No.

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
NATIONAL RIVER CONSERVATION DIRECTORATE (NRCD)
MINISTRY OF ENVIRONMENT AND FORESTS

THE STUDY
ON
WATER QUALITY MANAGEMENT PLAN
FOR
GANGA RIVER
IN
THE REPUBLIC OF INDIA

FINAL REPORT

VOLUME I SUMMARY

JULY 2005

TOKYO ENGINEERING CONSULTANTS CO., LTD.
CTI ENGINEERING INTERNATIONAL CO., LTD.

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Foreign Exchange Rate:

Master Plan
US$ 1 = JPY 109.09
US$ 1 = Rs 45.33
(As of March 2004)

Feasibility Study
US$ 1 = JPY 103.66
US$ 1 = Rs 43.70
(As of February 2005)

PREFACE

In response to the request from the Government of Republic of India, the Government of Japan decided to conduct “The Study on Water Quality Management Plan for Ganga River in the Republic of India” and entrusted to the study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Mr. Kazufumi Momose of Tokyo Engineering Consultants Co., LTD. and consisted by experts from Tokyo Engineering Consultants Co., LTD. and CTI Engineering Consultants Co., LTD. between February, 2003 and March, 2005.

The team held discussions with the officials concerned of the Government of Republic of India and conducted field surveys at the study area. Upon returning to Japan, the team conducted further studies and prepared this final report.

I hope that this report will contribute to the promotion of this project and to the enhancement of friendly relationship between two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of Republic of India for their close cooperation extended to the study.

July, 2005

Etsuo KITAHARA
Vice President
Japan International Cooperation Agency

Mr. Etsuo Kitahara
Vice President
Japan International Cooperation Agency

July, 2005

LETTER OF TRANSMITTAL

Dear Sir,

We are pleased to submit you the final report entitled “THE STUDY ON WATER QUALITY MANAGEMENT PLAN FOR GANGA RIVER IN THE REPUBLIC OF INDIA”. This report has been prepared by the Study Team in accordance with the contracts signed on 21 February 2003, between Japan International Cooperation Agency and Tokyo Engineering Consultants Co., Ltd. and CTI Engineering Consultants Co., Ltd.

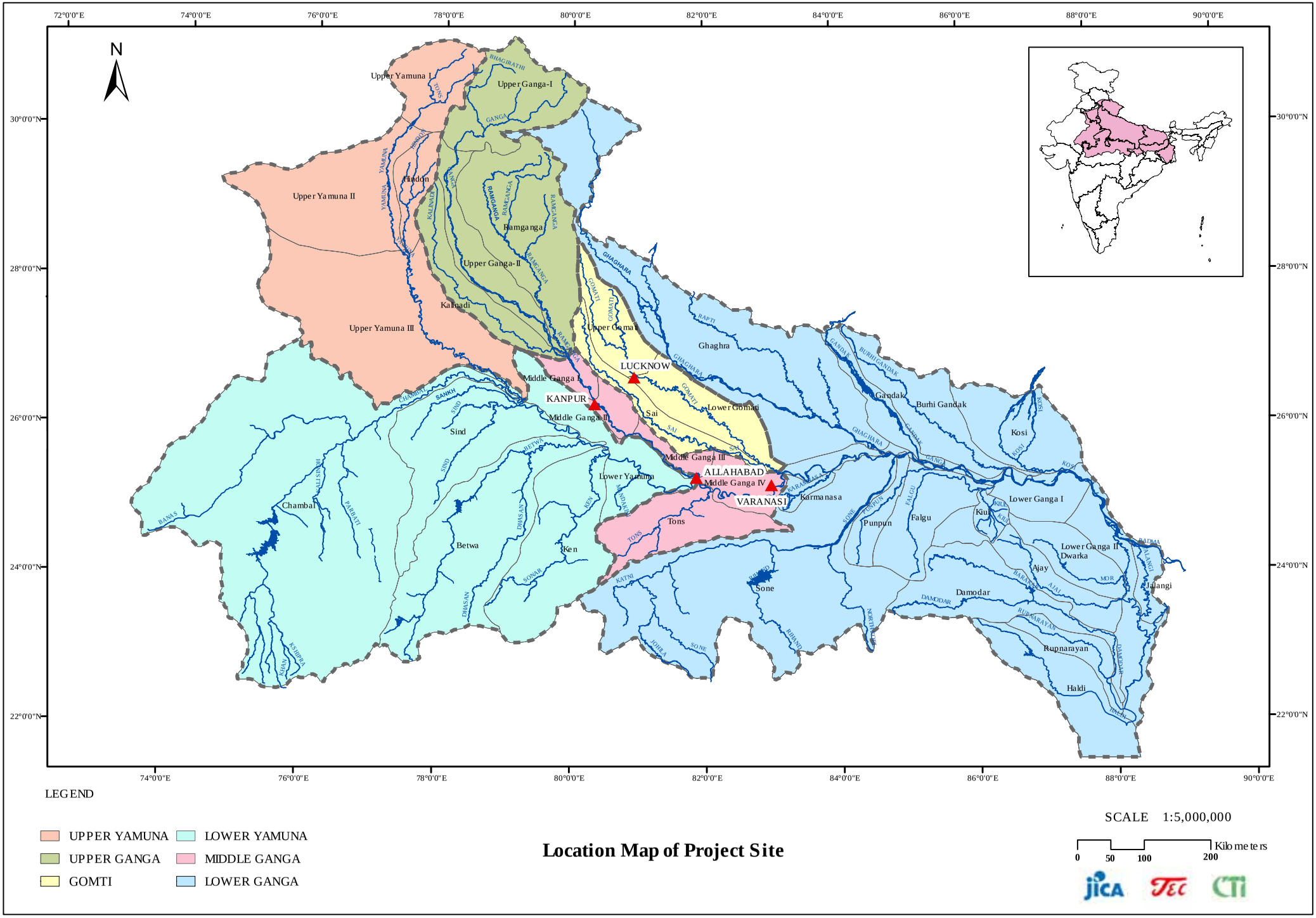
The report examines the existing conditions concerning water quality of Ganga River and sewerage system in four cities, i.e., Lucknow, Kanpur, Allahabad and Varanasi, and presents feasibility study on a priority project selected from the master plan.

This study aimed to improve the water quality of Ganga River and to formulate the plan for pollution reduction mainly concerned with sewerage system in the four cities. We are sure that the recommendations made in the report contribute to improving water quality of the Ganga River.

All the members of the Study Team wish to acknowledge gratefully to the personnel of your Agency, Advisory Committee, Ministry of Foreign Affairs, Ministry of Land, Infrastructure and Transportation, Ministry of Environment, Embassy of Japan in the Republic of India, JICA India Office, and also to the officials and individuals of the Government of Republic of India for their assistance extended to the study team.

Yours faithfully,

Kazufumi MOMOSE
Team Leader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Location Map of Project Site
SCALE 1:5,000,000
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OUTLINE OF THE STUDY RESULTS

1. BACKGROUND AND OBJECTIVES

Ganga basin, the largest river basin in the Republic of India, is supporting nearly 40 percent of the country's population. River Ganga and its tributaries, besides being a source of water supply and irrigation, are also regarded as sacred rivers and extensively used for bathing by millions of people.

In as early as 1980's, population explosion led to the deterioration in water quality of the river, which had negative impacts on human environment. In that scenario, Ganga Action Plan (GAP) was initiated by the Government of India and a national body, now National River Conservation Directorate (NRCD), was established in the Ministry of Environment and Forests. Under its initiatives, large-scale sewerage schemes in the major cities in the Ganga basin have been implemented and the water quality has improved to some degree.

As a further step to achieve the objectives of the GAP, the Government of India planned the study on Water Quality Management Plan for Ganga River Basin. The purpose of the study was to first analyse water quality deterioration mechanism in the rivers more broadly and technically and, based on the mechanism, to formulate measures that were required to control river water pollution not only in the immediate future but also for long term, i.e., up to 2030.

In response to a request from the Government of India, the Government of Japan has collaborated with Government of India on this important programme by providing assistance through the Japan International Cooperation Agency (JICA) for taking up the Development Study (the Study) relating to 'Water Quality Management Plan for Ganga River Basin'.

The Study has focused on formulation of the Water Quality Management Master Plan (M/P) for the four large and important cities namely, Kanpur, Allahabad, Varanasi and Lucknow (the four cities) with the following objectives:

- To formulate the M/P for the four cities for water quality management of Ganga river targeting the year 2030
- To conduct the Feasibility Study (F/S) for the priority projects identified under the M/P
- Technology Transfer in the course of the study

Of the selected towns, Lucknow is the capital of Uttar Pradesh State and has a population of around 2.4 million. The city is located along the bank of the river Gomti, one of the major tributaries of Ganga.

The town of Kanpur, situated on the bank of Ganga, is the biggest city of Uttar Pradesh having a population of 2.9 million and is an important centre of commercial and industrial activities.

Allahabad, with a population of 1.2 million, is one of the most sacred cities of Hinduism. It is located at the confluence of two of the India's holiest rivers, the Ganga and the Yamuna, called Sangam, which is the venue of many sacred fairs and rituals, and attracts several hundred thousands of pilgrims throughout the year. This number swells to millions during the Kumbh Mela and the Ardh Kumbh Mela that are celebrated alternatively once every six years for duration of about one and a half months.

Varanasi, having a population of 1.3 million and also situated on the bank of river Ganga, is one of the oldest towns in the world and the ultimate pilgrimage for Hindus. The river is a part of everyday life in the town and thousands of people bathe daily in the river along the famous seven kilometres stretch of ancient ghats of the town.

2. RIVER WATER POLLUTION CONTROL PLAN

It has been observed that water quality in the upper stretch of Ganga river is generally good because less pollution load is being discharged into it. The condition, however, worsens in the middle stretch (from Kanpur to Varanasi) because a large quantity of water is withdrawn for irrigation and domestic purposes thereby decreasing the dilution or self-purification effect of river water. Furthermore, a large quantity of untreated wastewater is discharged into the rivers from the cities located along river Ganga and its tributaries and hence the section of Ganga from Kanpur to Varanasi and the downstream section of Gomti from Lucknow are excessively polluted.

The Study results reveal that, to meet the water quality standard for bathing class, untreated domestic wastewater effluent in the project should be reduced by about 90 %. This means that almost all the domestic wastewater should be treated before being discharged into the river or utilised for irrigation purposes after treatment. Simultaneously, in order to maintain the water quality along the stretches of the Ganga, Yamuna and Gomti rivers, it is essential to reduce the future domestic pollution load generated and discharged from the major cities located upstream of the four cities by 70 to 80 %.

3. MASTER PLAN

(1) Proposed Plans

The main reasons for deterioration of river water quality are point sources in the form of discharge of untreated wastewater from the urban cities/towns located along the riverbanks and untreated industrial effluents. Other sources are in river activities like washing of cloths, cattle wallowing, etc., and surface runoff carrying pollution load from open defecation, solid waste dumping, etc. along the banks of the storm water drains or along the river banks. These pollution sources are known as non-point sources.

