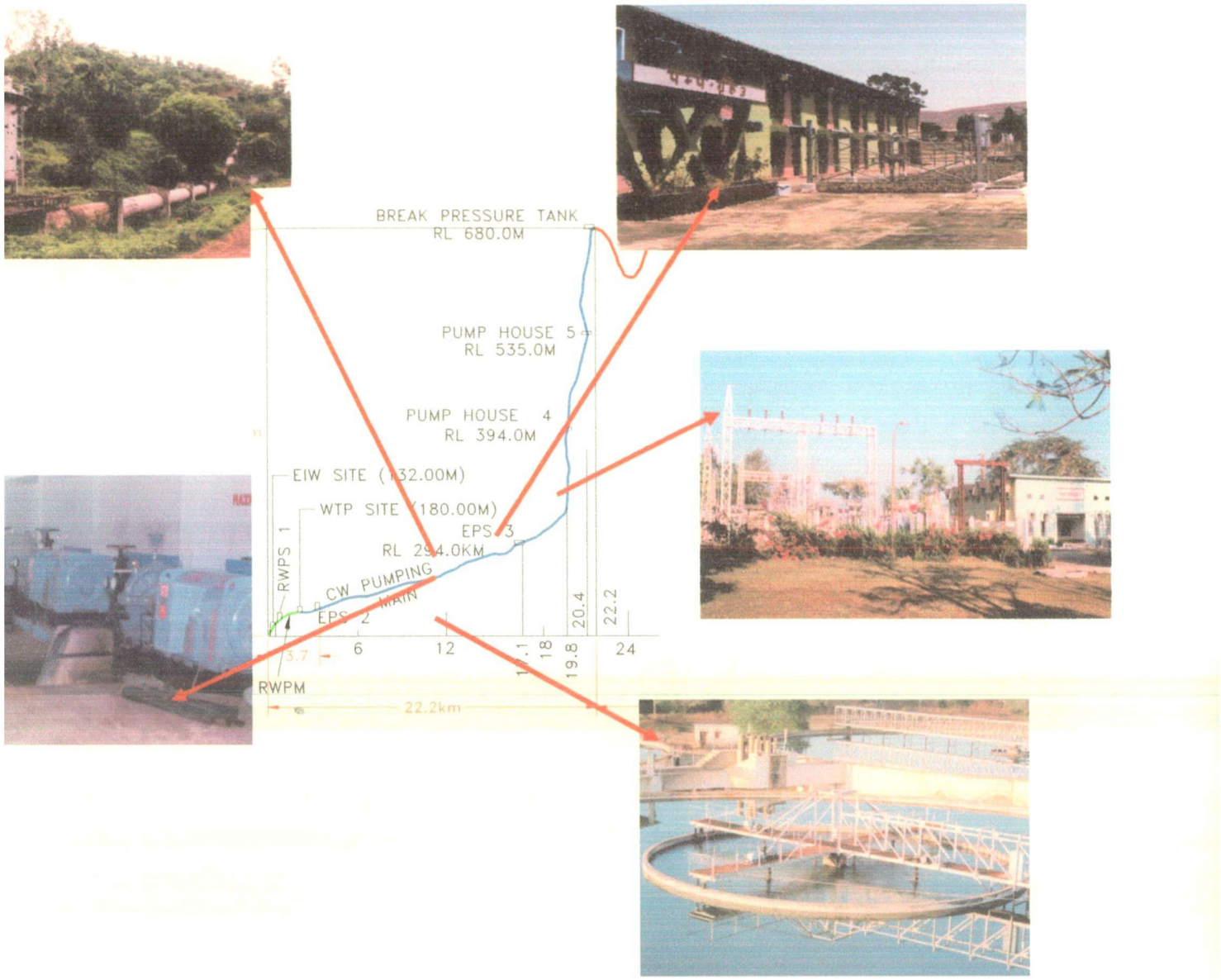


Fig. 5.60 Detail at 2

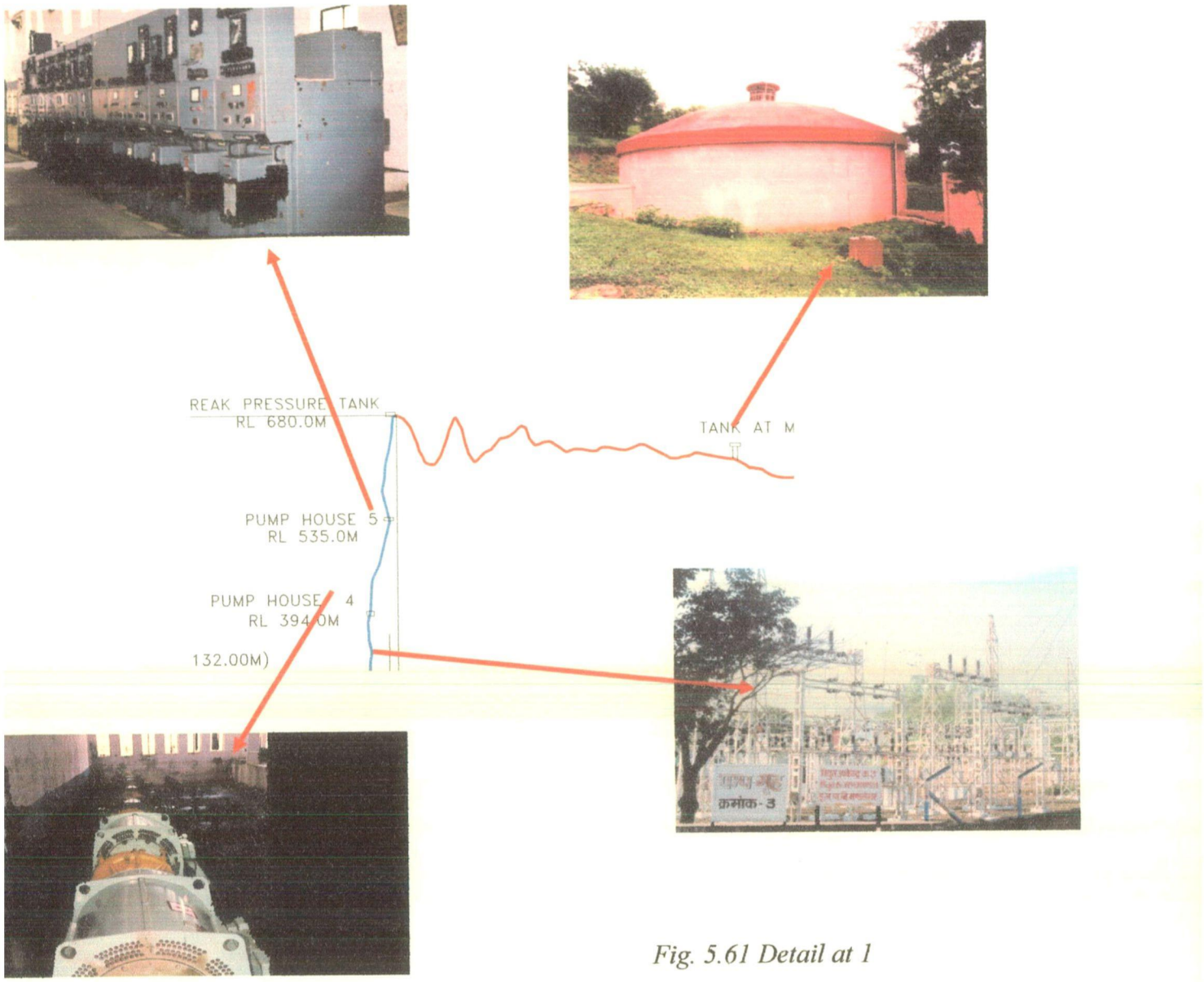


Fig. 5.61 Detail at 1

When water reaches till tank at pumping station number 5 which is 550 m above the main source, it needs no pump. Water just flows with gravity. The expenses in chemicals, electricity and salary and wages of staff have been discussed in survey data analysis.

5.6 Wastage and illegal use of water

Fig. 5.62 A shared water tap in Juni Indore

A lot of water is wasted at public water taps. People put their vassals below open tap and leave it open. This water is kept on overflowing. Fig.5.62 presents such a scene

Fig.5.63 shows a Narmada water connection, where the tap is not working. It flows like this only when it is supplied, i.e. 2 hrs daily. A lady washing utensils under this tap is shown.

Fig. 5.63 One more scene of Wastage of Water

Fig.5.64 presents a street in Mill area. One can take idea of wastage of water.

Fig. 5.65 One more scene of Wastage of Water

Fig. 5.66 direct pumping of Narmada Water

Fig.5.66 shows a Narmada water connection, where the water is directly pumped through machine. These things, affect the water pressure in the next neighbor. This is the reason, behind problem of low pressure of water.

Fig. 5.67 A wrong manner of taking connection

Fig.5.67 shows a number of connections taken at on place only. This creates mess at the time of water, and a lot of water is wasted by the crowd, in this mess.

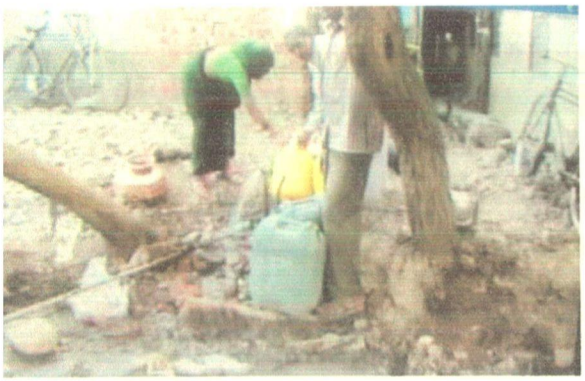


Fig. 5.68 contamination of water at the place of connection

Fig. 5.68 shows a water connection, where people have to take water from such a dirty condition. In Rainy seasons, this condition is worsening. If this water is mixed with the water pipeline, this makes it muddy.

Fig. 5.69 shows a sewage line passing just close to water line. Contamination of water is but obvious in such condition.

5.7 Other observations

Fig. 5.70 A view of core area

Fig. 5.71 A view of core area

Fig. 5.70 and fig 5.71 are the photographs of Indore taken from city centre. These present a high building density in core of the city with combination of greenery also. This area has a great potential of rain water harvesting, and ground water recharging, but there is a lack of open spaces in whole city. The area of city is 113.07 sq.km. and 16 lakh population, and city level parks are just two, the zoological garden and the Meghdoot Upwan. Public participation in ground water recharging is must.

Chapter 6: Application of theories

System Dynamics theory, (Forerheer, W.J.) has been adopted in this present investigation. A system functions as whole with the interaction of several sub-systems. All the subsystems of the system are interlinked and interdependent to each other, and forming a system. If one of the subsystems defunct, or partly functions or functions with higher degree (taking a lead role) during its function, its effects can be visualized in the entire system. Sometimes, system may not function at all in some cases, while in some cases the system may function, but with lot disturbances or the smooth functions of the system may be paralyzed.

In an urban system, the following sub-systems are linked together and form an urban system. They are:

1. Physical
2. Social
3. Economic
4. Ecology
5. Environment
6. Infrastructure, and
7. Institutions

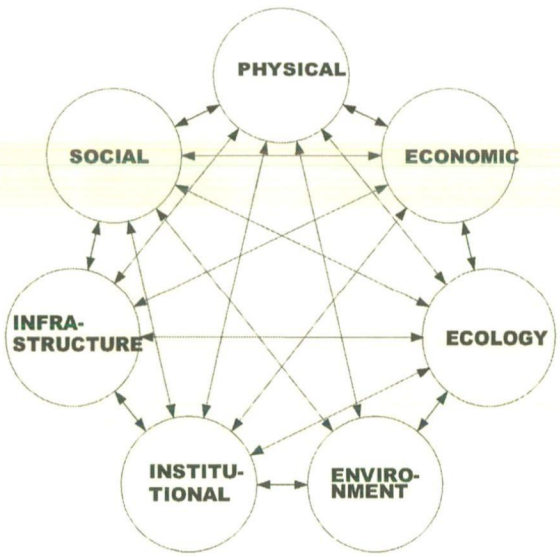


Fig. 6.1 System dynamics model

The functions of the urban system along with its various sub systems and are present in fig 6.1. These all the sub-systems are interlinked and interdependent to each other, forming a system and function as a whole. The functions of the system along with all the subsystems can be quantified, but because of the lack of time in Master's Thesis, the investigator has gone for descriptive approach to describe the functioning and factors affecting the functioning of the system.

6.1 Population Function

The population function is the one of the subsystem of the urban system. If population increases at an exorbitant rate, the effects of increase in population can be visualized in entire system. Population growth disturbs the ecosystem of the city. Physical and environmental subsystem will be affected by over use of the natural and manmade resources. Amalgamation of people at one place will result in the social transformation on one hand and this will generate new economic activities. All the subsystems of the urban system are derived by the population.

6.2 Interrelation of Subsystems

The interrelation of all the subsystems has been discussed below.

6.2.1 Physical subsystem

Physical subsystem consists of the land, topography, availability of water resources, vegetation, minerals and climatic conditions. These are the factor which can control the growth of any settlement as other part of physical subsystem consists of the danger of fire and flood, extreme climatic conditions, the possibility of earthquakes and volcanic eruption. These have been the determining factors in deciding whether to settle or to move to different sites.