The discharge of point pollution load is a main reason for deterioration of the river water quality, while the pollution contribution from in-river activities such as washing of clothes and other non-point sources is rather insignificant. However, the latter directly and indirectly influence the hygienic condition and aesthetics of the river front, especially along the bathing stretches.

The following schemes/programmes to tackle the pollution from urban areas have been identified in the Master Plan (M/P) and interventions are proposed to ameliorate the river water quality.

Sewerage Schemes

To arrest the discharge of untreated wastewater to the river, intermediate/long term plans, including immediate measures have been proposed in the Sewerage M/P. The immediate measures (Stage 1) include provision of interceptor sewers and pumping stations to tap storm water drains (nalas) and sewer outfalls flowing into the river and augmentation of the capacity of sewage treatment plants (STPs). The intermediate/long term approach (Stage 2) includes development of the internal sewerage system in the towns, re-connection of secondary sewers to trunk sewers and provision of new trunk sewers and sewerage and sewage treatment facilities for developed and developing areas. The immediate measures have been planned to be integrated with the long-term plan.

Various alternatives of the sewerage system comprising zoning options, treatment options, location of facilities, etc. have been evaluated and compared to select the most appropriate alternative for a particular town. Factors such as reliability, compatibility, feasibility and impact on downstream users are also considered while comparing the various options. The treatment technology for each location has been chosen based on the life cycle cost comparison (including capital, land and capitalized O&M costs) of the various feasible options and availability of land. Treatment technologies such as waste stabilisation ponds (WSP), aerated lagoons (AL), up-flow anaerobic sludge blanket (UASB) with adequate post treatment, activated sludge (AS) and fluidised aerobic bio-reactor (FAB), etc, have been considered for comparison purposes.

The proposed treatment process is mainly either WSP where enough land is available or UASB plus post treatment (Aerated Lagoons) where enough land is not available. These processes have been proposed to meet the prevailing conditions of the Study area like insufficient power supply and unavailability of trained operation and maintenance staff.

Non-Sewerage Scheme

Other sources of river water pollution and deterioration in hygienic conditions in the cities are open defecation and urination, which are rampant in the cities, especially in slum communities and banks of the rivers and storm water drains, and cloth washing activities at the bank of the rivers.

Besides sewerage components, non-sewerage schemes hava been planned to prevent open defecation and urination and to shift washer men (dhobis) who wash clothes in the river to inland area. In the scheme, community toilet complexes and constructed dhobi ghats (commercial washing or laundry places) have been proposed. The planning for non-sewerage schemes is based on demand-based approach rather than on supply-based approach to reflect user's needs with respect to site selection, design, size etc.

Social Consideration and Hygiene Education Plan

For the success of the sewerage and non-sewerage projects, understanding, cooperation and participation are essential from every stakeholder. Social consideration and hygiene education plan with the following planning concepts has been prepared to acquire these understandings, cooperation and participation from the various stakeholders on the proposed projects. In the plan, public participation and awareness (PP/PA) programme has been proposed to achieve this purpose.

Main Awareness to be heightened	Core Themes
• To heighten public awareness on consciousness/notion on health & Sanitation	Personal Health and Sanitation (personal issues)
• To heighten mutual understanding between communities and authorities concerned.	Community Issues and Public Participation
• To heighten recognition of burden sharing for operation and maintenance.	Cost sharing and Willingness to Pay (Urban Issues)
• To heighten public awareness on urban river environment	Environmentally Friendly Urban River

Institutional Development Programme

One of the areas of serious concern is sustainable operation and maintenance (O&M) of the facilities to be installed under the project. Currently many agencies (UP Jal Nigam, Jal Sansthans, Nagar Nigams (Municipal Corporations), Development Authorities etc.) are engaged in sewerage works with little coordination. So far no organisation is willing to take over the O&M due to inadequate financial and technical capacity, although legally the responsibility of O&M rests with urban local bodies, i.e., in the study area, the Municipal Corporations.

Institutional Development Programme (IDP) has been prepared for sustainable and proper O&M of the facilities as a prerequisite for the implementation of the project. The programme consists of institutional development, capacity building and financial strengthening of the local municipal bodies. Under the programme, a unified single agency responsible for sewerage will be set up.

(2) Sewerage Projects and Cost Estimation

The project outline of the M/P for each city including planning framework, treatment capacity and

preliminary cost estimation up to 2030 is summarised in the following tables.

Project Outline of Sewerage Master Plan

Item	Unit	Year		
		2003	2015	2030
1) Lucknow				
Total population		2,463,474	3,605,587	5,424,689
Population in sewer service area		325,530	2,732,594	5,424,689
Population connected to sewer		243,930	1,223,079	4,080,732
Percentage of total population		10%	34%	75%
Total wastewater generated	mld	367	537	841
Amount intercepted	mld	42	519	841
Treatment capacity	mld	42	511	855
2) Kanpur				
Total population		2,819,827	4,342,031	5,629,081
Population in sewer service area		1,848,335	2,983,898	5,629,081
Population connected to sewer		677,264	1,686,470	4,210,800
Percentage of total population		24%	39%	75%
Total wastewater generated	mld	395	630	873
Amount intercepted	mld	259	433	873
Treatment capacity	mld	171	550	890
3) Allahabad				
Total population		1,101,205	1,490,427	2,076,570
Population in sewer service area		308,304	596,170	1,661,300
Population connected to sewer		200,494	454,885	1,530,827
Percentage of total population		18%	31%	74%
Total wastewater generated	mld	226	261	322
Amount intercepted	mld	60	226	322
Treatment capacity	mld	60	249	340
4) Varanasi				
Total population		1,342,373	1,977,436	2,823,086
Population in sewer service area		976,223	1,371,717	2,708,520
Population connected to sewer		435,525	988,718	2,117,315
Percentage of total population		32%	50%	75%
Total wastewater generated	mld	289	366	438
Amount intercepted	mld	210	272	420
Treatment capacity	mld	88	325	430

mld: million litre per day

Summary of Sewerage Project Costs up to 2030

(Million Rs.)

Item	Lucknow	Kanpur	Allahabad	Varanasi
Trunk sewers (including manholes)	3,928.91	4,483.15	1,592.25	3,186.55
Branch sewers	10,378.76	7,348.54	2,163.50	2,523.96
Pumping stations	2,944.78	1,994.30	592.50	1,198.60
Rising mains	246.10	96.64	218.82	66.29
Treatment plants	1,384.40	1,554.00	1,088.60	899.00
Replacement of mechanical and electric assets	154.81	299.06	86.40	86.40
Sub-total	19,037.76	15,775.70	5,742.07	7,960.80
Physical Contingency (20%)	3,807.55	3,155.14	1,148.41	1,592.16
Cost of detailed engineering (15%)	2,855.66	2,366.35	861.31	1,194.12
Cost of project administration (10%) (1)	1,903.77	1,577.57	574.21	796.08
Land acquisition	634.00	707.20	620.40	596.00
Sub-total	9,200.98	7,806.26	3,204.33	4,178.36
Grand total	28,238.74	23,581.96	8,946.40	12,139.16

Base year: 2003

(3) Economic and Financial Evaluation

The estimated economic internal rates of return (EIRR) for M/P projects are shown below.

Index	Lucknow	Kanpur	Allahabad	Varanasi
EIRR	6.1%	Negative	Negative	14.2%

The results of financial analysis have revealed that estimated financial internal rates of return (FIRR) for all projects are negative.

4. FEASIBILITY STUDY

(1) Priority Projects

Priority projects for sewerage components to be implemented immediately have been identified in M/P Phase I works, with the aim of reducing the pollution load on the river. Besides sewerage works, scope of works for non-sewerage scheme, PP/PA and IDP have also been identified. The cost estimation and implementation schedule of each component for feasibility study are summarised in the following table in the next page.

(2) Environmental Impact Assessment (EIA)

The major impacts of the proposed projects identified are related to construction and operation and maintenance (O&M) of sewage treatment plants as given below. Appropriate mitigation plan has been proposed to reduce the negative impacts resulting from these project activities in the feasibility study.

Impact items	Phase	Spatial range	Range/ affected people
1. Resettlement due to construction of STPs	Construction	Agricultural fields	Farmers
2. Income loss of agriculture due to construction of STPs in agricultural field	Construction	(Social issue)	Farmers
3. Sludge disposal from STPs	Operation	Disposal sites	Disposal sites
4. Contamination of surface water and groundwater by treated effluent	Operation	River, irrigation canal and groundwater	Nearby villagers

In general the proposed projects are environmental mitigation projects by providing sewerage system to properly dispose off the municipal sewage. Therefore, the projects themselves have preferable environmental impacts on the water environment and the public health of the residents.

Summary of Project Cost by Component for Priority Projects

(Million Rs.)

City/ Scheme / Programme	Capital Cost	Physical contingencies/ Engineering/ Project Administration	Land Acquisition	Total Project Cost
1) Lucknow				
Sewerage Scheme	2,567.8	539.3	207.3	3,314.4
Non-Sewerage Scheme	135.7	33.9	0.0	169.6
Public Participation and Awareness	-	-	-	52.8
Institutional Development Programme	-	-	-	188.0
Total	2,703.5	573.2	207.3	3,724.8
2) Kanpur				
Sewerage Scheme	3,172.5	666.3	65.7	3,904.5
Non-Sewerage Scheme	70.3	17.6	0.0	87.9
Public Participation and Awareness	-	-	-	47.4
Institutional Development Programme	-	-	-	183.0
Total	3,242.8	683.9	65.7	4,222.8
3) Allahabad				
Sewerage Scheme	2,059.8	432.6	208.8	2,701.2
Non-Sewerage Scheme	86.4	21.6	0.0	108.0
Public Participation and Awareness	-	-	-	46.0
Institutional Development Programme	-	-	-	188.0
Total	2,146.2	454.2	208.8	3,043.2
4) Varanasi				
Sewerage Scheme	3,262.4	685.0	198.3	4,145.7
Non-Sewerage Scheme	278.4	69.6	0.0	348.0
Public Participation and Awareness	-	-	-	56.5
Institutional Development Programme	-	-	-	281.6
Total	3,540.8	754.6	198.3	4,831.8

Base year: 2003 for Varanasi, 2004 for the other 3 cities.

Implementation Schedule for Priority Projects

(Million Rs.)

City/ Scheme / Programme	Total Cost	Year					
		2007	2008	2009	2010	2011	2012
1) Lucknow							
Sewerage Scheme	3,314.4	339.7	625.4	560.3	591.6	827.6	369.8
Non-Sewerage Scheme	169.6	9.3	37.2	54.6	35.8	32.7	0.0
Public Participation and Awareness	52.8	11.1	9.0	8.7	8.4	7.6	8.0
Institutional Development Programme	188.0	37.6	56.4	56.4	18.8	9.4	9.4
Total	3,724.8	397.7	728.0	680.0	654.6	877.3	387.2
2) Kanpur							
Sewerage Scheme	3,904.5	210.5	797.7	608.1	762.7	998.4	527.1
Non-Sewerage Scheme	87.9	2.9	23.2	21.9	20.4	19.5	0.0
Public Participation and Awareness	47.4	9.7	7.6	7.4	7.6	7.4	7.7
Institutional Development Programme	183.0	36.5	54.9	54.9	18.3	9.2	9.2
Total	4,222.8	259.6	883.4	692.3	809.0	1,034.5	544.0
3) Allahabad							
Sewerage Scheme	2701.2	267.2	582.3	613.9	446.1	539.4	252.3
Non-Sewerage Scheme	108.0	2.2	28.3	26.6	26.6	24.3	0.0
Public Participation and Awareness	46.0	9.5	6.9	7.4	7.6	7.1	7.5
Institutional Development Programme	188.0	37.6	56.4	56.4	18.8	9.4	9.4
Total	3,043.2	316.5	673.9	704.3	499.1	580.2	269.2
		2006	**2007**	**2008**	**2009**	**2010**	**2011**
4) Varanasi							
Sewerage Scheme	4,145.7	385.5	910.2	948.4	674.9	899.1	327.6
Non-Sewerage Scheme	348.0	64.8	90.6	116.2	76.4	0.0	0.0
Public Participation and Awareness	56.5	13.0	10.3	9.6	7.8	8.1	7.7
Institutional Development Programme	281.6	56.3	84.5	84.5	28.2	14.1	14.0
Total	4,831.8	519.6	1,095.6	1,158.7	787.3	921.3	349.3

Note: The projects for Varanasi will be implemented earlier than the other 3 cities.

(3) Economic and Financial Evaluation

Following table shows the result of economic evaluation for F/S projects. EIRRs for all the projects are more than 5 %.

Index	Lucknow	Kanpur	Allahabad	Varanasi
EIRR	5.4 %	7.2 %	8.9 %	10.7 %

The estimated FIRRs for all projects are negative. The results of financial analysis have revealed that only a part of the O&M cost of the proposed sewerage system can be recovered from user charges and the remaining O&M cost and the capital cost cannot be recovered under existing financial conditions of Nagar Nigams and Jal Sansthans.

The main objective of sewerage projects, which are public works, is to provide basic urban infrastructure for better living conditions to the residents by improving the environment and sanitary conditions. In general, it is very difficult to make projects of such nature financially viable with only revenue from user charges like a commercial project for cost recoveries and profit as objectives. Following measures are recommended to improve financial sustainability of the projects.

i) Finding of government subsidy
ii) Increase of sewer service charges
iii) Improvement of sewer billing and bill collection, consisting of:
   - Increase in tax net
   - Reassessment of property value / annual rental value
   - Optimisation of billing system (computerisation of billing management)
   - Increase in productivity by introducing incentive schemes
iv) Utilisation of by-products, consisting of treated effluent for irrigation and generated dried sludge as fertiliser

5. IMPLEMENTATION OF PILOT PROJECT IN VARANASI

The objective of the pilot project was to improve the sanitary conditions of ghats and to abate water pollution from non-point sources such as open defecation, solid waste dumping, cremation, etc. Manikarnika Ghat in Varanasi was selected as a site for the pilot project, which is comprised of the following construction and renovation works:

1) Construction of changing room at Janana Ghat
2) Renovation of raised cremation platform
3) Renovation of ground cremation platform
4) Renovation of Chakra Pushkarni Manikarnika Kund
5) Construction of Heritage Corner
6) Repaving of Ramlila Maidan Ground
7) Renovation of Birla Dharmshala building as waiting room with lockers
8) Renovation of existing public toilet
9) Provision of dustbins
10) Provision of sign boards
11) Provision of pump for de-silting
12) Construction of mural in Heritage Corner

The construction works started in May 2004 and were completed in March 2005 followed by a ceremony to hand over the facilities to Nagar Nigam. Besides construction works, a community-based organization (CBO) was formulated for appropriate O&M of the facilities with assistance from the JICA Study Team. This pilot project will be used as a replicable model for improvement project for other ghats, subsequently.

FINAL REPORT

ON

WATER QUALITY MANAGEMENT PLAN FOR GANGA RIVER

JULY 2005

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VOLUME I

SUMMARY

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ABBREVIATIONS

AL	Aerated Lagoons
ARV	Annual Rental Value
ASP	Activated Sludge Process
B/C	Benefit Cost Ratio
BOD	Bio-chemical Oxygen Demand
CBO	Community Based Organisation
CDG	Constructed Dhobhi Ghat
CETP	Combined Effluent Treatment Plant
CPCB	Central Pollution Control Board
CRP	Chromium Recovery Plant
CTC	Community Toilet Complex
CVM	Contingency Valuation Method
CWC	Central Water Commission
DA	Development Authority
DG	Dhobhi Ghat
DO	Dissolved Oxygen
DUDA	District Urban Development Agency
E&M	Electrical & Mechanical
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EMC	Environmental Management Cell
EMP	Environmental Management Plan
F/S	Feasibility Study
FAB	Fluidised Aerated Bioreactor
FIRR	Financial Internal Rate of Return
GAP	Ganga Action Plan
GIS	Geographical Information System
GoAP	Gomti Action Plan
HP	Horse Power
IDC	Institutional Development Cell
IDCB	Institutional Development and Capacity Building
IDP	Institutional Development Programme
IEE	Initial Environmental Examination
JICA	Japan International Cooperation Agency
JS	Jal Sansthan
lpcd	Litres per capita per day
M&E	Mechanical & Electrical
M/P	Master Plan
mld	Million Liters per day
MLSS	Mixed Liquor Suspended Solids
MoEF	Ministry of Environment and Forests
MP	Maturation Pond
MPN	Most Probable Number per 100ml
MPS	Main Sewage Pumping Station
MUD	Ministry of Urban Development
NN	Nagar Nigam
NPV	Net Present Value
NRCD	National River Conservation Directorate
NRCP	National River Conservation Plan
O&M	Operation and Maintenance
PIC	Project Implementation Committee
PMC	Project Management Consultants
PP/PA	Public Participation and Awareness
PS	Pumping Station
SHG	Self Help Group
SS	Suspended Solids
STP	Sewage Treatment Plant
UASB	Upflow Anaerobic Sludge Blanket
UP	Uttar Pradesh
UPJN	Uttar Pradesh Jal Nigam
UPPCB	Uttar Pradesh Pollution Control Board
WSP	Waste Stabilisation Pond
YAP	Yamuna Action Plan

1

INTRODUCTION

1. INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Ganga Basin, the largest river basin of Republic of India, is supporting nearly 40 percent of the country's population. River Ganga and its tributaries, besides being a source of water supply and irrigation, are also regarded as sacred rivers and extensively used for bathing by millions of people.

In as early as 1980's, population explosion led to a drastic change in water quality, which had negative impacts on human environment and in that scenario, Ganga Action Plan (GAP) was initiated by the Government of India. Under the Ganga Action Plan, based on the water quality analysis, domestic wastewater was found to be the most significant contributing factor, followed by industrial effluent. Hence, a national body (Ganga Project Directorate) was established. Now National River Conservation Directorate, Ministry of Environment and Forests has succeeded its function and, under its initiatives, large-scale sewer schemes in the large cities have been implemented. The strategy of providing sewerage in the large cities has successfully achieved its objectives; to some degree water quality has improved.

In response to a request from the Government of India, the Government of Japan has collaborated with Government of India on this important programme by providing assistance through the Japan International Cooperation Agency (JICA) for taking up a Development Study relating to 'Water Quality Management Plan for Ganga River Basin'.

1.2 OBJECTIVES, STUDY AREA AND TARGET YEAR

The Study focuses on formulation of the water quality management Master Plan (M/P) for the four large and important cities, namely Kanpur, Allahabad, Varanasi (which are situated in the highly polluted middle stretch of river Ganga) and Lucknow (which is situated on the bank of river Gomti, a major tributary of Ganga) with the following objectives:

- To formulate the Master Plan (M/P) for water quality management for Ganga river targeting to the year 2030,
- To conduct a Feasibility Study (F/S) for the priority projects proposed under the M/P focusing on Lucknow, Kanpur, Allahabad and Varanasi (hereafter referred to as "Four Project Cities") and,
- To perform technology transfer (T/T) to the counterpart personnel in course of the Study.

1.3 SCOPE OF THE STUDY

Phase I : Formulation of the Master Plan for Water Quality Management

First Stage Field Work
1) Inventory Study
2) Analysis and Assessment

Second Stage Field Work
3) Formulation of Master Plan
4) Implementation of Pilot Project
5) Conducting Feasibility Study for Priority City (Varanasi)

Phase II : Feasibility Study of Priority Projects

Third Stage Field Work
6) Conducting Feasibility Study of Priority Project(s) for Lucknow, Kanpur and Allahabad Cities

1.4 ORGANISATION

The overall concept of the organisational structure of the Study is shown in the figure below. The Study has been carried out by the JICA Study Team in close cooperation with the National River Conservation Directorate (NRCD), Ministry of Environment & Forests, Government of India; Central Pollution Control Board (CPCB); Uttar Pradesh (UP) State Government; UP Pollution Control Board; UP Water Corporation (UP Jal Nigam) and various local bodies/municipal organisations in the four towns. Local NGOs and beneficiaries in the four towns are also being actively involved in this Study to make the programme more sustainable.

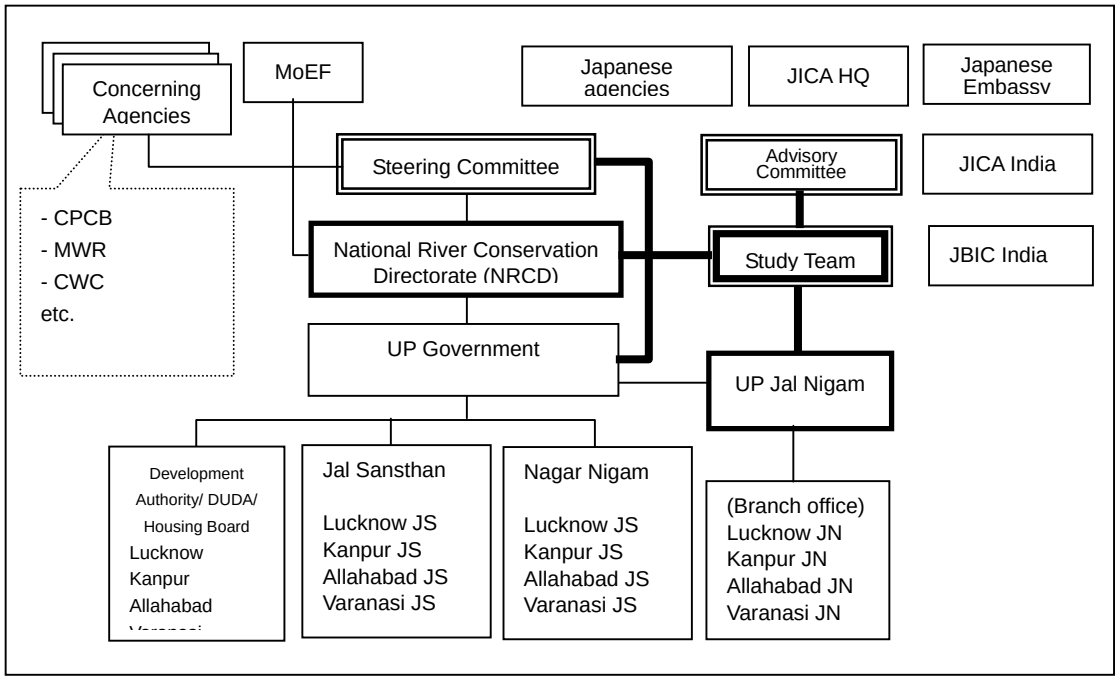


Figure 1.1 Organisation Structure for the Study

1.5 BASIC PROFILE OF GANGA RIVER

The river Ganga originates from Gangotri in the Himalayas and traverses a distance of approximately 2,500km before discharging into the Bay of Bengal (Figure 1.2). Ganga and its tributaries are regarded as sacred rivers and used extensively for bathing by the people apart from serving as the source of water supply and irrigation.