Many early villages were located on sites that offered some natural protection, site such as elevated terrain, islands, and peninsulas; otherwise they would have to build some artificial protection around their settlement. The larger early urban areas, with some exception, are found where the climate is relatively moderate. Geographic studies indicate that most of the urban settlements are located on relatively flat terrain. Some cities are located at higher altitudes, but the slope of the land is relatively level. For example, Denver, Colorado, and Mexico City are more than 5000 feet above the sea level but the terrain at these sites is relatively flat[1].

Physical conditions derive the type of settlement, architecture, food, clothing, culture and civilization. For example in hilly regions of North-East of India, make sloping roofs of their houses, so that in heavy rains the water could drain out of the roof. They wear thick cloths for

[1] Gallion B. Arthur, Eisner S., 1986 "The Urban Pattern" S.K. Publishers, Delhi

prevention from cold. Ample water and fertile land encourage people to grow rice, so rice has become the bread basket of this region. Similarly in Rajasthan, where the terrain is relatively flat, and rainfall and vegetation are less, people go for flat roof, stone jalis in their buildings and colorful cloths.

Physical subsystem decides the boundaries of the settlement. Riverside cities are linear and somewhere hills and ponds define the boundaries of the city. City's physical subsystem consists of housing, public buildings, market and offices, parks and playgrounds, roads, flyovers and bridges etc. Man's intervention converts natural environment into built environment. Urbanism brings about many changes in surrounding environment. Building occupying formerly open land, pavements on streets, smoke from vehicles and factories, can alter the climate. Solid and liquid wastes from housing, industries and market can destroy the natural environment. Environment and health are important then they need to be preserved and conserved. This conservation requires health facilities and can be taken in use with the capital investment. Important thing is that all the functioning of subsystems of the city i.e. physical, social, economic, ecology, environment, infrastructure and institutions is interlinked with each other.

6.2.2 Social Subsystem

Social subsystem can be observed in the behavior pattern of the people, religion, caste-system, tradition, culture and civilization. Man is a social animal and society has been built by the hands of natural forces. The fear from animals, and natural calamities, inspired people to live in groups and hence they formed society. Communities are the part of nature and people have suffered from many evils they have inflicted on the environment. They have faced the necessity to improve economic security, correct social maladjustments, discard mass superstitions, or resist seizure of power by autocrats bent upon personal glory and self-aggrandizement[2].

The main distinguisher of urban and rural system is the social and political organization. Social advancement lies in the people but can make permanent aesthetic changes. For example the Romans built their cities complete with temple, theatre, stadium, great bath, and villas, etc. The built environment of Rome indicates the strong social, political and administrative structure of the city. The built environment of Orrisa, indicates the religious and architectural development of

[2] Gallion B. Arthur, Eisner S., 1986 "The Urban Pattern" S.K. Publishers, Delhi

society, as there are so many temples built in stone and with a special style of architecture. Social advancement gives promotes education, administration and economy. Ancient times there were Religious schools, like Madarsa of Islam, Buddhist school and Ashrams of Hindus and these were there for religious education. However, in Gurukuls and Ashrams the lessons of physical training, meditation (Yoga), war, music, dance and drama were also taught. Rest of the culture was being transferred by old generation to next generation in the houses only. This education was restricted to a special caste of the society and boys only. Girls were taught in houses only. Nowadays with the consequence of social transformation the educational parameters are expanded, and education has become open to all the sectors of the society, and for both the genders. Field of education is also expanded from religion, war and arts to technology, marketing, advertisement, industrial training and several other sciences.

Social gatherings, religious functions, sports conventions, fashion shows, theatre, cinema, marriages, etc., are such parts of social subsystem which have major role in economic subsystem.

6.2.3 Economic subsystem

People are engaged in economic activities to lead a comfortable life. The whole emphasis of activities is given on gaining and spending wealth. People want to upgrade their lifestyle, and this greed results in the multidimensional growth, in terms of economic activities. Money is required first to fulfill the basic needs (physical), and then to fulfill the demands (luxury and comfort). Economic development is dependent over availability of natural resources, human capital, education, technological advancement, public health, healthy social conditions and availability of market and customers.

As the economic conditions are improved, more and more people are shifted from primary sector of economy (agriculture, forestry, fishery, horticulture and allied activities) to secondary (manufacturing units), and tertiary (service, administration and education) sectors, and as the economy is developed, the GNP in primary sector will be reduced.

A high average level of real income per head is always associated with high proportion with working population engaged in tertiary industries. Low level of income per head is always associated with low proportion of working population engaged in tertiary sector. Primary sector of economy lies in the rural settlements and urban economy lies in secondary and tertiary sectors.

Manufacturing sector, i.e., industries is associated with the production of processed materials and goods. More the number of industries require more number of skilled and unskilled manpower. This gives rise to housing requirement, market, health services, schools, and safety and security measures and in this way the tertiary sector of economy is naturally developed. The physical subsystem is affected by the economic subsystem in order to develop the industries and the other requirement of industries, i.e. housing, amenities and other infrastructural services.

Secondary sector of economy requires a well developed infrastructure, i.e., water, electricity, sewerage system, roads, transportation, and market (commercial area; economic subsystem). This means that economic subsystem must be well supported by physical subsystem for its proper functioning.

The consequences of proper functioning of economic subsystem are the increase in the income and saving and improvement of lifestyle on one hand and environmental degradation on the other hand. Industries produce smoke, dust, solid waste, waste water, chemicals, etc, and hence cause environment pollution. In this way the environmental subsystem is disturbed. If the balance between industrial production and environment is to be maintained, it also requires technological advancement to control pollution and also the assets to afford the applied technologies. Economic growth then becomes necessary to sustainability, as it alone can provide the necessary financial resources and technological capacity required to deal with environmental problems.

There is a strong relationship between the economic, institutional, and social subsystem too. Whenever there is commercial, industrial or educational development, it attracts the people of different areas for employment opportunities. As the people from different places accumulate at a place, they bring different culture and this amalgamation of different cultures brings an altogether culture. The social stratification which was done according to religion, cast and community is done over the basis of occupation and economic status.

6.2.4 Ecological Subsystem

Ecology and economics both the words are derived from a same root, which deals with "housekeeping" in the sense of management of man's works. Extending economic cost-accounting to include the natural environment, as well as man made structures and developments is an

important step in redressing dangerous imbalances between these two necessary components of man's total environment.

The ecological subsystem consists of many bio-systems. System is a regularly interacting of interdependent group of items forming a unified whole. The communities (human and animal) and non-living environment function together as an ecological system or ecosystem. Urban subsystem contain human population, birds and animal population, large number of trees substantial area of grass and shrubs, and in many cases, lakes and ponds-so they do have a autotrophic components or green belt. This large system can be compared with a large, mature forest, like a large elephant which have a tremendous metabolism and requires a large flow of energy to sustain it. There is no such thing as steady thing as a large stone, but the circulation of energies within the body, be it a city, forest or body of an elephant. Sometimes elephant may not get food, or forest may not get rains, but they have ability to sustain for sometime, even without fulfillment of all the needs. Natural ecosystem has this ability. Whatever the hazards occur, nature has ability to come back into its own, original and healthy state, but this ability is rarely found in the urban system, as the urban system is the fuel-powered ecosystem, or industrial system. Here, highly concentrated potential energy of fuel replaces, rather than merely supplements, sun energy. The other sources of energy are non-renewable and hence non-sustainable.

However, the organic production (energy) of the city's green belt does not contribute appreciably to the support of people and machines that so densely populate the urban-industrial area. The urban forests and grasslands do have an enormous aesthetic value and they do contribute indirectly to pollution abatement by reducing noise, carbon dioxide, and other waster products of fuel consumption, but fuel and labor expended in watering, fertilizing, pruning, removing wood and leaves, and other work required to maintain the city's private and public green belts, adds to the energy cost (money) of living in the city.

6.2.4 Environmental subsystem

Total natural environment can not provide the comfortable living conditions to mankind; it has to be molded in such a way that the resultant built environment can give safety from harsh natural conditions and animals. Built environment consists of buildings, barricades, roads, parks, playgrounds, etc. Cities are themselves a unique form of natural, built and cultural environment. As a natural environment, cities have their own distinctive properties, such as the urban heat

island, wind tunnels created by large buildings, and air intervention effects, etc. Yet the natural environment is molded into artificial environment, but in the absence of favorable built environment human health may suffer a lot. The functions of natural environmental subsystem are

- There are natural resources for production and consumption, principally raw materials and energy.
- The natural environment operates as a sink for society's waste products, and
- It provides a series of free services; like fresh air, water and vegetation.

Here the relation between physical, and economic subsystem can be understood. If the physical subsystem is not built properly then the human physical and mental health is badly affected and to get rid of this difficulty, the support of social and institutional subsystem (health services) and economic subsystem (funds for availing the health services) is required.

Urban environmental subsystem is not just the built environment, but the social, economic and political environment. Social, economic, and political environment determine the quality and growth of the physical environment. Environment means physical conditions, not psychological[3]. The total environment of the city consists of this entire environment. Urban sprawl can pose particular problems by eating into valuable natural habitats, whilst cities also pass on some of their impacts, making intensive demands on the environmental resources of their hinterlands, such as quarries for building materials. Estimation of economic value of the natural resources is never ever done before its over- exploitation, however the commodities which are made out of these natural resources, or with the help of these resources have their own market price.

6.2.5 Infrastructural subsystem

The role of infrastructural subsystem is to run all the activities in urban system. Infrastructure development is a sign of technological advancement, systematic institutional framework, and economic affluence in the city. Infrastructure's function is must for smooth functioning of whole urban system, as it is a physical framework of services, facilities and amenities. Infrastructure can be classified as follows;

- Physical: water, drainage, sewerage, solid waste management system, roads, rails, gas, airways, and waterways, etc.

[3] U.S. Supreme court 1983

- Social: Health, education, security, safety, recreation, tourism, shelter, justice
- Economic: All kinds of work centers, workshops, Industries, market, banks
- Electronic: accessibility to internet connection and e-governance
- Ecological: parks, nurseries, water bodies
- Defense: provision of military services during war and internal riots, at proper time and place, and,
- Hazard pretension or emergency: Economic back-up and institutional framework readily available at the time of floods, earthquake, or any other natural calamity.

In this way infrastructure is required in each sector of the urban system. It is not just a physical framework made only with natural resources and economic support, but it requires a strong institutional framework to run the activities properly.

The population of the Indian cities is growing and there is rapid growth in demand. Indeed, there is a wide gap between demand and supply as because of migration large number of people is coming towards city, the demand for infrastructure is more and supply is less. There is lack of resources, and even the financial resources are less. Institutional parameters show that there is lack of public and private partnership for the development of infrastructure. The use of ineffective and obsolete technologies is also the governing factor for poor infrastructure development. Even if the physical infrastructure is built, the lack of maintenance pulls it behind and leaves in unusable state.

6.2.6 Institutional subsystem

Integrated functioning local governing bodies, working for planning and maintenance of the city are required for the overall development of the city.

6.3 System Dynamics in the present investigation

The dependency of all the subsystems over each other has been discussed in the above section. Drinking water supply is a part of infrastructure. The primary survey, which was conducted in study area, was based upon such heading which are directly associated with it. The relation of the headings of the primary survey is explained below.

6.3.1 Income

Income is the dependent variable, and it is dependent over some independent variables which are the causes the income. Some causes are direct causes while some act like catalyst in the income generation. Direct causes are the population, education, availability of industries and market and employment opportunities. Only education or only work force can not do anything alone. They need to be well supported by institutional structure, capital investment and government policies. The catalysts to increase income are technological advancement, skills, administrative services, social conditions etc.

The time when the caste system was too rigid, people did not have freedom to choose their own occupation; they were supposed to adopt the ancestral occupation only irrespective of their own interest and talent. Therefore, the income distribution was also according to caste. Higher caste people (Khshatriyas and Vaishyas) had higher income and lower caste people had lesser incomes. These restrictions restricted the economical development, as there was no proper investment of manpower, skills and talent. As a consequence of social transformation the rule of choosing the occupation according to caste system was eliminated and people were freed to choose any field to earn their livelihood. Social conditions put impact over income, not only by the caste system, but also by other conditions. These are participation of women in economic activities, percentage of marriages and divorces, age of marriage, interest in child raring, family system and culture.
Indian culture gives importance to religious activities, rituals and festivals. Culture is an important part of routine life of people, and in many places it effects the time of working hours, and the turn-over of any company or organization is directly related with the working hours.

Environmental conditions also affect income, as these are responsible for physical and mental health of people. Good physical health conditions, cause good mental health of people, and enhance their work quality. Better work poses better income.

Institutional structure is also a very important criterion for income generation. Institutional structure is made according to level of governing bodies (centre, state, district, city, local etc.), their composition (according age, qualification, experience and interest and physical health conditions), matters a lot in implementation of policies and proper functioning of the system. The per capita income and of gross domestic product (GDP) both are complementary to each other. If the per capita income rises, then the GDP also rises. Different level institutes have their own

system, and they constitute the whole system. As the per capita income and GDP are dependent over each other, the working of different level institutes is also dependent over each other.

The water requirement of households depends upon the income. Water requirements of higher income group is greater then the lower income group people. The primary survey was carried over 100 households of four groups of income level ranging from annual income of Rs. 100000/- to more then Rs. 400000/-. Apart from this investigator visited the slum areas to carry out the same survey. The poverty line of Indore city is described as Rs 522.64 per capita income per month and the people dwelling in slum areas come under the poverty line. These areas do not even have hygienic drinking water supply. There are no sanitary services, and tanks for water storage. As these are the temporary migrants, and visit the city randomly. The water requirement of such people is very low as compared to the other income groups.