The catchment area of Ganga Basin is about 840,000km^2 (25% of the country's landmass) and nearly 400 million people live in the basin (Table 1.1). The river basin is characterized by diversified cultural and religious activities along riverbanks and is populated by people with significant variation in socio-economic conditions. The major features of Ganga river basin are summarised below:

Table 1.1 Length and Basin Population of River Ganga

River Stretch	River Length (km)	Sub-Basin Area (km^2)	Total Population in 2001	Urban Population in 2001	Rural Population in 2001	Population Density ($prsns/km^2$)
Ganga river (main stem)	2480.6	84,693	74,388,088	23,772,297	50,615,790	878
-The origin to Kannauj	668.4	36,969	11,332,556	2,705,849	8,626,707	307
-Kannauj to Gomti Confluence.	500.1	18,835	22,806,470	6,666,500	16,139,969	1,211
-Gomti Cnfl. to the Mouth	1312.1	28,889	40,249,062	14,399,948	25,849,114	1,393
Ganga Basin Total	**-**	**838,583**	**397,305,839**	**91,446,931**	**305,880,995**	**474**

1.6 FOUR STUDY CITIES

The pollution level of river Ganga and its tributaries is comparatively higher in the middle stretch because of low river flow due to abstraction of river water in upper reaches for irrigation resulting in lower dilution effect and higher pollutant contribution from cities located in this densely populated zone. Therefore, the four large and rapidly expanding cities (having population growth rate of 2-3% per annum) in the middle part of Ganga Basin, i.e., Lucknow, Kanpur, Varanasi and Allahabad, which are major sources of pollution to the river, have been selected for this Study.

Of the selected cities, Lucknow with a population of around 2.4 million, is the capital of Uttar Pradesh State. The city is located along the bank of the river Gomti, one of the major tributaries of Ganga.

Kanpur, situated on the bank of Ganga, is the biggest city of Uttar Pradesh. It has a population of 2.9 million and is an important centre of commercial and industrial activities.

Allahabad, with a population of 1.2million, is one of the sacred cities of Hinduism. It is located at the confluence of two of India's holiest rivers, the Ganga and the Yamuna called Sangam, which is the venue of many sacred fairs and rituals, and attracts hundreds of thousands of pilgrims throughout the year. This number swells to millions during the Kumbh Mela and the Ardh Kumbh Mela that are celebrated alternatively once every six years for a duration of about one and a half months.

Varanasi, having a population of 1.3million and also situated on the bank of river Ganga, is one of the oldest towns in the world and the ultimate pilgrimage for Hindus. The river is a part and parcel of everyday life in the town and thousands of people bathe daily in the river along the famous seven kilometres stretch of ancient ghats of the town.

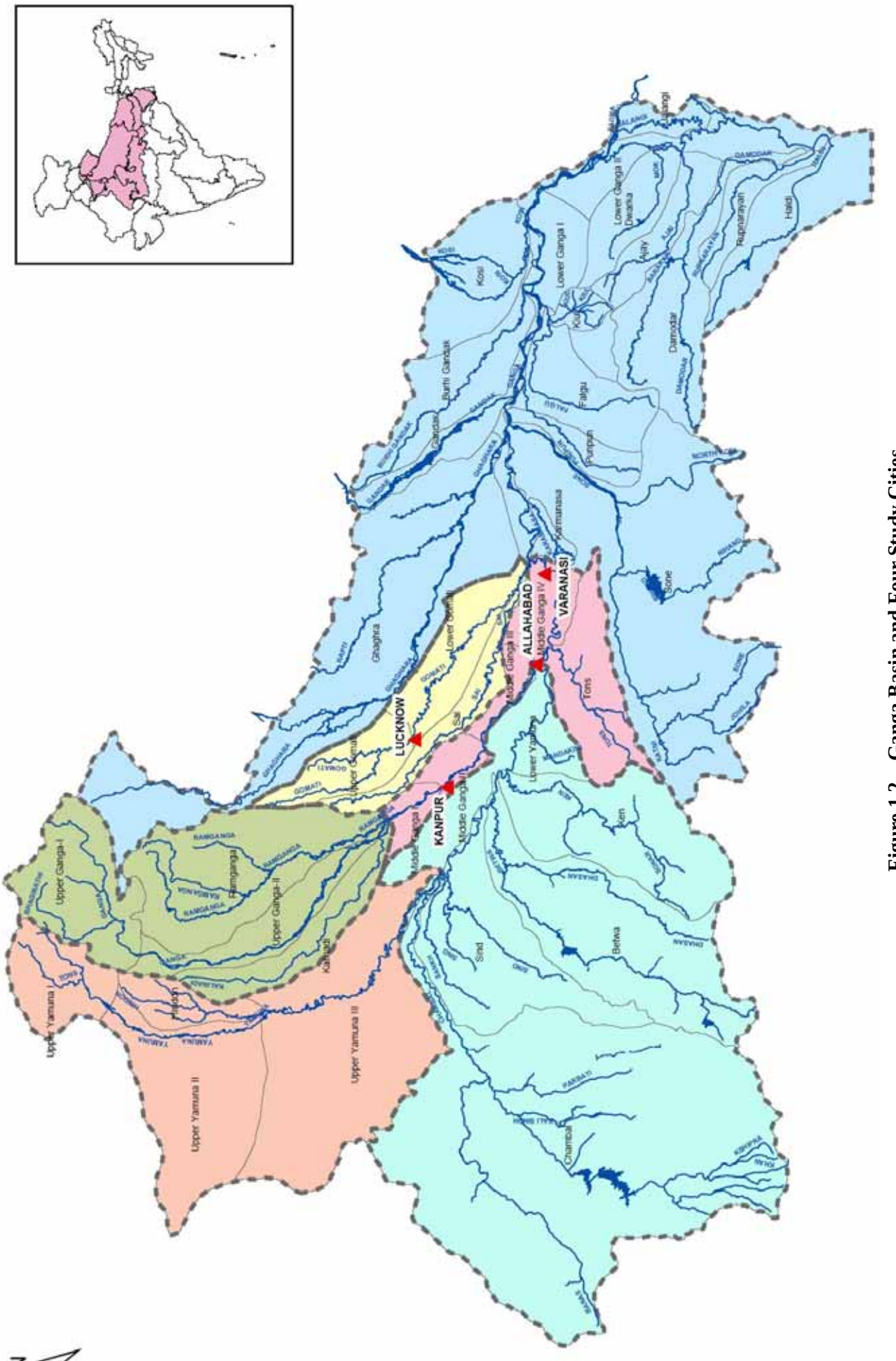


Figure 1.2 Ganga Basin and Four Study Cities

1.7 OBJECTIVE OF THE PROJECT

The Central Pollution Control Board (CPCB) has classified various rivers in the country into the following five categories as shown in Table 1.2 based on their 'Designated Best Use. The stretch (Kanpur through Allahabad to Varanasi) of the river Ganga is classified as Class B; Outdoor Bathing while the Gomti, tributary of the river Ganga as Class C. The primary objective of this Project is to attain Class B or C levels of water quality in these stretches. This is also the objective of the national policy of river action plan, which is stipulated in the National River Conservation Plan (NRCP).

Table 1.2 Water Quality Standards Based on Designated Best Use

Class A	Drinking water source without conventional treatment, but with chlorination	pH: 6.5-8.5 DO: > 6mg/l	BOD: < 2mg/l TC: 50MPN/100ml
Class B	**Outdoor bathing**	**pH: 6.5-8.5 DO: > 5mg/l**	**BOD < 3mg/l Total Coliform: <500MPN/100ml**
Class C	Drinking water source with conventional treatment	pH: 6.5-8.5 DO: > 4mg/l	BOD < 3mg/l TC: 5000MPN/100ml
Class D	Propagation of wildlife and fisheries	pH: 6.5-8.5 DO: > 4mg/l	Free Ammonia: 12mg/l
Class E	Irrigation, industrial cooling and controlled waste disposal	pH: 6.0-8.5 SAR: 26	Boron: 2mg/l

*Note: Primary quality criteria of class B regarding coliform number has been recently revised by CPCB as follows;
Faecal coliform : <500 MPN/100ml (Desirable), <2,500 MPN/100ml (Maximum permissible).

1.8 RIVER POLLUTION SOURCES AND POLLUTION REMEDIAL MEASURES

The sources of river pollution in urban area can be classified into point and non-point sources as follows:

Point sources:
(i) Untreated domestic sewage
(ii) Untreated industrial wastewater

Non-point sources:
(i) Open defecation and urination from non-toilet households
(ii) In-river activities (bathing, washing cattle in the river (cattle wallowing), washing of clothes, throwing of half-burnt/un-burnt dead bodies and offering of flowers, fruits etc into the river)

The main reasons for deterioration of river water quality are point sources of discharge of untreated domestic sewage from the urban cities/towns located along the riverbanks and untreated industrial effluents. Another source is runoff from open defecation classified as non-point source.

The discharge of point pollution load is the main reason for deterioration of the river water quality, whereas the pollution contribution from in-river activities such as washing of clothes is rather insignificant. However, these factors directly and indirectly influence the hygienic and aesthetics condition of river front, especially along the bathing stretches. Other aesthetic impact is dumping of solid waste in the river and on the ghats.

The measures to tackle the pollution from urban point and non-point sources were identified and interventions were proposed to ameliorate the situation in River Action Plans. The schemes in these plans have been called as Sewerage and Non-sewerage schemes (also called Non-core schemes).

Table 1.3 summarises pollution sources in the urban area, causes of pollution, major impacts by them and some remedial measures.