6.3.2 Social conditions

Social fabric of Indore consists of Maharashtrian, Gujrati, Marwadi, Sindhi, Punjabi, Sikh, Bengali, Bohra, Muslim and Christian and South Indian communities. These all communities work together for the common goals. They all are engaged in academics, industries and market, irrespective of the caste and culture. The healthy interaction of all these communities, maintain the peace in the city.

Religion

The religion is one of the main drivers of economic activities in India. Marriages, festivals and fares engage many people in the control system and in temporary market which is created occasionally. For example, religious camps are organized for Radhaswami Community. Some priests come in the city and give lectures (known as Satsang, i.e. company of truism, and sanctity). People come to listen these lectures from far off places. These activities take place in open grounds or community halls. Accommodation and lodging for these devotees engage a big market. This time pressure over infrastructure is also increased. The load over water supply and sewage is suddenly increased. The load over transportation is also increased. Indore is closed to Ujjain, which is one of the twelve Jyotirlingas (main Shiva temples), and one of the place for Mahakumbh. Mahakumbh is a fare organized once in the period of 14 years. People come in huge numbers, i.e. in crores also. Varanasi, Haridwar, Ujjain and Nasik are the four pilgrimages where this holy fare is organized, once in 14 years.

Yet this occurs once in 14 years but it requires a huge control and administrative system and preparation of years together to arrange the accommodation of crores of people in a small city. As Indore is on the route of the Ujjain, so many people take halt at Indore and even they stay in Indore, and do up down to Ujjain for the rituals.

Vicinity of Omkareshwar and Maheshwar also cause the accumulation of people in Indore all around year.

Many other religious festivals are celebrated socially in Indore. These social gatherings need ample amount of drinking water supply.
Marriage season also affects city's system a lot. Cooking gas, electricity, transportation and water supply all are required in the concentration. Marriages in India play very important role in economy. These are the only occasions when maximum sectors of market are utilized. Jewelry, saris, garments, hosiery, fashion design, crockery, furniture, catering, lighting, tent house, lodging all get flux during marriage season. Load over water supply is but natural this time. Piped water supply in Marriage halls and gardens does not remain reliable. The marriage gardens are supplied the tanker water.

This implies to all the social gatherings, religious conventions, and sports conventions all are dependent over mobile water supply, i.e. tanker water.

The routine activities of some of the communities are also different. For example in Islam, wastage of water is assumed equal to evil; this naturally causes the controlled water use in their daily activities too. Importance to cleanliness and respect for natural resources has been given in every religion. Buddhism, Hinduism, Christianity, all have given due respect for preservation and conservation of natural resources. It is another fact that personally, how one gives importance to this.

Family size and type

Family size, the number of children per person, and the family type, i.e., joint family or nuclear family put impact over all the requirements, whether these are the daily needs commodities whether infrastructure requirements or the land requirements. The resources are limited and their growth is limited, while the growth of population is exponential. If a person has two children, his

family's next generation will consist of two families, and in this way, more the number of children per person, will increase the population exponentially. Although, wars, natural calamities, divorces and family planning all have control over births still population growth can not be stopped, if the family size is greater. An estimate of increased expenditure in a separated family (from a joint family) has been given in table no. 4 of survey analysis.

If people live together in a joint family then all the expenses are controlled and the expenses of the same family after separation are certainly increased. This is not just the matter of personal expenditure, but the other activities in the urban system too. If a boy is separated from joint family, then he goes at different place, takes services of other place, i.e., milkman, grocery shop, daily needs shop, newspaper, household servants ,etc. In this way he adds something to the property and other markets of the new location, where he is shifted, and on the other hand the circulation pattern of the traffic also is used in a changed manner. All the family members choose different route to go to their work place or school or college. Effected areas after the separation of joint families:

1. Land and Housing and Environment
2. water supply, electricity, sewage, telephone line and cooking gas services
3. Transportation
4. Daily needs market (indirectly the manufacturing industries)
5. Household services
6. Culture, love and belonging
7. Safety and security (elderly people, women and kids)

Condition of the Women

There is a direct and immediate relationship between women and natural environment[4]. Degradation of environmental conditions put the maximum effect on the women. It does not matter, whether it is tribal area, rural area or urban area. Women in tribal and rural areas have to collect fuel and fodder. If something causes damage to fields, forests or mountains, than too females only have to suffer. This implies to the water scarce areas also. Women have to walk miles just to bring drinking water in the house. Kumaon region in Uttaranchal is known for its scenic beauty. A study was done over three villages of this region and it revealed that women have to put in an extraordinary time and labor to fetch fuel and fodder. In Haryana, Madhya Pradesh,

[4] Raj Rani "Environmental degradation and women ", Kurukshetra Jan-Feb 1997

Maharashtra (Ratnagiri district), and Tamilnadu (Kanyakumari district) the agricultural workload of women increased after men took up jobs in cities.

The survey in the study area reveled that sex ratio is higher in Indore. Even out of 100 households, there were 293 females against 288 males, but certain areas are there where women have to suffer. Traditionally, women have been responsible for subsistence and survival economies and culturally accepted division of labor within the family. During summer when water is scarce, women have to bring water from far off places. Women living in apartment and shared housing suffer a lot when there water is supplied for limited time. In many of the apartments the overhead tanks are common, so in the greed of taking maximum use of water people store water in the drums, so women have to spend two hours of their day over water. The people living in the upper floors of apartment housing have to suffer a lot as they have to lift water at greater heights.

The relation of women with the water scarcity is presented in fig. 6.2.

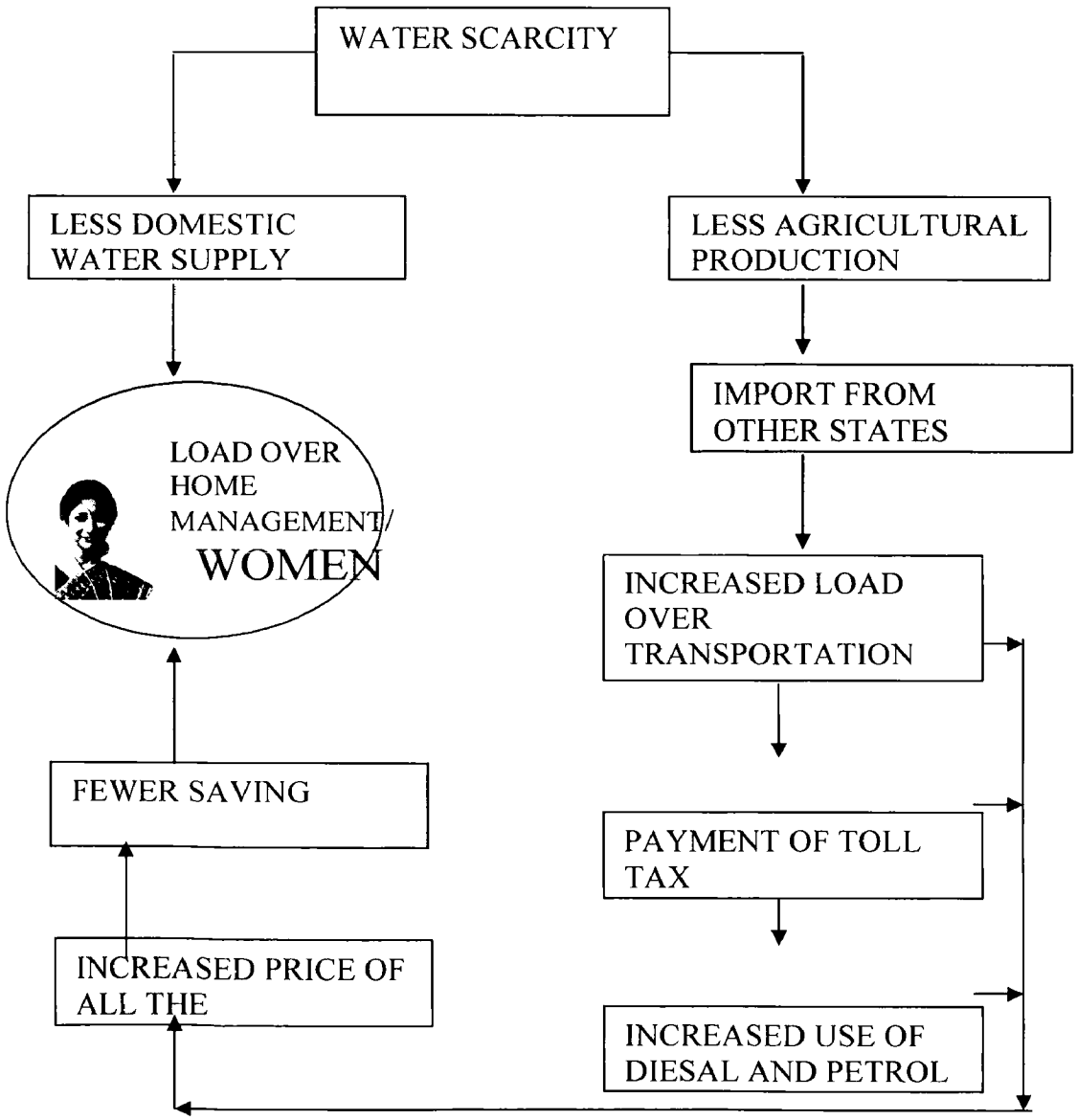


Fig. 6.2 Water scarcity and women

6.3.3 Economic characteristics

The study area is an important centre for industries, commercial activities, educational services, health services and administrative services. Relation of income with rest of the system has already been discussed. The water requirements of different occupations are different. For example, the water requirement of a hospital is different then the hostel. Indore contains a number of hospitals, pathologies and other laboratories, hotels, and restaurants, industries, factories and workshops, institutes, public schools, boarding schools, crèches, nursery schools, administrative centers, libraries, and city level entertainment centers, like zoo, museums and amusement parks. Now the new arena of income generation is opening up. A software park and a multiplex are under construction. Already there is a multiplex (velocity, with 4 cinema theatre), and a shopping mall (Treasure Island) in the city. The new style of architecture comes with the new technologies. The sanitary system of these advanced buildings is also contemporary. They have adopted automatic flushing system, touch taps, recycling waste water plants in these advanced buildings. The water requirements of all such work centers are different. Technological advancement should suit to development and prudent resource management, and then accepted by the society.

The System Dynamics Model is developed and employed for population projection in the present investigation, and is presented in the next chapter, i.e., Chapter 7.

Chapter 7: Projections

7.1 Population Function

Population is one of the dynamic elements in urban ecology. Settlements are like living organisms, i.e., constantly they change in their growth pattern, influencing and being influenced by their neighboring settlements. The major factors that influence the population growth of the city are political, administrative and socio-economic activities that have occurred in the past decades. The amount of population in the city is based on the total population of the city, its growth rate, death rate, and immigration and out-migration rates. These all parameters function together and decide the total population. The population growth can be altered by altering immigration rate, out-migration rate of the system and conducive atmosphere for population growth within the system. System dynamics Model has been employed in the present investigation to understand the population growth in the system in the year 2031 A.D..

7.2 System Dynamic Modeling

System Dynamics modeling is one approach that can help the Planners and Managers to meet the challenges of decision-making and policy formulation for the development of a system. It represents the key feedback structures in the system. Simulating the model shows the effect of the system structures on policy interventions. It is a problem evaluation approach based on the premise that the structure of a system, that is the way essential components are connected, generates its behavior. It is well suited to analysis of problems whose behavior is governed by feed back relationships, has a long-term time horizon , and not suited to one-time decisions. The process of creating a simulation model helps clarify the resource management problem and makes modeler assumptions about the way the system works explicit. The most important advantage of this model is once the model is built, it can be used to simulate the effect of proposed actions on the problem and the system as a whole. In this regard, Forrester (1987) noted that, this kind of tool is necessary because, while people are good at observing the local structure of the system, they are not good at predicting how the complex and interdependent the system will behave.

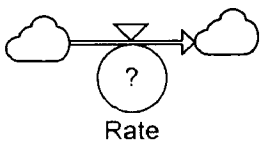
7.3 Notations and Equations Adopted in Modeling

The various variables in the System Dynamic models are the level, rate and auxiliary variables.

Level variable (L)

Auxiliary variable (A)

Constant (C)



Rate variable (R)

A level variable depends only on a rate variable; and presented by

$L(t) = f_l(R(t))$

A rate depends on level variables and/ or auxiliary variables, and on constants, and is presented in any of the forms depending on the various variables and used based on the requirements. The equations are as given below:

$R(t) = f_{r1}(L(t), C)$

$R(t) = f_{r2}(A(t), C)$

$R(t) = f_{r3}(L(t), A(t), C)$

An auxiliary variable can be a function of level and/or other auxiliary variables and constants and is presented in any of the forms depending on the variables and used based on the requirements. The equations are as given below:

$A(t) = f_{a1}(L(t), C)$

$A(t) = f_{a2}(A(t), C)$

$A(t) = f_{a3}(L(t), A(t), C)$

The algorithm for numerical solutions by Euler integration of the system dynamic model is presented as:

$L_i(t) = L_i(t\text{-}DT) + \Delta L_i(t\text{-}DT, t)$, for all i

$\Delta L_i(t\text{-}DT,t) = DT * d/dt\,(L_i(t\text{-}DT))$

Where, Li (t) = Level values at the end of the time step for all i

t = time period

DT= time step

Accordingly the model derived for calculation of population projection is given in figure 7.1.

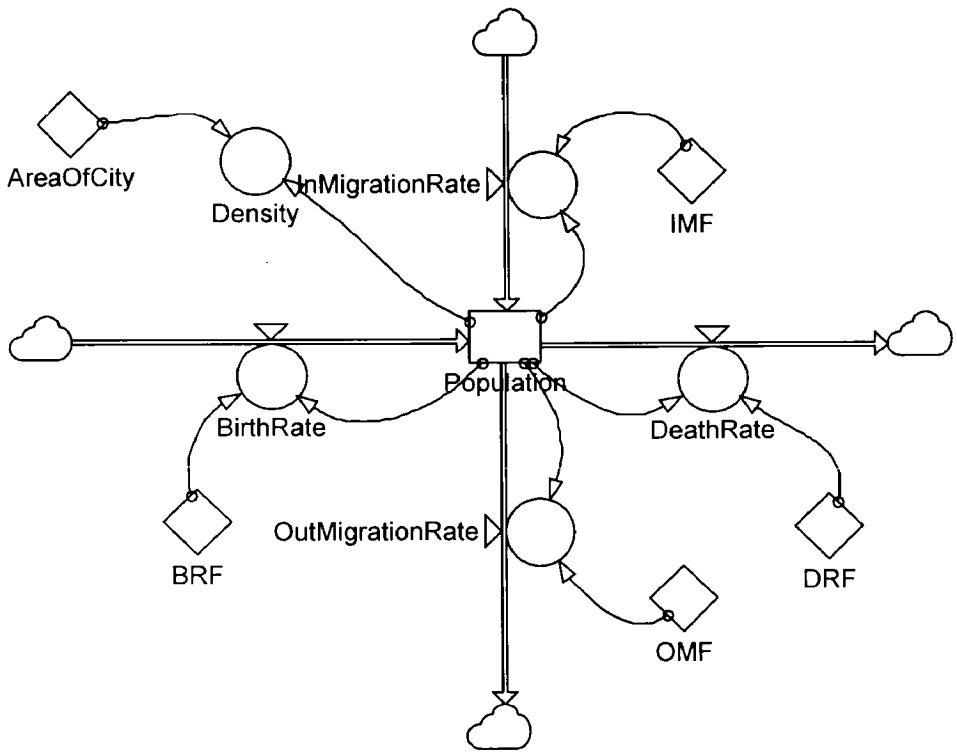


Fig. 7.1 Population projection

Population projection-

This population projection has been done for the optimum condition. The extreme situation under which the population will be maximum is the city area is constant and other factors, i.e., immigration fraction (IMF), death rate fraction (DRF), birth rate fraction (BRF), out migration fraction (OMF) will be constant, while the rate variables will be out migration rate, in migration rate, birth rate, and death rate. Indore city has following data

init Population = 1597441
flow Population = +dt*InMigrationRate
-dt*DeathRate
-dt*OutMigrationRate
+dt*BirthRate
doc Population = Population of Indore as per 2001 Census in number
aux BirthRate = Population*BRF
aux DeathRate = Population*DRF
doc DeathRate = Death rate in Pune
aux InMigrationRate = Population*IMF
doc InMigrationRate = In migration rate in
aux OutMigrationRate = Population*OMF
doc OutMigrationRate = Out migration from
aux Density = Population/AreaOfCity
doc Density = Population Density of Indore U A
const AreaOfCity = 113.17

The projected population is presented in Table 7.1. Fig. 7.2 presents the graph of the same. The following data has been calculated by system dynamics model and power sim software.

Table 7.1 Population Projection

S. No.	Year	Population
1	2001	1597441
2	2006	1825059
3	2011	2085111
4	2016	2382217
5	2021	2721658
6	2026	3109466
7	2031	3552533

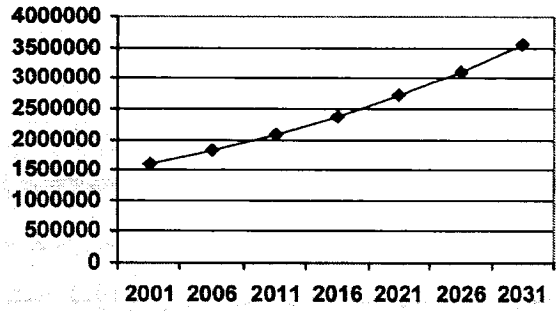


Fig. 7.2 population Projection

7.2 Density projection

The population density in 2001 was 8386 persons per sq. m. . The projected densities are presented in Table 7.2 and Figure 7.3.

Table 7.2 Population density Projection

S. No.	Year	Density in Sq. Km
1	2001	14115.41
2	2006	16126.71
3	2011	18424.59
4	2016	21049.91
5	2021	24049.30
6	2026	27476.07
7	2031	31391.12

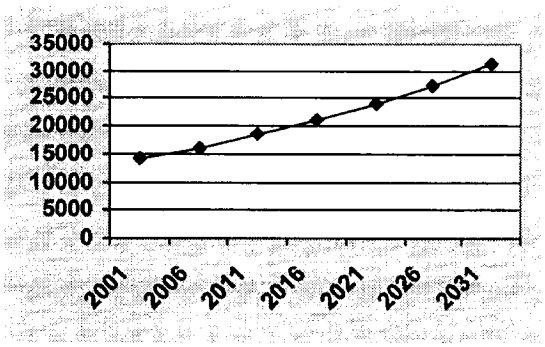


Figure 7.3 Population Density per sq. km.

7.3 Water demand projection

According to PHED the water demand standard is 135 litters per capita per day. It is 180 lpcd according CPHEE manual . The requirement of slum dwellers and EWS people are comparatively less, but the authentic slum population data is difficult to find out, as the slum dwellers are mostly migrants and do not stay permanently. Water demand is considered as 135

lpcd in the present investigation. According to this the water demand is calculated and presented in Table 7.3 and Figure 7.4.

Table 7.3 Water demand Projection

S. No.	Year	Population	Water demand (MLD)
1	2001	1597441	215.65
2	2006	1825059	246.38
3	2011	2085111	281.48
4	2016	2382217	321.60
5	2021	2721658	367.42
6	2026	3109466	419.77
7	2031	3552533	479.59

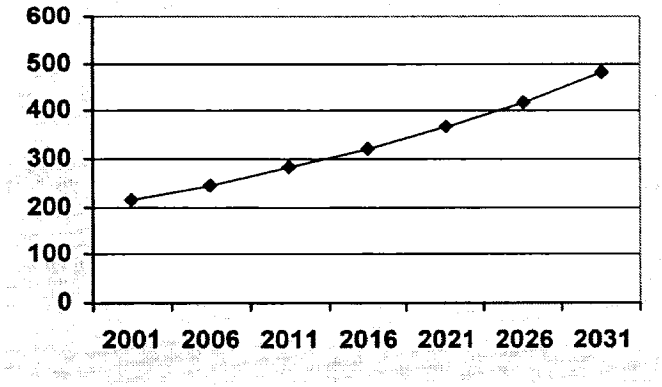


Figure 7.4 Water demand in MLD

The present water supply consists of 222 MLD installed capacity, and for year 2031 the demand is 279.59 MLD. Phase III of Narmada Project is designed for 360 MLD installed capacity for year 2021, however the demand in this year is 367.42 MLD. There are two pipelines at present, and for future it will require the next pipeline. It is just not feasible to be more dependable over Narmada Project. The locally available resources must be strengthened.

Chapter 8: Results and Discussions

The following observations are made in the system based on the analysis of secondary data, primary data and visual analysis indicate the following conditions.

8.1 Physical Parameters

Physical subsystem affecting drinking water supply system consists of the area of city, resources availability, population and infrastructure.

8.1.1 Topography

City has natural boundaries, by Bijasan Tekri, in West and Devaguradiya, in South, so the expansion is possible in East and North only. The urban land suitability for physical Expansion of has been presented in Figure 8.1.

This map reveals that highly suitable areas for development are 50 per cent of the existing built up area, while the less suitable area is greater than existing built up area. Still development can take place here. The estimated population for year 2031 is 3552533, the population for year 2001 was 1597441, and area of city was 113 sq. km. The new development should be made with due consideration for rain water harvesting and preservation of the existing water bodies.

8.1.2 Water Resource availability

Locally available resources

Ground Water- The ground water strata has been presented in Figure 8.3. This map clearly shows that the maximum area is covered by the buildings, followed by the areas with good to moderate prospects for ground water. Areas with zero prospects for ground water are minimum. Yet the ground water table is declined, rain water harvesting will definitely help in raising this level. The ground water resources have been presented in Figure 8.2.

Surface resources The existing water bodies in Indore Municipal Corporation area are Yashwant Sagar, Sirpur Talab, Pipliya Pala Tank and tributaries of Khan and Saraswati. The locally available resources have been presented in Figure 8.3. Restoration and conservation of existing water bodies can not be neglected. The average annual rainfall is 700 mm. The area under all the water bodies is 1392 hectares. If the water bodies are maintained well and used for rain water harvesting then 974400 cubic meters, i.e., 974.4 million litter water can be stored within these.