Table 1.3 Pollution Sources in the Urban Area, Cause of Pollution, Major Impacts and Remedial Measures

Urban pollution sources	*Scheme*	*Type of source*	*Magnitude of pollution load*	*Place*	*Cause of river pollution*	*Major impact*	*Remediation Measure*
Household connecting sewer	Sewerage	Point	Heavy	City	Discharge to nala and river through sewer without treatment	• **Deterioration of river water quality** • Unsanitary condition	• Treatment • Enhancement of public awareness
Household connecting drain or nala	Sewerage	Point	Heavy	City	Direct discharge of domestic wastewater to nala and river	• **Deterioration of river water quality** • Unsanitary condition	• Tapping, divert, and treatment • Sewer connection and treatment • On-site treatment • Enhancement of public awareness
Open defecation and urination	Non-sewerage	Non-point	Middle	City	Open defecation on the bank and in river and nala	• **Deterioration of river water quality** • Unsanitary condition	• Low cost sanitation (toilet complex and individual toilet) • Enhancement of public awareness
Bathing at ghat	Non-sewerage	Non-point	Light	Ghat only	Offering (Open urination and defecation)	• None • (Unhygienic condition) • (Disturbance of bathing)	• Toilet complex • Enhancement of public awareness
Washing cloth at traditional dhobi ghat	Non-sewerage	Non-point	Light	Ghat only	Soap and detergent and some organic pollution from dirty cloth	• Unhygienic condition	• Constructed dhobi ghat • Enhancement of public awareness
Cremation at ghat	Non-sewerage	Non-point	Light	Ghat only	Throwing un-burnt and half burnt body in river, using huge amount of woods	• Unhygienic condition • Loss of forests	• Improved wood crematoria • Electric crematoria • Enhancement of public awareness
Cattle wallowing at ghat	Non-sewerage	Non-point	Light	Ghat only	Cattle wallowing and cow dung	• Unhygienic condition	• Pond or alternate facility • Patrolling and penalty • Enhancement of public awareness
Solid waste	Non-sewerage	Non-point	Light	City	Free dumping at ghat Free dumping in nala and sewer	• Unaesthetic conditions • Choking nala and sewer	• Garbage bin at ghat and collection • Appropriate collection system • Enhancement of public awareness
Industrial effluent	Industrial pollution control	Point	Heavy to light depending on profile	City	Discharge to nala and river through sewer Direct discharge to nala and river	• River pollution • Unsanitary condition	• Municipal sewer and treatment • Centralized Effluent Treatment Plant (CETP) for industrial zone • Preliminary treatment on site • Regulation and penalty • Strong enforcement

2

RIVER POLLUTION MANAGEMENT PLAN

2. RIVER POLLUTION MANAGEMENT PLAN

2.1 EXISTING RIVER WATER QUALITY AND POLLUTION LOAD

2.1.1 Water Quality Status

It has been observed that water quality of the upper stretch of Ganga river is good because less pollution load is being discharged into it, and the self-purification capacity is also high. The condition, however, worsens in the middle stretch (from Kanpur to Varanasi) because a large quantity of water is withdrawn for irrigation and domestic purposes thereby decreasing the dilution or self-purification capacity of river water as can been seen in the figure given below. Furthermore, a large quantity of untreated wastewater is discharged into the river from the cities located on the bank of river Ganga and its tributaries and hence the section of Ganga from Kanpur to Varanasi and the downstream section of Gomti from Lucknow are excessively polluted.

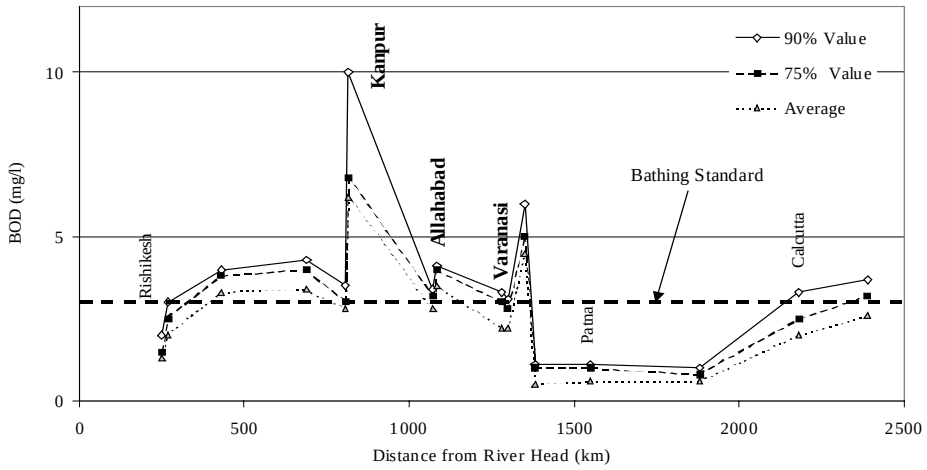


Figure 2.1 Water Quality (BOD) of Main Stretch of Ganga River

Table 2.1 Water Quality (BOD) of Gomti River

Station Name	BOD (mg/l)			
	90%	75%	50%	Average
At Sitapur u/s at water intake	2.6	2.4	2.2	2.23
At Lucknow u/s at Water Intake point	3.0	2.6	2.4	2.45
At Lucknow d/s	7.4	7.0	6.1	6.39
At Jaunpur d/s	5.9	5.0	4.5	4.42

Data: 1997-2001 CPCB monitoring data

On the other hand, there is no serious problem regarding river water quality in the downstream stretch where large cities such as Patna and Kolkata are located along the riverside. This is because of the increased flow rate of river water due to the confluence of several large tributaries such as Sone, and Ghaghra into the main stem.

2.1.2 Inventory of River Water Pollution

The previous inventory of pollution load generation in the Ganga Basin was prepared in the year 1984. The inventory has hence become obsolete making it indispensable to update it using recent conditions and data of the basin. The information collected in this Study is essential for any rational formulation of updated pollution control policies and measures.

The need and importance of basin-wide study of water quality as well as various factors that trigger pollution load generation and runoff are emphasized because the results would be useful as basic information for river water pollution control. Based on the analysis of collected data and information it was observed that water pollution arising from industrial and urban wastewater is very significant. Besides, the rural surroundings and agricultural fields are also found to be potential sources of river water pollution.

Using the prepared inventory, basin-wise pollution load runoff from different sources has been computed. It is estimated that out of the total pollution load runoff reaching the river streams, the load from point sources (urban wastewater and industrial effluents) is significantly high (94 %), including 79 % load from municipal sewage and 15 % load from industries. The remaining 6 % is observed to be contributed by non-point sources such as agricultural and forestry runoff, livestock, rural households, etc (Figure 2.2). This implies that there is a need to address the pollution originating from municipal wastes and wastewater and industrial wastewater on priority basis in order to control the increasing pollution of river Ganga. This can be achieved by the preparation of effective measures and plans to control the pollution loads from these sectors after appropriate assessment of the existing conditions and future estimations of these pollution contributions from the cities/towns located along the river Ganga and its major tributaries.

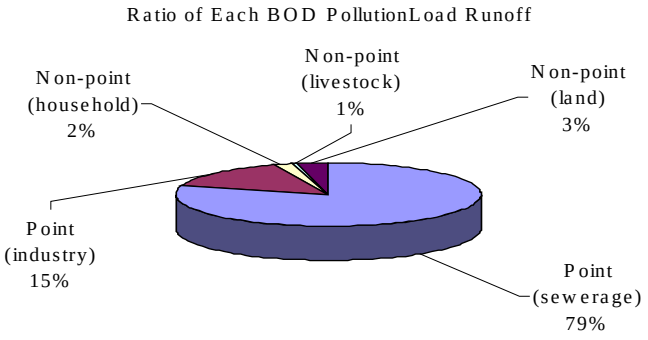


Figure 2.2 Ratio of BOD Pollution Runoff from Entire Ganga Basin

2.1.3 Pollution Load Runoff

The estimated density of BOD in the pollution load runoff from each river system, which indicates the contribution of pollution load from the basin to the Ganga river, is illustrated in the figure below for the case of without project in the year 2030.

As can be seen from the figure below, the density of BOD in the pollution load runoff is highest in Middle Ganga (where Kanpur, Allahabad and Varanasi are located), followed by Upper Yamuna (where Delhi and Agra are located) and Gomti (where Lucknow is located).

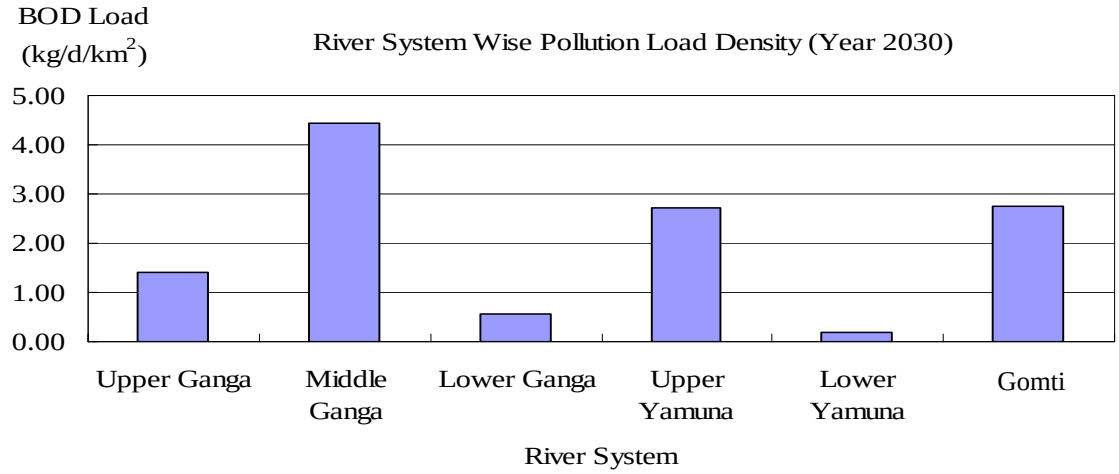


Figure 2.3 River System wise Pollution Density in 2030 without Project

2.1.4 Highlight of the Four Cities

In connection with the BOD density estimation, apart from the river reach of Yamuna from Delhi to Agra where the Yamuna Action Plan II for the improvement of river water quality is scheduled to start soon, the estimated density of pollution load runoff is also very high in the Middle Ganga and Gomti river systems compared to the others. Therefore, the urgent improvement of river water quality is also very necessary for the middle river reach of Ganga where Kanpur, Allahabad and Varanasi are located, and in Gomti river where Lucknow is located.

In the next section, a detailed river water quality simulation for the four cities has been conducted for the estimation of existing and future river water quality and for the urgent development of an integrated sewerage and sewage treatment system for all of these cities.

2.2 ESTIMATION OF RIVER WATER QUALITY AND POLLUTION LOAD REDUCTION

2.2.1 Pollution Load Reduction in Upstream Areas

A preliminary simulation of future water quality for Ganga river indicates that wastewater discharged into river from the cities located upstream of the four cities should be reduced in addition to reduction of discharged sewage in the four cities to meet the BOD criterion (3 mg/l). The river water quality at upstream monitoring stations of the four cities in 2030 is simulated with the following conditions and its results are shown in the figure below.