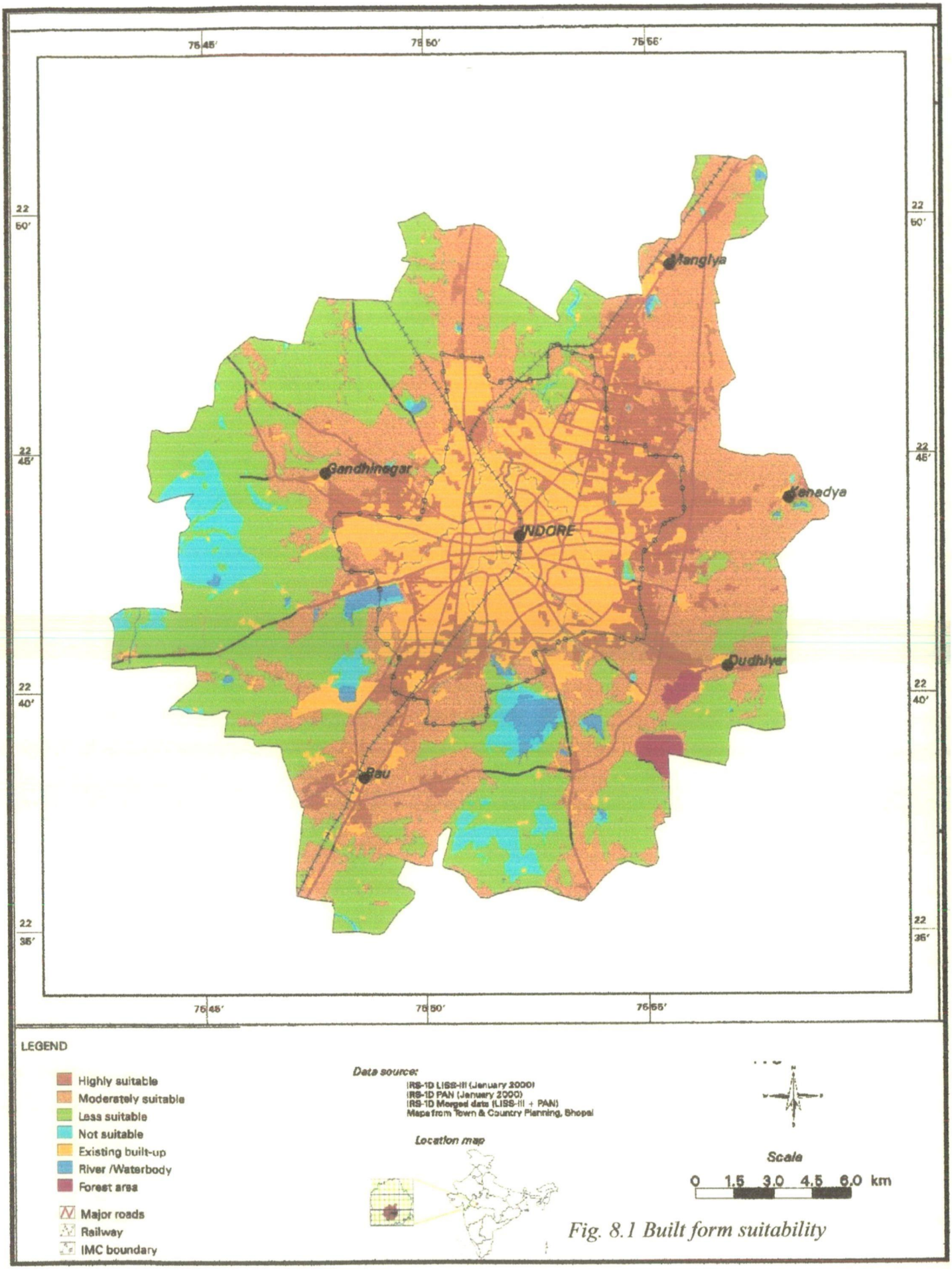


Fig. 8.1 Built form suitability

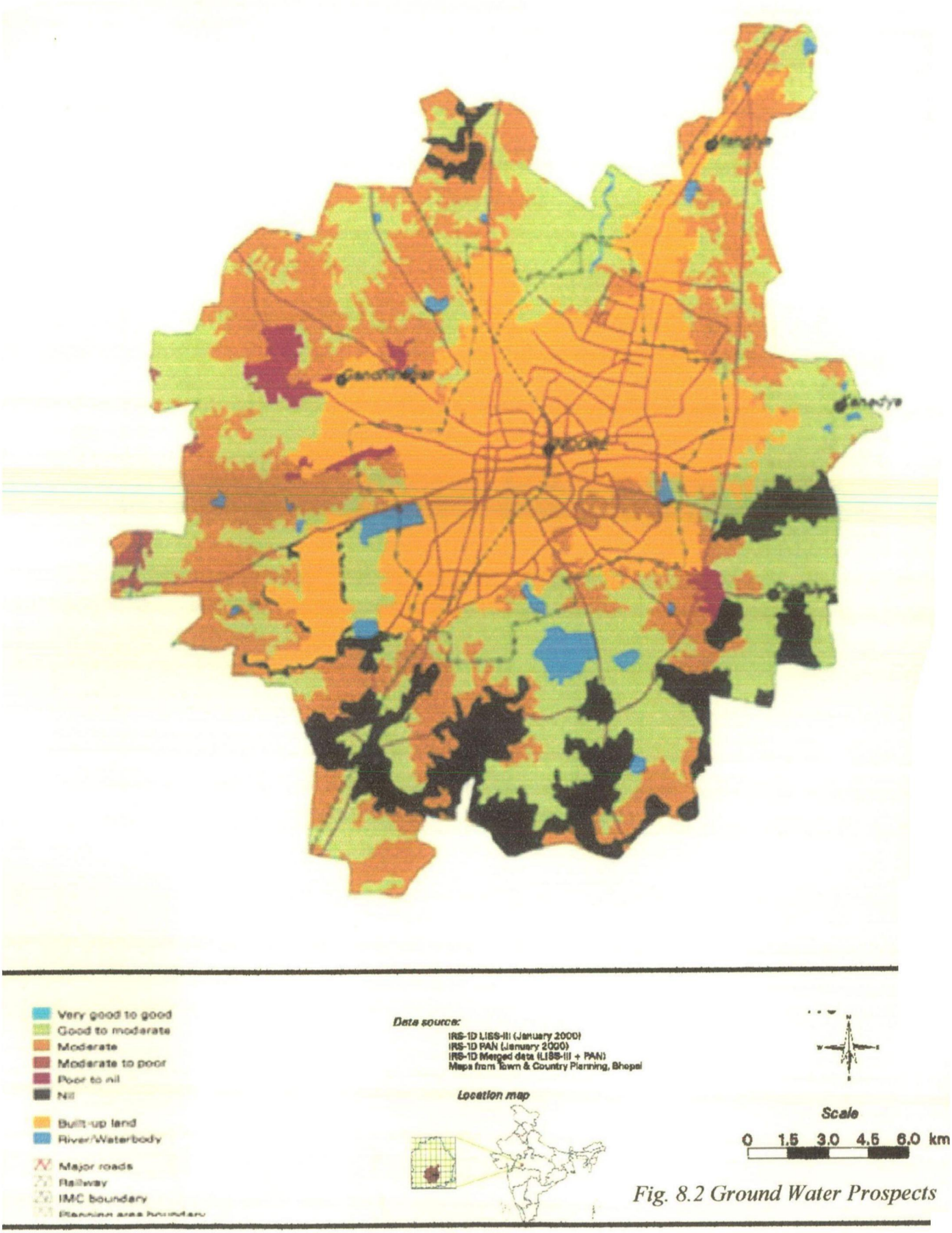


Fig. 8.2 Ground Water Prospects

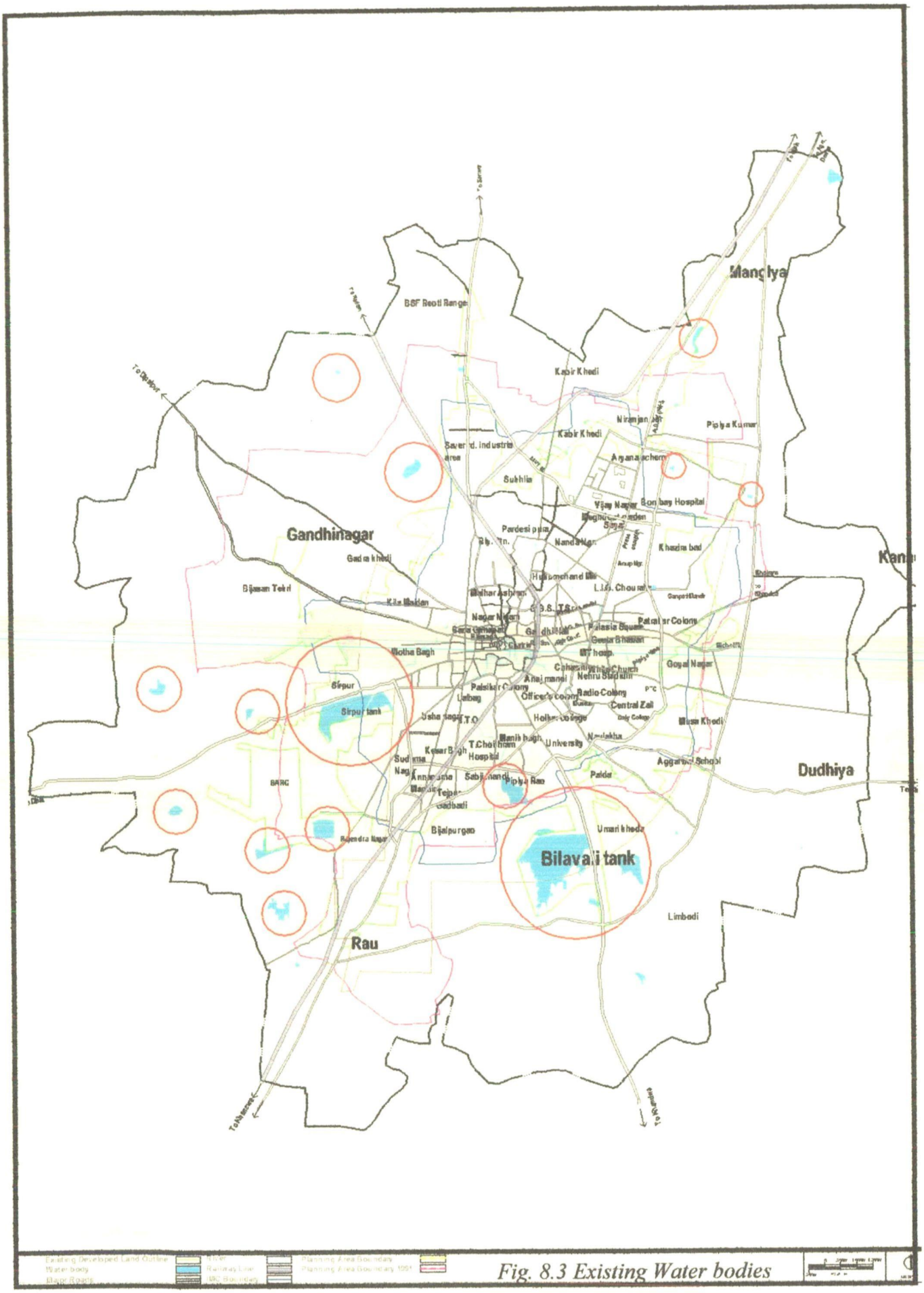


Fig. 8.3 Existing Water bodies

8.1.3 Condition of the River

The major activities along river which affect the ecology of river (from South to North) are hospital (T. Choithram), crematorium (Rambagh and Juni Indore), Mill housing, Dhobighats (M.O.G. lines and Palasia), temples and kiosks, fish market, whole sell market, and river is serving as a dumping ground and sink for sewage from whole city. Activities along river are given in Figure 8.6. T. Choithram hospital has its own incinerator, and the refuse from hospital might be toxic. The toxic wastes are, ashes from crematorium, organic wastes from fish market, foam of the detergents and blue used in dhobighats, organic wastes from hospital, untreated sewage. The non-toxic wastes are, paper, plastic and polythene garbage of whole sell market, organic wastes from vegetable market. Infrastructure for solid waste collection, treatment and disposal needs to be strengthened.

Resource outside the city- The outer sources are five rivers namely Gambhir, 22 km away, Chambal , 43 km away, both flowing from South to North West of Indore, Kalisindh, 64 kms from Indore and Narmada River 70 km south of Indore. There is another small river namely river Khan, which passes through the city and flows from South to North meeting river Kshipra near Ujjain. The reliable source Narmada River water supply have become essential for the city, but there are many problems associated with the Narmada project, these are

- The pipelines are too long, and it is very difficult to examine any damage or leakage, in it, and in case even if it is detected, it is risky to be repaired, as the hills are too steep and are presented in Figure 8.4 and 8.5.
- Already there is electric shortage in the State, and the electric charges in the whole project are most expensive.

Narmada water can not be fully utilized for Indore, same river waters are to be used by other cities of Madhya Pradesh, Gujrat and Maharashtra States also.

Fig. 8.4 a view of steep slope of mountain

Fig. 8.5 a view of pipeline

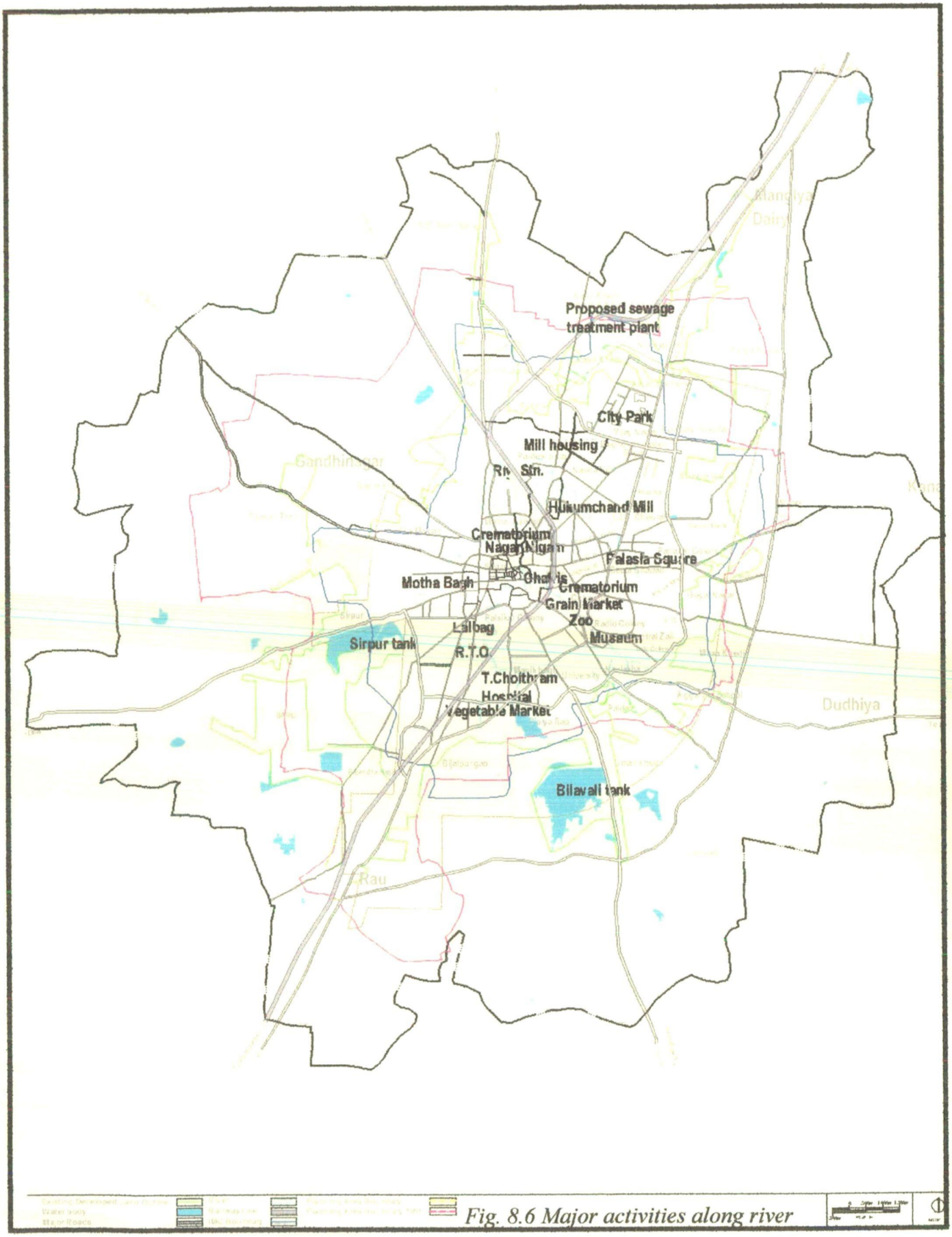


Fig. 8.6 Major activities along river

8.1.4 Built and Open spaces-

The percentage of open spaces and recreational spaces is very less in the city. For rain water harvesting hard paved areas are also suitable (c.r.f.no. 8.1).

8.2 Economic Conditions

1. City's industrial and commercial development is taking place, and the migrated workforce is playing major role in it.
2. The resource and economic planning in past was up to the mark, but as the population increased tremendously, the resources became redundant.

8.3 Infrastructure

8.3.1 Existing Water Supply system

The projected population for year 2031 is 35, 52,533. This is more than the double of the present population; hence the water requirement will also be more than double. The designed capacity of Narmada Project I and II together is 180 MLD.

In fact it was expected that the Narmada Water supply project can not serve the purpose, but work the other way. Since the city started to grow much faster due to this project, as a consequence, the Narmada water supply also never serve this purpose fully.

The Narmada water supply system was designed for a total population of 12 Lakh (projected year 2006), the city again faced water problem due to the unexpected increase in population growth, and by the year 1991-92 the population of the city crossed the designed population of the scheme, which lead to expansion of the scheme further. Subsequently, looking at the unexpected growth of population, Phase-III of Narmada Project in prepared by having the following parameters.

- Estimated Cost - Rs. 497 Crore
- Designed Population for the year 2021 - Rs. 28 Lakhs
- Designed Water requirement of the year 2013 - 360 MLD

This project is yet to start, again the situation came that there was a greater demand in comparison to available water. A Project for strengthening of distribution system is executed by taking loan from HUDCO, and is executed in two phases. Project details are given below

(i) HUDCO Phase – I Scheme :-

Cost of Scheme - Rs. 26.00 Crore

Period of Completion - Started in 1995 & Completed 2000-01

(ii) HUDCO Phase – II Scheme :-

Cost of Scheme -Rs. 7.05 Crore

Period of Completion -Started in 2001-02 works are under progress.

The development has been conceived in taking in most opportune time when the infusion of this input is most vital as the third phase of Indore Water Supply Scheme is not possible but the existing water supply system has to be strengthened to match with the pace of development of the city keeping in view the steep rise in population and expansion of the city. Besides the age of single transmission main which has completed its 25 years of life and nearly expired, suffers frequent bursts which are repaired on war footing in targeted time schedule to restore the water supply every time. The third phase of Narmada Project has been planned with the total installed capacity of 360 MLD for the year 2021. As per the projection made in this investigation the demand in year 2021 is 367.42 MLD.

8.4 Potential for rain water harvesting

There is a need of finding out the new alternative of water supply system. One of the main problems in the study area was the depletion of ground water. The calculation of rain water harvesting potential is given below.

Number of households in the survey area = 100

Population = 587

Run off Coefficient = 0.8

Average annual rainfall in Indore = 800 mm = 0.8

Roof area calculation

700 x 35 = 24500 sq. ft.

1000 x 52 = 52000 sq. ft

1400 x 19 = 26600 sq. ft.

1800 x 13 = 23400 sq. ft

Total 126500 sq. ft

126500 sq. ft. = 11758 sq. m

Water harvesting Potential =Rainfall x Area of Catchment x Runoff coefficient

= 0.8 x 11758 x 0.8 = 7525.12 cu. m.

= 7525120 lit per year

Calculation for Annual water requirement

Daily water requirement per person = 120 lit

Annual water requirement per person = 120 x 365 = 43800 lit

Annual water requirement of the surveyed population = 587 x 43800= 25710600 lit

$$\text{Percentage} = \frac{7525120 \times 100}{25710600} = 29.3\%$$

This calculation concludes that 29.3% of the annual water requirement can be fulfilled by just rain water harvesting in the residences only. The existing water bodies have capacity to store 974.4 million litter water. However the storage capacity could not be assumed as supply. Assuming that, if 50 per cent water is supplied:

Percentage of this comes

$$\text{Percentage} = \frac{974400000 \times 100}{25770600 \times 2} = 18.9\ \%$$

This is clear from the above calculations that 48.2 (29.3+18.9) per cent annual water requirement can be fulfilled by rainwater harvesting in the existing water bodies and residential buildings. Apart from this there are many effort being done on government buildings and public parks. Private level participation is not yet much satisfactory. According to India's best Practices Catalogue, 2003, only 3000 residential buildings have adopted rain water harvesting in the period of three years. Yet this figure is good at initial level.

8.3.1 Sewage System

The sewage system in the city is good as only four per cent of the households reported problem of overflow, so there is less risk of ground water contamination through residential areas, but at the same time the whole burden of sewage is over the rivers. The only remedy to control the contamination in Rivers is treatment of sewer. Daily drinking water demand is just about 10 lpcd, rest of the water is flown in to the sewers. If the daily demand has come down to 120 lpcd, and if 20 lpcd water is used for gardening (assumption), then water disposal comes around 90 lpcd. The population of Indore city in 2005 was 16,00,000. As per the above calculations the total sewage carried by whole sewage system of the city would be

= 90 X 587= 52830 litters

If after treatment its 30 per cent water is regenerated then 15849 litter water could have been again supplied daily, and (15849 X 365 = 5784885) 5.78 million litter annually.

Annual water requirement of the surveyed population = 25710600 lit

Percentage generated by Treated Water = $\frac{5784885 \text{ X } 100}{25710600}$

= 22.5%

Rain Water harvesting can generate the 29.03 per cent requirement and sewage treatment can generate 22.5 per cent, hence **51.53 percent** water requirement can be fulfilled just by the activities within system.

8.4 Natural Resource Conservation

There is a great potential for conservation of the existing river and the tributaries in the city. Map 6 presents the present condition of river. Regeneration of the river will enhance the environmental quality of the city and also add something to recreational activities.

Chapter 9: Findings and Recommendations

9.1 Findings

Indore is facing rapid population growth, and the population is going to increase tremendously by the end of 2031. There is water scarcity at present on one side and the available water also the resources have not been judiciously utilized on the other. The basic problem is with the population and their attitudes. If the same rates of migration and birth rate are continued, then probably even the Narmada River Water will also not be sufficient to fulfill the requirements. Water has given rise to socio- economic development, and water scarcity can just hinder all the activities of development.

Existing conditions/ problems

- ***Insufficient domestic water supply***

According to CPHEEO manual recommendations, per capita demand of water in the urban area is 40 gallons per day, i.e., 180 liters per capita per day. This standard quantity was never been supplied in the city. Even there is a steady decline in per capita per day supply (lpcd) of water, which has decreased from 129 lpcd in the year 1997 to 116 lpcd in the year 2000. Summer seasons the situation is further worsen. The water supply comes just about 82 lpcd.

The areas which are recently being developed are not yet connected with piped water supply. Some of them which are connected, especially in the extension of mill area, share ½ inch pipe connection with 4 to 5 houses, and water is supplied just for an hour or two hours a day.

People, who can not afford expense of ground water boring, have to depend upon the mobile water supply, and it will create adverse effect in the system. They have to spend two hours daily just for water.

- ***Problems during Summer Season***

Madhya Pradesh is facing problem of electricity shortage after separation of Chhattisgarh. Daily 2 hours load shading is common in Indore City. As the piped water comes from greater distance, electricity shortage obstructs the regular supply of water. Water supply is irregular when it rains lightly, and also at the time of electricity shortage. Water is supplied for one hour in two days, and sometimes even once in three days, that too at very low pressure during summer season.

- *Irregularities in tariff collection.*

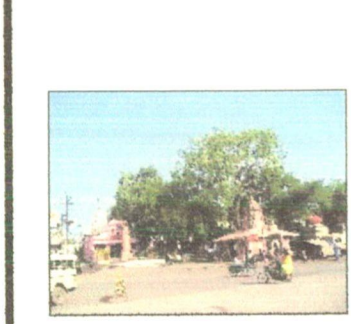
The initial cost of even first phase of Narmada Project has not been recovered, because of the low rate of the tariff. Many connections are unmetered and the even there is irregular collection of revenue from the metered connection is also observed. In fact, there are no norms for ground water extraction. Some people extract ground water and supply it to the city by tankers. There is a need to regularize the ground water extraction too, otherwise there would be a greater distress in the system.

- ***Problematic drainage system***

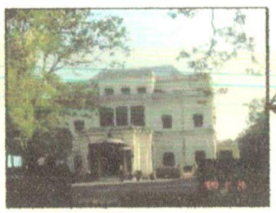
One pipe system is followed for drainage in the whole city. Soiled and unsoiled water are drained through a common pipe from all the localities. Treatment of such sewage is expensive so that entire drainage in the city is dumped in river Khan and Saraswati, that too without any treatment. The rivers are also used as dumping ground at many places. At present, environment along the river is highly unhygienic.

- ***Degradation of heritage sites***

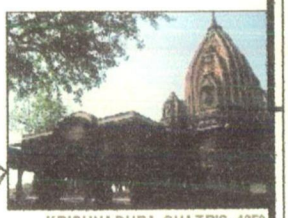
The riverside village was well planned. There are temples and dhobighats along the river, and at the end of the old settlement a crematorium is located. The other uses of the river Saraswati would have been transportation also. The major architectural development done by Holkars was on the River Saraswati stretch. The major ones are three major gardens, along the river- Manik Bagh, Gopal Bagh, and Lal Bagh. Holkars constructed beautiful halting places, i.e., umbrellas, (Chhatri in local language) and palace along the banks. Chhatripura, krishnapura, Pandharinath, and Harsiddhi temple, Ganesh temple, etc. Now the pedestrian linkage between these monuments has been encroached by shops, and heavy traffic roads. The river front which was the main criteria for design of these monuments has been turned into highly polluted and unhygienic environment. Monuments and temples were river are constructed to prevent the river, from pollution and to enjoy the water front. The monuments along river have been presented in Figure 9.1 and the degradation is presented in Figure 9.2. If the same land use is adopted now, as it was in past then it will definitely enhance the quality of environment.



GHATS OF RAMBAG

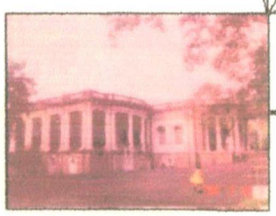


LALBAGH- 1885



KRISHNAPURA CHATRIS- 1850

BOLIYA SARKAR'S CHATRIS-1858



RESIDENCY KOTHI- 1820

HANUMAN MANDIR

Fig. 9.1 Monuments along river

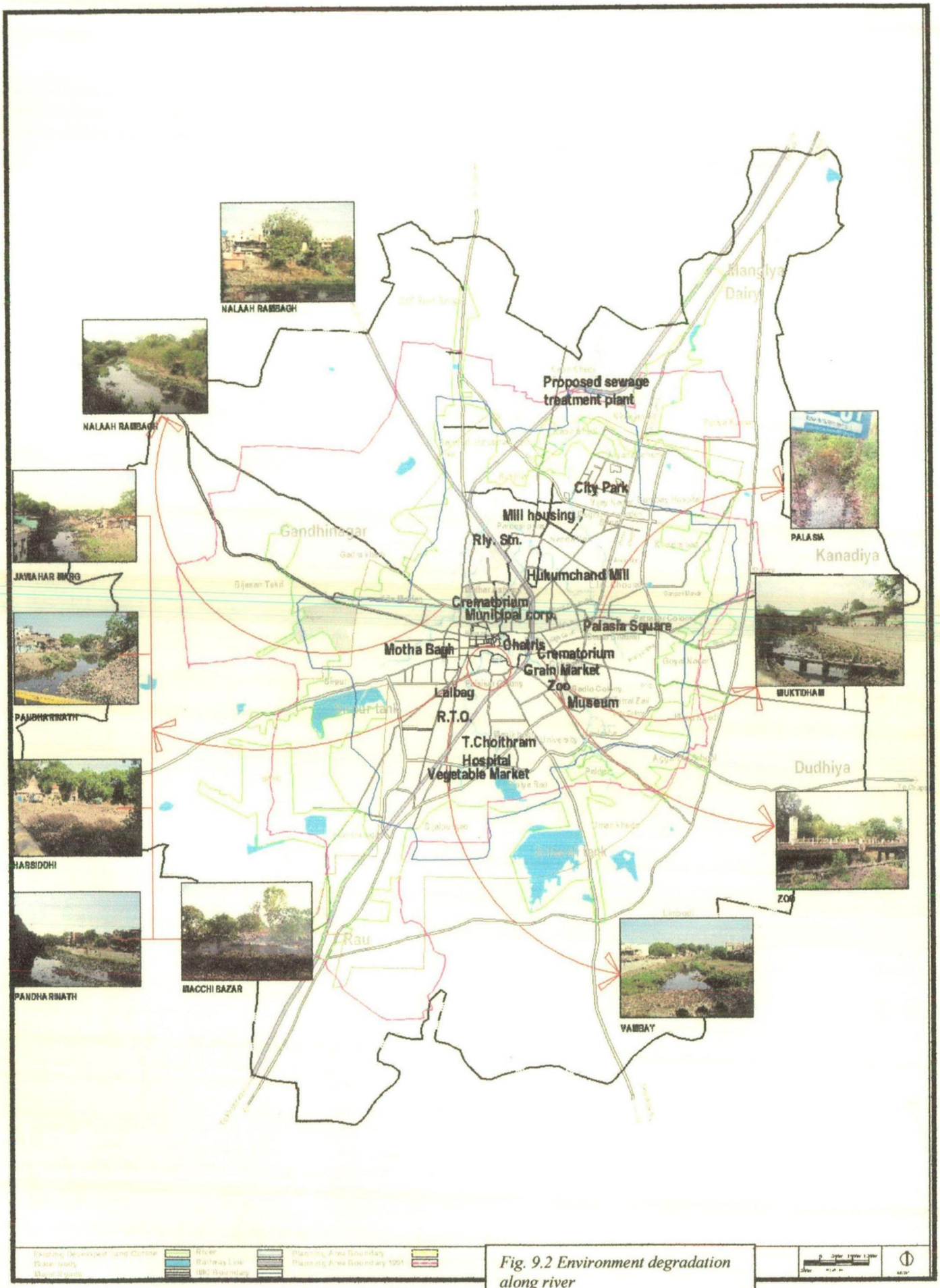


Fig. 9.2 Environment degradation along river

- *Wastage of water*

A lot of water is wasted at public water taps just because of the habits of the people. Sometimes the taps are kept open without use. Water used for vegetable, and washing in kitchen can be used for gardening but, it is directly drained. Only fresh water is used for cleaning floors, utensils and vehicles and washing cloths.