Domestic wastewater reduction scenario in medium and large cities in the Ganga Basin

- Without any sewerage project (current installed capacity of sewage treatment plant)
- 50 % reduction of the total pollution load from the domestic wastewater
- 75 % reduction of the total pollution load from the domestic wastewater
- 80 % reduction of the total pollution load from the domestic wastewater

Without any sewerage project, the water quality of the upstream of the four cities exceeds by far the water quality standards (BOD 3 mg/l). To comply with the standards in the stretch of the four cities, it is required that about 60-75 % of pollution load from domestic wastewater of the upstream cities should be reduced.

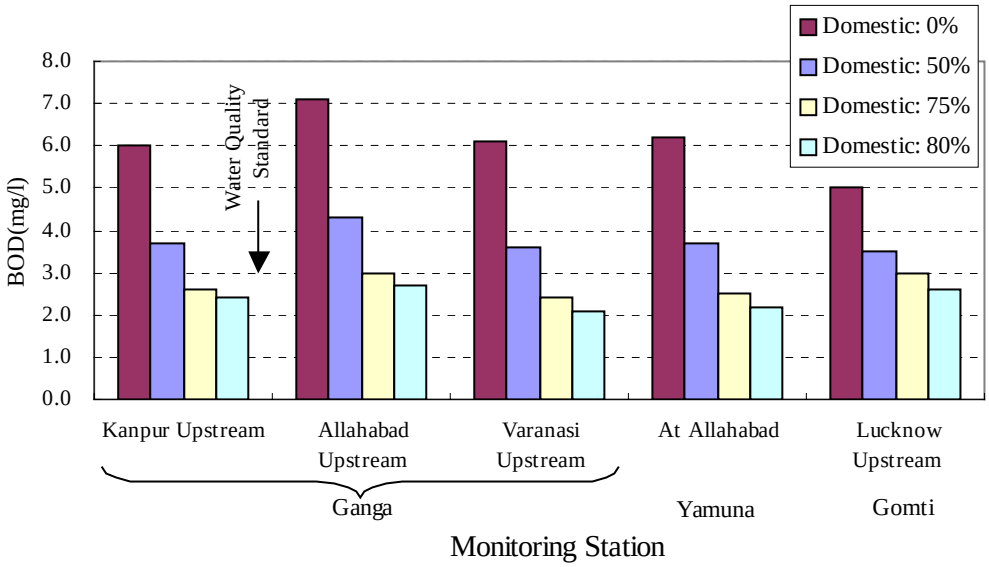


Figure 2.4 Water Quality Estimation at the Upstream of the Four Cities in 2030 with Domestic Wastewater Reduction Scenario of Upstream Cities

Thirty-five priority cities that contribute to the river pollution in the four cities have been selected for the simulation study and detailed future simulation has been conducted. As a result, to meet the BOD criterion of 3 mg/l at the upstream monitoring station of each of the four cities, it is necessary to reduce by 70 to 80 % the future domestic pollution load generated and discharged from these 35 selected cities in 2030.

To maintain the desired level of water quality at monitoring location just upstream of the city of Kanpur, it is necessary to prepare sewerage development and pollution abatement plans for the cities of Barielly, Moradabad, Farrukhabad cum Fatehgarh, Kannauj, Rampur, Budaun, Meerut, Sambhal, Amroha and Chandausi that are located along river Ganga on the upstream of Kanpur.

In order to keep the water quality of river Yamuna within the desired level at the monitoring location upstream of Allahabad, it is inevitable to prepare pollution abatement plans and sewerage development planning for the cities of Agra, Firozabad, Delhi, Fetehpur, Faridabad Complex, Mathura, Etawah, Bharatpur, Jhansi, Banda, Bhind, Kota, Shikohabad, Orai, Gurgaon, Ghaziabad, and Hathras located along river Yamuna on the upstream of Allahabad.

Furthermore, more stringent regulations such as TMDL (Total Maximum Daily Loading), in addition to sewerage development, should be required to accelerate the reduction of pollution load.

2.2.2 Detailed Simulation of Organic Pollution in the Four Cities

The results of simulation of organic pollution in the four cities are shown in the figure below. To meet the water quality standard (BOD: 3 mg/l) in 2030, untreated domestic wastewater effluent in these cities should be reduced by 80 % to 90 %. This indicates that almost all the domestic wastewater should be treated and discharged into the river or utilised for irrigation purposes after treatment.

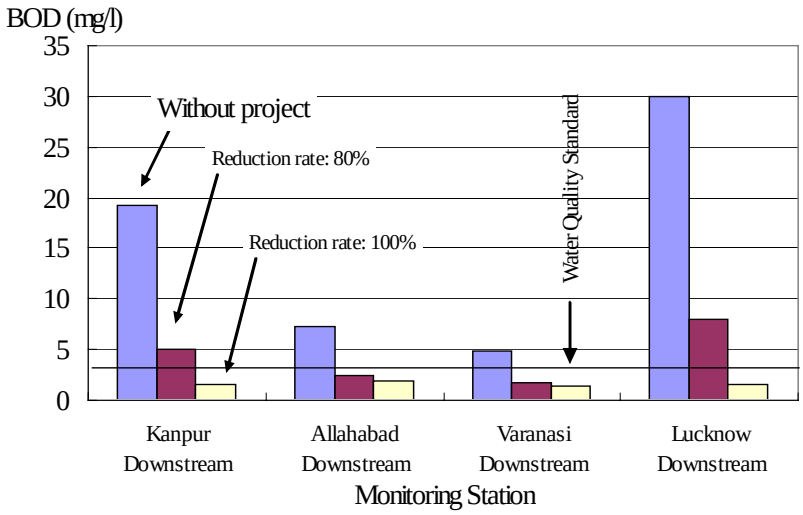


Figure 2.5 Simulated Water Quality of Ganga River at the Downstream of the Four Cities with Domestic Wastewater Reduction Scenario

2.2.3 Future Bacterial Pollution in the Four Cities

In addition to simulation of organic pollution (BOD), simulation of bacterial pollution (faecal coliform) is tried in this study. The followings are conclusions for the reduction of bacterial pollution:

- The simulation based on the existing water quality data shows both non-point and point sources are major contributors of bacterial pollution. Thus both pollution sources should be tackled and reduced.
- To meet the water quality standard of faecal coliform in the river, coliform reduction measure such as chlorination of domestic wastewater effluent is required in all the four cities.

Although these results have been obtained, for more reliable simulation, followings steps are recommended in terms of bacterial pollution data.

- The composition of non-point bacterial pollution sources is unknown and the detailed study is required to identify it.
- Reliability of the existing water quality data should be further verified by checking the existing sampling points and the process of water quality analysis including conveyance method from the sites to the laboratory.

2.3 INDUSTRIAL POLLUTION CONTROL

Among the four cities of Kanpur, Lucknow, Allahabad and Varanasi, Kanpur contributes most of the industrial pollution load to the Ganga Basin. The major pollutant industry in Kanpur is tannery industry. The number of tanneries increased from 175 in 1990 to more than 350 during 2000, and most of these tanneries are located in a small area by the Ganga river called Jajmau. Industrial wastewater discharged from such tanneries contains chromium, which probably affects the groundwater and its surrounding environment.

The Common Effluent Treatment Plant (CETP), which has a capacity to handle 36 million litres per day (mld), treats a combination of tannery effluent and municipal waste in the ratio of 1:3. In addition to the CETP, the tanneries are also required to set up primary ETP facilities to treat their own effluent. Most tanneries in the cluster now have a primary ETP.

The discharge from the primary ETPs is taken to the CETP through a covered drain. The industrial

wastewater treatment is facing serious problems, and satisfactory treatment has not been done due to the shortage of electricity and necessary funds, legislative issues and so on. Especially, it is necessary to consider the performance improvement of CETP and construction of the Centralized Chrome Recovery Plant (CRP).

The following steps are the recommendations to manage industrial liquid effluent:

(1) Technical Recommendations

The technical recommendations for improvement of the existing industrial liquid management in Kanpur are as follows:

- Improvement of leather tanning technology
  - Aluminium tanning technology
  - Recycling of chromium in tanning operations
- Reduction of chromium induced toxicity to CETP
- Establishment of CRP
- Effective monitoring of CRP functioning in tanneries
- Restricted use of CETP effluent
- Capacity building of CETP performance monitoring system

(2) Legislative Recommendations

The legislative recommendations for improvement of the existing industrial pollution management in Kanpur are as follows:

- Need for special water discharge permits
- Comparison of effluent water quality standards for sewerage system in Japan & India
- Temporal discharge standards
- Proper technology based legislative specifications
- Proper cognisance of legislative guidelines
- Need for mass based standards
- Increased frequency of industrial discharge monitoring

(3) Institutional Recommendations

The institutional recommendations for improvement of the existing industrial liquid effluent management in Kanpur are as follows:

- Stake holder participated management of CETP
- Pollutant concentration & incentive based cost sharing of CETP
- Waste load allocation for industrial discharge for Ganga river at Kanpur
- Forced benchmarking of industrial water consumption
- Transfer of technology for cleaner production
- Adoption of ISO 14000 Environmental Management Systems
- BOD based water quality trading
- Environmental performance rating of tanneries

2.4 OPTIMISATION OF WATER QUALITY MONITORING

2.4.1 Issues in Water Quality Monitoring

During the study, the Study Team has identified the following technical and administrative problems regarding water quality monitoring.

The technical problems include improper location of the sampling site; lack of adequate facilities for transportation, storage and preservation of the samples; non-availability of enough number of

professionals dealing with sampling, analysis and reporting of data. The sampling locations are not placed appropriately often and hence do not represent the indicative values sometimes leading to error. The change in water quality level due to improper storage and preservation of collected samples might also lead to erroneous figures. The absence of required number of skilled professionals delays and impedes the water quality monitoring activities.

The administrative problems consists of issues such as scarcity of funds and trained manpower; lack of facilities and delayed repairing of instruments; delayed transmission of data; and absence of assessment of the fitness of water bodies for different uses. Many of the existing equipment for water quality analysis are out-of-date and inefficient. Besides, trained manpower for field and in-house work for water quality monitoring is inadequate. The lack of funds for operation and maintenance of costly and advanced equipment provided for the water quality monitoring supportive programme have been observed in many of the laboratories.

2.4.2 Recommendations for Appropriate Water Quality Monitoring

In the Study area, Central Pollution Control Board (CPCB), a central government institution, and UP State Pollution Control Board (UPPCB) are responsible for river water quality monitoring. Under the circumstances, institutional, financial improvement and procurement of necessary equipment are recommended for the CPCB and the UPPCB. The capacity building measures are required for both administrative and ground level staff to increase the competency of staff engaged in analysis and supervision of water quality monitoring.

Reliable data of water quality monitoring and their utilisation are indispensable for the river pollution analysis and the management of river water-related environment. Currently existing upstream and downstream monitoring stations in the four cities are mostly located within the city area due to the recent expansion of city area, and are affected by direct pollution load inflow. To solve these issues, additional and new monitoring stations are recommended. The sampling points located at the upstream and downstream of Kanpur, Allahabad, Varanasi and Lucknow need to be investigated to adjust them to the correct sites. Besides, the additional monitoring stations should be selected at the lowest point and confluence points of tributaries of the Ganga, to understand the pollution load balance in the entire Ganga Basin.

To monitor water quality under the recommended basis, laboratory equipment and training must be improved. Moreover, to maintain the full functioning of laboratory equipment, operation and maintenance (O&M) financing is required. Besides, continuous power supply should be ensured for appropriate analysis of water sample in the laboratory.

3

SEWERAGE AND NON-SEWERAGE MASTER PLAN FOR PROJECT CITIES

3. SEWERAGE AND NON-SEWERAGE MASTER PLAN FOR PROJECT CITIES

3.1 PLANNING STRATEGY FOR MASTER PLAN

3.1.1 Planning Process

The water quality simulation model developed has confirmed the necessity of pollution load reduction in the four cities as well as the upstream towns. In the four cities covered under the Study, only about 30% of the sewage generated in these cities is being treated at present, with the remaining 70% flowing untreated into the river.

In these cities, frequent interruption in power supply (despite diesel generators being installed) leads to disruption in pumping and treatment of sewage making the problem worse. In addition, problems in the sewerage collection system such as choking of sewers due to solid waste, inadequate sewer cleaning, broken sewers resulting in bypassing of flow, inadequate carrying capacity of sewers, etc. result in sewage finding its way into the river through storm water/surface drains.

The initial stage of this study examined prospective urban development to the year 2030, evaluated alternative sewerage projects, and selected the priority components for the Feasibility Study (F/S) that was carried out in subsequent stages.

To arrest the discharge of untreated sewage to the river, intermediate/long term plans, including immediate measures have been prepared. The immediate measures include provision of interceptor sewers and pumping stations to tap storm water drains flowing into the river, increasing the capacity of sewage treatment plants (STPs) and ensuring continuous supply of electricity. The intermediate/long term approach would include development of the internal sewerage system in the town, re-connection of secondary sewers to trunk sewers, provision of new trunk sewers and sewerage facilities for developed and developing areas and periodical sewer cleaning. The immediate measures are to be integrated with the long-term plan.

Various alternatives of the sewerage system comprising zoning options, treatment options, location of facilities, etc. have been evaluated and compared to select the most appropriate alternative for a particular city. Factors such as reliability, compatibility, feasibility and impact on downstream users have also been considered while comparing the various options. The treatment technology for each location has been chosen based on the life cycle cost comparison (including capital, land and capitalized O&M costs) of the various feasible options and availability of land. Treatment technologies such as waste stabilization ponds (WSP), aerated lagoon (AL), up-flow anaerobic sludge blanket (UASB) with adequate post treatment, activated sludge (AS) and fluidised aerobic bio-reactor (FAB), etc. with disinfection options have been considered. For sustainable and proper operation and maintenance of the facilities to be installed under the project a plan for institutional development & capacity building and financial strengthening of the local municipal bodies has also been prepared.

3.1.2 Need for a Sewerage Master Plan

The GAP projects and proposals have focused on reducing pollution loads by diverting sewage at the tail end of drains during dry weather only. GAP does not address the need for removing sewage from the drains to prevent pollution during wet weather. Nor does it address issues of public health and sanitation within the city.

In the absence of a sewerage master plan, urban development continues without adequate infrastructure for public health and sanitation. New sources of pollution crop up as the population grows and as new areas develop:

- Existing sewer facilities are overloaded, effluent at treatment plants becomes a significant pollutant load
- The amount of wastewater in open drains increases thereby overflowing at existing diversion facilities
- New sources of pollution appear as natural drains serve as outlets for wastewater from new developments

Diversion facilities constructed under GAP are not designed to operate during wet weather, therefore the use of open drains for wastewater disposal remains a source of pollution during wet weather.

Diversion of drains, as proposed under GAP is an important first step for improving water quality. However, the Government of India and NRCD have recognized that the benefits of GAP will be short lived unless these activities are framed within a more holistic approach to the development of sewerage infrastructure in large urban centres. In the absence of a comprehensive plan, efforts at pollution control will always remain reactive, never quite catching up with the source of the problem.

3.1.3 Key Issues for the Planning and Implementation of Sewerage Master Plan

(1) Consideration of existing and sanctioned sewerage facility

In formulating Sewerage Master Plans, existing sewerage zoning system and alignment of existing sewerage facilities of sewers, pumping stations and treatment plants have been considered. Also sanctioned projects are considered fully implemented and regarded as existing.

(2) Adopting a decentralized approach

The Sewerage Master Plan divides the urban centre into sewerage districts. A decentralized approach has been favoured to minimise conveyance costs and reduce the size of sewerage facilities. Also it eases the monitoring activities of sewer system. Smaller treatment works will simplify site selection and land acquisition. Furthermore, it is generally easier to manage the operation and maintenance of smaller facilities. However, some scale has been maintained considering scale of economy of construction, operation and maintenance costs in dividing the sewerage system, especially for treatment plants and pumping stations.

(3) Coordinating development of branch sewers with trunk sewers

The trunk facilities identified in the master plan are the backbone of the sewerage system. It will open the way for extending the branch sewer network into parts of the city that are not presently served. It is essential that existing and future development areas be connected to this backbone in order to achieve water quality, health and sanitation objectives. Jal Sansthans, and Nagar Nigams must implement programmes for improving and extending the branch sewer system. A concentrated effort will be required to connect existing and future growth areas, else the trunk sewer system will fail because there will be insufficient wastewater to achieve self-cleansing velocities.

(4) Adopting and adhering to the sewerage Master Plans

The Master Plans for sewerage must be formally adopted by the authorities responsible for the development of cities. A formal mechanism is required to make it mandatory for Development Authorities and Housing Boards to adhere to the Master Plan. Continuing in the present mode whereby new colonies are developed without proper outlet to trunk sewer facilities will only add to the drainage and pollution problems of the city.

(5) Cost sharing for trunk facilities: user pay principle

Implementation of new developments must proceed in a planned manner. Major trunk facilities should be extended to service planned communities. In keeping with the user pay principle, it should be made mandatory by law for developers, whether private or government to share in the cost of trunk sewers and treatment plants.

(6) Land acquisition for future facilities

Land identified for sewage treatment works and pumping stations must be acquired as soon as possible and reserved for the future development of the sewerage system. Similarly, right of way and maintenance easements are required along trunk sewer alignments to prevent encroachment.

(7) Improving power supply

Pumping stations and treatment plants must be provided with a reliable and continuous power supply. These facilities must be designated as essential services and should be given top priority for service by the electrical utility. Emergency power generators must be provided at all facilities and funding for fuel must be guaranteed to prevent overflows of untreated sewage during lengthy power cuts.

3.1.4 Selection of Treatment Technology

The various treatment technologies considered in the Master Plan include:

- Waste Stabilisation Ponds (WSP)
- Conventional Activated Sludge Process (ASP) + chlorination
- Aerated Lagoon (AL) + Maturation Pond (MP)
- UASB + Post-treatment with Aerated Lagoons (AL) + chlorination
- Fluidised Aerated Bio-reactor (FAB) + chlorination

These treatment technologies are usually, in a techno-economic analysis, compared on the basis of the following general parameters:

- Suitability to meet discharge standards
- Capital costs
- O&M costs
- Power requirement
- Land requirement
- Treated effluent discharge
- Sludge disposal requirements
- Resource recovery in terms of re-use of methane gas

The technology adopted shall meet the present project discharge standards stipulated by NRCD:

(i) BOD – 30 mg/l
(ii) SS – 50 mg/l
(iii) Faecal Coliform -10,000 MPN/100 ml (Maximum)

Regarding the above parameters, their related importance in the comparison of alternative sewage treatment technologies for the present project has been decided in view of the following site constraints:

(i) Power Constraint: - Power outages are common in the four Target Cities. Hence a technology with a high dependency on power for effective and reliable treatment of waste water would not be desirable for the cities where power cuts occur.

(ii) Land Constraint: - The cities are densely populated and hence, offer few choices for locating the sewage treatment facilities except two proposed STP locations in Allahabad.

If the land availability is the major parameter to be considered for treatment process, the following guidelines are recommended based on the comparison of each technology.

(1) If land availability is not a major constraint WSP is the best alternative.
(2) If land availability is a constraint and is not enough for WSP, UASB+AL is the best alternative.
(3) If land availability is very limited and alternate land is not available FAB is recommended.
(4) If augmentation is proposed and land has been procured for that purpose in existing STP sites, same technology as existing one has been adopted considering coherence of the facility and operation and maintenance.

3.2 POPULATION PROJECTIONS FOR PROJECT CITIES

3.2.1 Urban Growth Patterns

As the cities have grown there has been an increased land area that has come under urbanization. Characteristically, the development has been more influenced by the road networks (the visible infrastructure) and less driven by the master plans for directing growth.

The importance of sewerage systems (the under-ground, hence not so visible infrastructure) and water supply have often been relegated in importance to the business of making housing developments and all civic infrastructure seems to play the ever-loosing game of playing catch-up with the changing demographic landscape.

3.2.2 Understanding Past and Present Population

Using 2001 census data, information was gathered on the most recent documented population of the urban areas and the municipal extents of each of the four cities.

Table 3.1 Comparison of Census Data for the Urban Areas and Municipal Areas: Year 2001

Item	Lucknow	Kanpur	Allahabad	Varanasi
Year 2001 Census data for Urban Area	2,266,933	2,721,145	1,081,622	1,202,443
Year 2001 Census data for Municipal Area	2,207,340	2,531,138	990,298	1,093,925

Additional background information was acquired to provide an understanding of population numbers in earlier decades and to assess the decadal growth rates.

Table 3.2 Comparison of Population Data and Growth Rates from 1951 to 2001

Year	Lucknow Urban Area Population	Kanpur Urban Area Population	Allahabad Urban Area Population	Varanasi Urban Area Population
1951	496,861	705,383	332,295	355,771
1961	655,673	971,062	430,730	489,864
1971	813,982	1,275,242	513,036	617,934
1981	1,007,604	1,641,064	650,070	773,865
1991	1,669,204	2,111,284	844,546	1,030,863
2001	2,266,933	2,721,145	1,081,622	1,202,443

3.2.3 Population Growth Projections Strategy

The (city) master plans for each city formed the basis of developing the population forecasts. While the (city) master plan for Varanasi is projected only till the year 2011, the other cities have developed the (city) master plans and projections till the year 2021.

As the (city) master plans (except that of Lucknow) had been developed without the benefit of the 2001 census data, this data was used to refine the estimates of the master plans.

Benchmarking the population estimates with the figures from the 2001 census, revised population forecasts were developed. In general, the effort has been to develop estimates on the higher side, albeit with the benchmark of the 2001 census data. Consequently the growth rates used in the master plans have been adopted to develop the growth projections, rationalizing them based on the trends that emerge from looking at the decadal growth rates from 1951 to 2001. The geographical boundary for population estimation is the future urban area that consists of existing municipal administration area and expected future expansion area. The estimation also includes floating population. The resultant projections developed and adopted by the Study Team for sewerage development are given below.