The equipments used in the house are also responsible for wastage of water. For example use of continuous flushing system of flushes of greater capacities in toilets, or greater diameter of domestic pipes, use of showers, ill design of toilet sill, low pressure taps in kitchen, etc. are more responsible for wastage of water.

- *Insufficient water for industrial development*

The rate of industrial development is reduced just because of acute water scarcity in the system, which result into less development in the system.

9.2 Recommendations

Investigator gives following recommendations based on these findings.

9.2.1 Assessing the existing water resources

Sustainable planning deals with full and judicious use of the locally available resources. The water sources within the city are rainfall, ground water, River Khan and Saraswati (after regeneration) and reservoirs and ponds. Repair and maintenance of tanks and reservoirs should be given utmost attention.

9.2.2 River regeneration

River is no more functions as Nallah since it is converted to Nallah. The Investigator noted the major activities functioning along this belt. Many spots along the river are important; some of them are needed to be preserved. Some patches of river need immediate attention. Indore Municipal Corporation must take utmost attention for prevention of direct disposal of solid waste into river. River can be regenerated by following measures:

1. Removal of garbage by cranes
2. Provision of 900 mm diameter pipeline for connecting all the disposal points of sewer line all along the river.

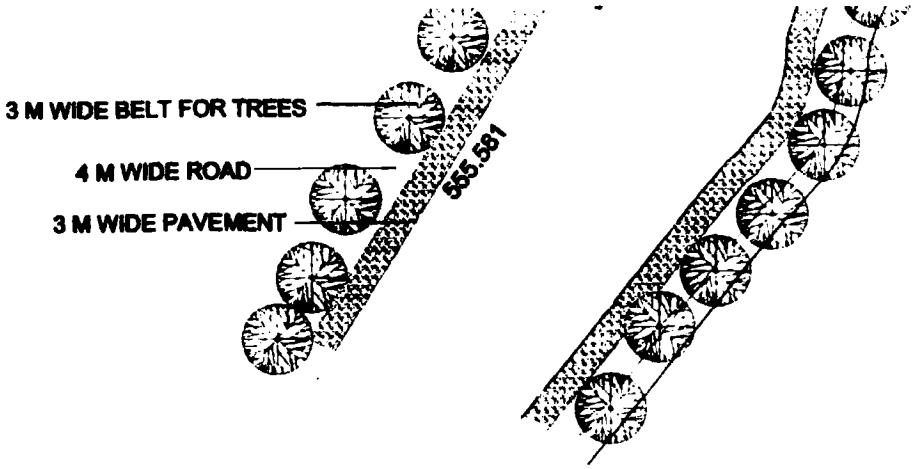


Fig. 9.4A typical plan for River Regeneration

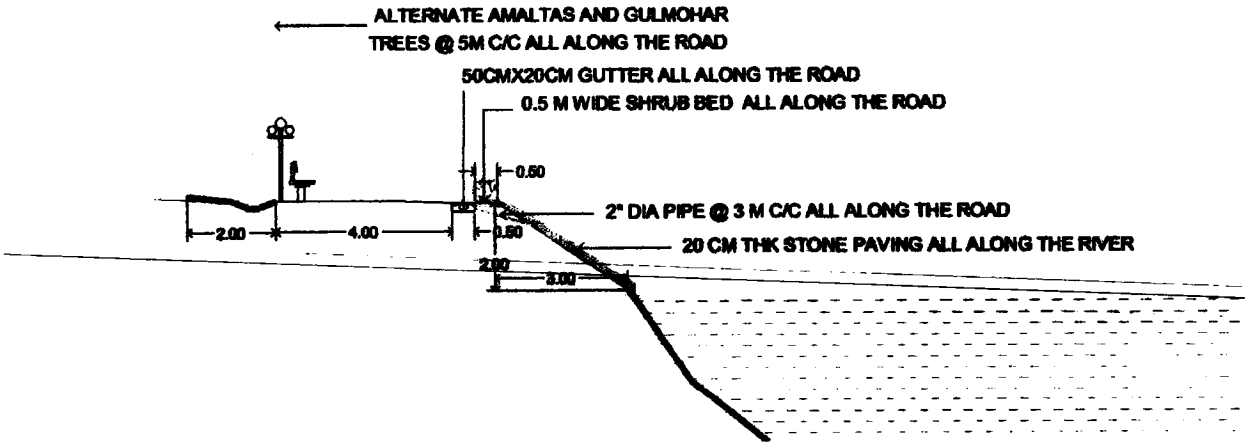


Fig. 9.5 Detailed Cross section for River Regeneration

River regeneration will completely change the environment of its surroundings. A graphical presentation of this recommendation is given in Figure 9.6. This is a site near Lal Bag palace. The two pictures present in the existing situation and recommended one. As there is a lack of open spaces in Indore, river stretch can provide excellent place for recreation and even a place for public gatherings. There is a problem of traffic congestion during marriage season on roads. The river bank, and the developed site alongwith it can even house the marriage and birthday party like celebration also. The care taken after introduction of these activities is the prevention of river from wastes from parties. Even people's habits can also be changed by providing sufficient infrastructure, like immobile dustbins, etc.

Existing

Proposed

Fig. 9.6 Existing Situation and a recommendation for a site near Lal Bagh

Activities like fishing and picnic spots will generate revenue for maintenance and development of river.

9.2.2 Attempts at household level

1. Building Services- Dwelling is the smallest built up unit in the city. Water for drinking, kitchen use and toilets and bathrooms can be processed as household level, by providing separate pipes for each. Waste water from bathrooms and wash area consists of soap water; this can be supplied in toilet flush. The water from oil and grease traps of kitchen can be directly disposed to main sewer line, as at needs expensive treatment. Water used for cleaning vegetables, can be reused for watering gardens.

Other option is, to provide two separate pipe system for soiled and soap water. Soiled water is rich in nutrients for watering the plants after some treatment. Whereas the treated soap water can be reused for washing floors, vehicles and roads (occasionally). Drinking water supply system is dependent over Narmada water, and after introduction of sewage treatment plant one other pipeline can be provided for use of treated water.

2. Use of water saving appliances- Water saving appliances, like toilet flush with low lead, and pressure cleaning, pressure cleaning taps for kitchens, washing machines can be used, to save water.

3. Rain Water Harvesting- This must be made compulsory for each and every dwelling unit.

1. Restoration and Conservation of heritage sites along river- Urban designers should be employed to regenerate the old character of heritage sites. The following sites need utmost attention
    - Pandharinath temple and Harsiddhi temple complex
    - Chatripura
    - Krishnapura
    - Rambhagh and Narayanbagh
    - Hanuman Mandir and Zoo
    - Rare side of Lal Bag Palace

These sites have been marked in figure 9.1. Some recommendations are presented graphically in Figure 9.7 and Figure 9.8 shows the existing condition of Ghat of Hanuman Mandir and the recommended development of river bed near the same.

Existing **Proposed**

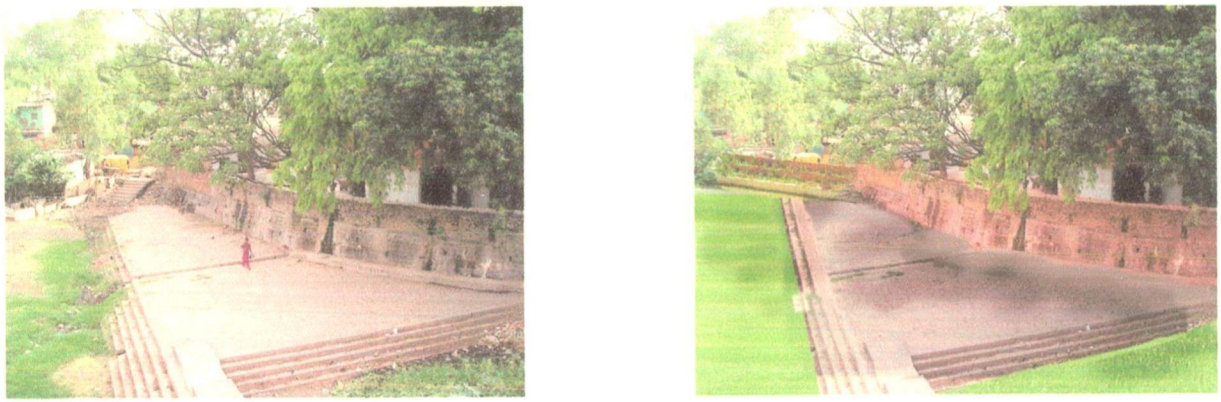


Fig. 9.7 Existing Situation and a recommendation for Ghats of Hanuman Mandir

]

Existing

Proposed

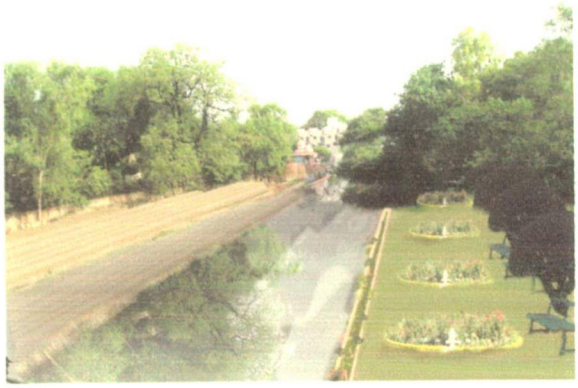


Fig. 9.8 Existing Situation and a recommendation for a river stretch near Hanuman Mandir

9.2.3 Physical parameters and infrastructure

1. The size of city is expanding, without any norms for open spaces. The norms for built and open spaces should be regularized at neighborhood level.
2. The roads should be designed with due consideration for vegetation and rain water drainage and incorporate the ground water recharging.
3. Norms for rain water harvesting in housing must be made compulsory.
4. Due consideration should be given to the maintenance of places of community water tap.
5. High quality materials may be used for construction of sewage lines so that it can be as durable as much possible and in turn the leakage (contamination of ground water) and maintenance problems can be minimized.

9.2.4 Social parameters

1. Norms for family planning should be made strict to control the population growth.
2. Public meetings and awareness campaign should be launched for thoughtful use of resources.
3. Care for environment and ecology should be made part of education at school level.
4. Public participation in planning, not only in economic terms but also for their opinion and suggestions should be encouraged.

9.2.5 Economic parameters

1. Water tariff must be increased to meet with the recovery of expenditure made for water supply project.
2. Norms for fine for not filling the water bill should be made strict.
3. Fine must be imposed for illegal connection of water.
4. Ground water extraction norms must be established

9.2.6 Environmental parameters

1. Norms should be made for treatment of sewage and garbage before disposing into the river.
2. Establishment of Sewage treatment plants should be made standardized and compulsory.
3. Awareness program may be conducted need based in the system to protect the environment.

9.3 Conclusion

Cities are engines of economic growth, but economic development must be supported by a healthy and peaceful living environment. The study revealed that Indian cities have been suffering from environmental problems and lack of infrastructure. Cities function like a whole system, and such kind of problems affect the functioning of whole system and thus the economy. India is rich in natural resources, it has rich cultural heritage of architecture and civilization. Hinduism, Jainism, Buddhism, guide humanity to safeguard the natural environment. These all factors, i.e. culture, civilization and natural heritage, together make a healthy and comfortable living environment. This era demands attention towards protection of nature and environment. Man has disturbed the natural ecosystem while developing the system, but this development will no longer be sustainable without protection of nature. It is said that third world war will happen because of scarcity of water. Scarcity of water has attracted the attention of planners to work upon its sustainability.

Investigator had chosen Indore City for this investigation since this city has numerous amount of problems associated with water supply. The Investigation aimed at evolving plausible plan for drinking water supply system in the study area. Having this aim, required amount of data were collected, analysis thoroughly, population projection were made and the requirement of water for domestic use was calculated for the year 2031. System dynamics Theory has been employed to project the population in the system for the year 2031. The study concluded with a set of recommendations for achieving sustainable drinking water supply system in the system – Indore City.

References

1. Lumberton G. "Sustainable Sufficiency- An Internally Consistent Version of Sustainability" Sustainable Development Feb 2005. vol. 13 number 3, pp.53-68
2. Rees William E. "Ecological Footprints and appropriated carrying capacity: what urban economics leaves out" Environment and Urbanization, vol. 4, No.2, Oct 1992, pp. 121-129
3. Byrne, J. etal. (1985), 'The post industrial imperative: energy, cities and the featureless plain' In Byrne, J. and Daniel Rich (editors), Energy and Cities, Energy Policy studies, Vol. 2 Transaction, New Brunswick
4. Byrne John, Young-Doo Wang, Bo Shen and Xiuguo Li. "*Sustainable urban development strategies for china*" Environment and Urbanization, vol. 6, No.1, April 1994, pp. 174-187
5. Patara Shrashtan "Shelter andsustainable development" Development alternatives Jan1993 p.17
6. Rees William E. and Westra L. "Cities, communities and environmental justice"
8. CIA: the world factbook
9. Environment and urbanization vol. 4 No. 2 oct 1992
10. McMichael 1993
11. Hopwood B.,Mellor M., O'Brien G. "*Sustainable Development: Mapping different approaches* , Sustainable development 13 , 2005 April 1992, p. 39
12. Mitlin Diana "*Sustainable Development: a guide to literature*" Environment and Urbanization, vol. 4, No.1, April 1992, pp. 112-123
13. Ludwig Harvey F. "Moving toward Economic-cum-Environmental Sustainability in Asian Developing Countries", The Environmentalist, vol.10 Number 4 (1990), p. 258
14. Smit Jac and Joe Nasr "Urban agriculture for sustainable cities: using wastes and water bodies as resources" Environment & Urbanization Oct. 1992 vol. 4, No. 2. pp. 141-151
15. Heimlich, Ralph E. (1989), Land Use Transition in Urbanizing Areas, proceeding of workshop, ERS/USDSA, Washington DC
16. Lunven Paul (1992) presentation at Urban nutrition conference, Mexico City
17. Dublin Statement. A/Conf.151/PC/112, annex, Principle No.1.

Bibliography

Collected literature

7. Jouhari V.P. "*Sustainable Development of Water Resources*". A Mittal Publication, New Delhi
8. Nath V. "*Urbanization in India: Review and Prospects*" Economic and Political Weakly 21(8), 22 feb 1986: pp 339-52
9. Farrell Alex and Maureen Hart. "*What does sustainability really mean? The search for Useful Indicators*" Environment Nov.1998 Volume 40 Number 9. pp. 5-9
10. Jordon Sara and Wagner Fritz "*Meeting women's needs and priorities for water and sanitation in cities*" Environment & Urbanization Oct. 1993 vol. 5, No. 2. pp. 135-143
11. Haughton Graham and Hunter Colin "*Sustainable Cities*" Cromwell Press :Ltd Meiksham, Wiltshire Great Britain

12.. Arvind S.S. and E.V. Muley "*Labellingecofriendly products in India- an emergingoption for environmental production*" The Environmentalist. 1995 vol. 15, pp.115-121
13. Reddy S. Devendar "*Need for community involvement in plan preparation: The AUPSP Experience*" ITPI Journal 2004 1:1 pp. 39-44
14. Gerald L. Young "Environment: term and concept in the social sciences" Social scienceInformation 1986. vol. 25 pp. 83-124
15. Abaza Hussein, Andrea Baranzini "*Implementing Sustainable Development*" 2002 Published by Edward Elgar Publishing Limited, Glensanda House, Montpellier Parade, Cheltenhan UK
16. Afolabia A. Adedibu and A.A. Okekunle "Issues in the Environmental
17. Smit Jac and Joe Nasr "Urban agriculture for sustainable cities: using wastes and water bodies as resources" Environment & Urbanization Oct. 1992 vol. 4, No. 2. pp. 141-151
18. Editorial "*Sustainable Cities*" Environment & Urbanization Oct. 1992 vol. 4, No. 2. pp. 3-8
19. Parkinson Jonathan and Tayler Kevin "*Decentralized wastewater management in peri-urban areas in low-income countries*" Environment & Urbanization. Apr. 2003 vol. 15, No. 1. pp. 75-89
20. Patara Shrashtant "*Operationalising the concept of sustainability*" Development Alternatives Sep 2004 pp. 2-5
21. Singh Amrita "*Human Security and Sustainable Livelihoods*" Development Alternatives Dec 2004 pp. 6-7
22. Anand Kumar "*Role of Remote Sensing and GIS in Sustainable Development*" Development Alternatives Dec 2004 pp. 9-11
23. Dragun Andrew K. and Jakobsson Kristin M. "*Sustainability and Global Environmental Policy*" 1997 Edward Elgar Publishing Limited, 8 Lansdown Place, Cheltenham, UK
24. Projects "*Water Reuse Plant Adds High-Rate Clarification to Process*" Water Environment & Technology. April 1992 pp. 11-16
25. Law & Government section "EPA Guidelines Developed for Water Reuse". Water Environment & Technology. Aug 1992 pp. 19-22
26. Randall C. Osburn, Carl E. Burkhead. "Irrigating Vegetables with Reclaimed Wastewater" Water Environment & Technology. April 1992 pp. 38-43
27. Lejano Raul P., Grant Frank A., Thomas G., Richardson Bradley M. Smith, Farshid Farhang "*Assessing the Benefits of Water Reuse*". Water Environment & Technology June 1992. 44-50
28. Rogalla Frank, Paillard Herve, Blondeau Francois, Sibony Jacquues, Lamure Dominique "Washing Wastewater the Wise Way" pp. 55-57
29. Loomis John B. "Environmental Valuation Techniques in Water Resource Decision Making". Journal of water resources planning and management. Nov. Dec. 2000 .pp.339-344
30. Hoehn John P. and Douglas J. Krieger. "Economic Analysis of Water Service Investments and Tariffs in Cairo, Egypt" Journal of water resources planning and management. Nov. Dec. 2000 .pp.345-350
31. Gordon Ekateria, Uri Shamir, Fellow, ASCE, and Jacob Bensabat "Optimal extraction of water from regional aquifer under salinization" Journal of water resources planning and management. Mar-Apr. 2001 .pp.78-88
32. Mistry J.F. and Purohit M.U. "*Environmental Considerations in Planning of Water Resources Projects*" Bhagirath 1985-86 Vo. 32-33 pp. 96-99

33. Anuradha T.N., "*Fresh Water Year 2003*" Development Alternatives June 2004 pp.6-14
34. Alfredo Stein "*Participation and sustainability in social projects: the experience of the local development programme (PRODEL) in Nicaragua*" Environment & Urbanization Apr. 2001 vol. 13, No. 1. pp. 11-35
35. Vitanen P. "Community-*based natural resource management in Mozambique: A critical review of the concept's applicability at local level*" Sustainable Development Feb 2005. vol. 13 number 3, pp.1-12
36. Hernandez M.G. and Martin-cejas R.R. "*Incentives towards sustainable development (Case study of Bulgaria)*" Sustainable Development Feb 2005. vol. 13 number 3, pp.13-24
37. Lamberton G.. "Sustainable Sufficiency- An Internally Consistent Version of Sustainability" Sustainable Development Feb 2005. vol. 13 number 3, pp.53-68
38. Barbara Ward. "A sustainable planet" Environment and Urbanization, vol. 4, No.1, April 1992, pp. 99-109
39. Mitlin Diana "*Sustainable Development: a guide to literature*" Environment and Urbanization, vol. 4, No.1, April 1992, pp. 112-123
40. Furedy Cristine "*Garbage: exploring non-conventional options in Asian cities*" Environment and Urbanization, vol. 4, No.1, April 1992, pp. 43-61
41. Rabinovitch Jonas "*Curitiba: towards sustainable urban development*" Environment and Urbanization, vol. 4, No.2, Oct 1992, pp. 63-73
42. Margarita Pa"Recycling in Bogota": Environment and Urbanization, vol. 4, No.2, Oct 1992, pp. 75-79
43. Rees William E. "Ecological Footprints and appropriated carrying capacity: what urban economics leaves out" Environment and Urbanization, vol. 4, No.2, Oct 1992, pp. 121-129
44. Byrne John, Young-Doo Wang, Bo Shen and Xiuguo Li. "*Sustainable urban development strategies for china*" Environment and Urbanization, vol. 6, No.1, April 1994, pp. 174-187
45. Dr. C. S. Sharma, 8-10 June, 1999, Section-1-Opening and Keynote Addresses, Paper presented at International Symposium on Efficient Water Use in Urban Areas, Water Use Efficiency- India scenario.

Books and Reports

1. Eugene P. Odum, 1975 *Ecology* Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi
2. Cloud, Preston, ed. 1969. Resources and Man, San Francisco: W. H. Freeman
3. Julan Aggeman, Robert D Bullard and Bob Evans. "*Just sustainabilities*": Development in an unequal world, Earthscan Publications Ltd. London
4. "*Environmentally sustainable buildings*" Organization for economic cooperation and development

- Academy for Mountain Environs "*Urban environment workbook*":, Dehradun Consultant Engineering Services, Delhi *"Comprehensive traffic and transportation studies".*
- Vastu Shilpa Foundation ,Sangath, Ahmedabad. "*Improvement scheme on city core*" ,
- *Master plan* 1971 for Indore city
- *Master plan* 1991 for Indore city
- *Master plan* Master plan 2001

- Patrick Geddes "Town Planning towards city development. A report to The Darbar of Indore" 1918 (library of Indore Development Authority)
- A report on Narmada project : by PHE department of Indore Municipal Corporation

Websites

http://www.rrcap.unep.org/reports/soe/sa_part2_4.pdf as viewed on July 2, 2005.
: http://www.indiaurbaninfo.com/niua/table/table1.htm as viewed on July 4, 2005.
, Planning Commission Government of India, URL: http://www.planningcommission.nic.in/reports/genrep/wtrsani.pdf as viewed on June 27, 2005.
: http://www.rainwaterharvesting.org/Crisis/Urbanwater-scenario.htm as viewed on June 20, 2005.
Increasing demand and inequities in water supply URL: http://www.teriin.org/division/padiv/wrpm/docs/ft02.pdf as viewed on July 4, 2005.
: http://www.ecoworld.org/Home/Articles2.cfm?TID=332 as viewed on June 22, 2005.
http://www.teriin.org/division/padiv/wrpm/docs/ft02.pdf as viewed on July 4, 2005.
http://www.planningcommission.nic.in/reports/genrep/wtrsani.pdf as viewed on June 27, 2005.
http://www.rainwaterharvesting.org/Crisis/Urbanwater-scenario.htm as viewed on June 20, 2005.
http://planningcommission.nic.in/plans/planrel/fiveyr/10th/volume2/v2_ch6_2.pdf as viewed on June 28, 2005.
http://www.deccanherald.com/deccanherald/july062004/spt1.asp as viewed on July 6, 2005.
http://lnweb18.worldbank.org/mna/mena.nsf/0/6C586003928975DE85256949006FC441?OpenDocument as viewed on June 22, 2005.
: http://yap.nic.in/yamuna-in-delhi.asp as viewed on June 22, 2005.
http://www.indiatogether.org/2003/oct/gov-muniwater.htm as viewed on June, 23, 2005.
http://www.silsoe.cranfield.ac.uk/iwe/projects/cmf/hyderabad.pdf as viewed on June 28, 2005.
: http://nird.org.in/clic/aus_gov.html as viewed on June 28, 2005.
http://web.mit.edu/urbanupgrading/waterandsanitation/resources/pdf-files/WaterTariff-2.pdf as viewed on July 6, 200.
http://www.indiatogether.org/2003/oct/gov-muniwater.htm as viewed on June, 23, 2005.
: http://www.cepis.ops-oms.org/muwww/fulltext/repind48/principles/principles.html as viewed on June 29, 2005.
: http://www.wbdg.org/design/water_conservation.php?print=1 as viewed on June 29, 2005.
http://www.epa.gov/owm/water-efficiency/ as viewed on June 20, 2005.
: http://www.epa.gov/owm/water-efficiency/princweb.htm as viewed on June 22, 2005.
http://planningcommission.nic.in/plans/annualplan/1999-00/ap9920ch6c.htm as viewed on June 22, 2005.

Annexure I: Survey Schedule

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE
(Formerly University of Roorkee)
DEPARTMENT OF ARCHITECTURE AND PLANNING
ROORKEE -247667, (UTTARANCHAL).

Survey Schedule for M.U.R.P. Thesis "Planning for sustainable water supply in Indore City"

1. Demographic Characteristics

i. Name of the head of the household
ii. Address
iii. Religion
iv. Caste
v. Mother Tongue

Table I

S. No.	Relation with the household	Gender	Age	Income	Education (tick)				Occupation	
					Primary	secondary	Graduate		Primary	Secondary
							Tech.	Non-tech		

2. Physical Characteristics

i. Housing
ii. Type of House (Tick): Detached/ semidetached/ Apartment/ Row Housing
iii. Year of construction:.....
iv. Ownership (Tick): Rented /Owned / Other
v. Monthly Rent (if not owner).....
vi. Area of Plot (sq. ft).....
vii. Covered area (sq. ft).....
viii. Open area (sq. ft).....

Table II

Services

1. Water supply

S. No.	Source	Time of Supply	Distance
1	Narmada		
2	Yashwant Sagar		
3	Tube well/ Bore well		
4	Community water tap		
5	Hand pump		
6	Municipality		
Remarks			

- Capacity of Collection tank
- Capacity of overhead tank
- Total Quantity
- Quality of water

Good Fair Bad

- Tariff per month
- Provision of rain water harvesting (tick)

Yes No

- Cost of installing this is about Rs. 2000/- to Rs. 4000/- .Do you accept to have it

Yes No

- If the sewage water is treated and taken in use of vegetable farming an landscaping, , are you in favor of this?

Yes No

- If water is harvested at community level then will you participate in this?

Yes No

Drainage/ Sewerage

- Availability Of: Septic Tank/ Soak Pitl Sewer/ No Facility.
- Drains: Open/ Coveredl No Drains.
- Problems: Overflow I Cloggingl Bad Odourl No Problem.
- Over Flow Of Drains During Rainy Seasons (Yes/ No)

Waste disposal:

- Method of collection at house:

a). Storage container b) dustbin/ PVCbag
c) Frequency of collection fromthe area:
Everyday Alternate days 3 days

4 days weekly

- Agency for collection:

a) Nagar Nigam b) Private Agency c) NGO
c) burning d) throwing out

Environmental characteristics:

- Water Quality: Very Good / Good Moderate/ Poor
- Air Quality: Very Good / Good/ Moderate/Poor
- Land Quality: Very Good / Goodl Moderate/ Poor .
- Noise Pollution: Very High I High/ Moderate/ Low
- Quality of living: Excellent / Good I Bad

Remarks