Table 3.3 Population Projections for Urban Areas

Year	Lucknow Urban Area	Kanpur Urban Area	Allahabad Urban Area	Varanasi Urban Area
2003	2,463,474	2,819,827	1,101,205	1,342,373
2015	3,605,587	4,342,031	1,490,427	1,977,436
2030	5,424,689	5,629,081	2,076,570	2,823,086

3.2.4 Distribution Patterns of Existing Population

A map showing the municipal ward extents corresponding to the 2001 census was obtained from the Nagar Nigam Offices. This was used to create a GIS-based map of the municipal wards and associate the 2001 population (census) data. Using GIS tools the ward areas were computed and population densities calculated to provide a better understanding of the demographic distribution and correlation with other project data.

To characterize the population distribution outside of the municipal limits, the urbanized areas outside of the municipal wards were located on the maps and their spatial extents marked using satellite imagery dated to the year 2003.

Using the satellite imagery, the population density maps generated for the municipal areas were re-examined. It was determined that to present a more realistic assessment of population densities and growth patterns, it was necessary to adapt the areas within the municipal boundaries to exclude spaces

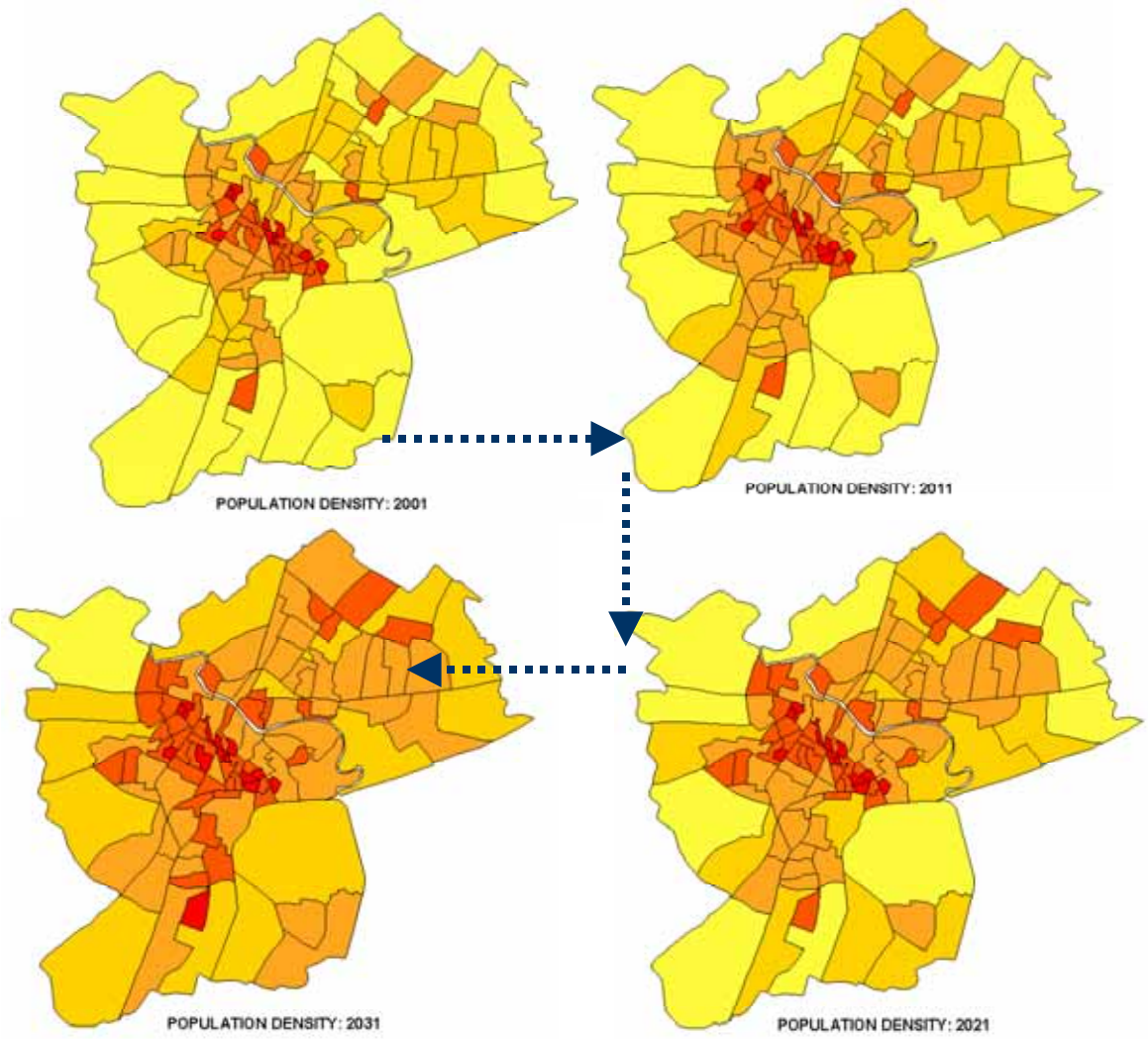
such as that falling in the river channel, the river bed, other water bodies and open spaces. This helped to reassess the areas of each municipal ward to the "developable area" as well as define the development extent outside the municipal limits.

3.2.5 Population Distribution Projections

For the purposes of developing the population dispersion model, the city wards have been characterized to broadly allocate growth rates for each ward. These growth rates have been further refined based on their designated master plan category, current population density, proximity to major road systems, and known development of new housing colonies. This population dispersion approach has been applied to the existing municipal wards and to the peri-urban areas using a temporal growth model that reflects shifting growth patterns radiating away from the city core towards the more open, better planned housing developments, with an inversion bringing back growth into the city by redevelopment of available spaces and lower density development as real-estate increases in value and is complemented by improved infrastructure, as is expected under this project activity as well.

The ward character generally allocated across the study are given below, with modifications to each city based on its unique urban character:

- Core Area: The original city core, in most instances the cultural core as well, which is currently very densely developed
- Low Growth/ Dead Area for Growth/ Not to be included in Sewerage Estimates: areas such as the cantonment boards that are not a current sewerage study concern as well as very high density wards which have far exceeded the master plan densities
- Proximal to Core: Areas proximal to the city core which makes them a preferred place for development
- Outer Area: Areas lying at the outskirts of the city, or away from the city core. Generally having a character of extensive open space with potential for increased development with increased infrastructure and transportation systems.
- Growth Directed By Catalysts: Areas where development is expected to be accelerated due to the intervention of developers and/ or major road network development



Having analysed the available demographic data and the master plan projections, the growth potential outside of the municipal limits were also assessed. Using current satellite imagery data along with the inputs from professionals, planners, and from field observations, the growth patterns were analysed and specific areas of growth identified as complementary to the growth areas within the municipal limits.

3.3 SEWERAGE MASTER PLAN FOR LUCKNOW CITY

3.3.1 General

The methodology of this study has been to determine the least cost approach for meeting Lucknow city's sewerage and pollution control needs. This has involved the consideration of existing infrastructure and proposals by UPJN for GoAP-II, alternative service coverages, alternative technologies, and alternative wastewater treatment and disposal methods. A summary of relevant population, water supply and wastewater data is presented in Table 3.4.

Table 3.4 Project Data Sheet for Lucknow City

(1) Population

	2003	2015	2030
Municipal	2,365,389	3,048,255	4,172,976
(Core area)	793,729	922,551	1,086,280
(Other)	1,571,660	2,125,704	3,086,696
Outside municipal boundary	98,085	557,332	1,251,713
Total	2,463,474	3,605,587	5,424,689

(2) Water Supply

		2003	2015	2030
Population served by municipal system		2,598,000	3,859,000	5,363,000
Demand (UPJN estimated)	mld	447	664	924
Water supply treatment capacity				
Existing	mld	300	300	300
Proposed	mld		364	624
Total	mld	300	664	924
Water sources				
Municipal-river	mld	241	664	924
Municipal-well	mld	193	0	0
Private	mld	47	47	47
Other	mld	10	10	10
Total	mld	491	721	981

(3) Wastewater

		2003	2015	2030
Population in sewer service area		325,530	2,732,594	5,424,689
Population connected to sewer		243,930	1,223,079	4,080,732
Percentage of total population		10%	34%	75%
Wastewater return rate per capita (core)	lpcd	220	190	155
Wastewater return rate per capita (other)	lpcd	115	135	155
Total wastewater generated	mld	367	537	841
Amount intercepted	mld	42	519	841
Treatment capacity				
Existing	mld	42	42	42
Sanctioned	mld		345	345
Proposed	mld		124	468
Total	mld	42	511	855

Lucknow city's population is projected to double from 2.5 million in 2003 to 5.4 million by 2030. At present the total domestic wastewater load is about 367 mld vs. an installed treatment capacity of 42 mld. The amount of wastewater collected and diverted to treatment represents just over 10% of the total amount generated. Remaining wastewater is discharged to Gomti river through open drains. The two largest drains are GH Canal and Kukrail nala.

Water supply and sanitation services are inadequate for Lucknow's present population. The installed raw water treatment capacity is 300 mld, while the total production from all sources is 491 mld. Distribution of water supply is higher in the central core compared to other parts of the urbanized area. Production per capita in the city core is approximately 282 lpcd while in other areas it is only 147 lpcd. Water supply is intermittent, and tube wells are becoming unreliable as the groundwater table continues to drop every year. Adverse sanitation conditions (including defecation in the open) cause increasing hazards to public health.

The sewer infrastructure is old, and poorly maintained. Many of the existing trunk sewers do not have sufficient hydraulic capacity for projected wastewater loads.

3.3.2 Existing and Sanctioned Sewerage Facilities

(1) Existing Facilities

Existing sewerage system in Lucknow may be broadly divided in to two parts, Cis Gomti and Trans Gomti. Two parallel trunk sewers, along the river Gomti, were laid on both the banks of the river, Cis Gomti Trunk Sewer (CGTS) and Trans Gomti Trunk Sewer (TGTS). Both these sewers receive sewage, generated from the city through lateral intercepting sewers.

TGTS starts from the Daliganj No 2 drain and receives discharge from the following sewers: Mohan Meakin, Daliganj, Mukarim Nagar, Art College and University. The sewage from TGPS finally overflows into Gomti river.

CGTS sewer starts from Sarkata nala near western gate of Chota Imambara and receives sewage from the following sewers: Sarkata 'A', Sarkata 'B', Pata, Shahmina Road, Wazirganj, Kutchchary Road, Ghasiari Mandi, Chamber lane, and Ashok Marg. The sewer finally discharges the sewage to the pumping station, Cis-Gomti Pumping Station (CGPS). The sewage from Wazir Hasan Road sewer is also pumped into the sump of CGPS through an auxiliary pumping station located in the same campus. The sewage from CGPS is presently pumped into river Gomti without any treatment.

Currently, one sewage treatment plant with 42 mld capacity exists at Daulatganj, which treats the sewage collected in the District I, upstream of the core area of Cis Gomti.

(2) Sanctioned Facilities

Gomti Action Plan (GoAP) phase I has resulted in the interception and treatment of only about 11% of total present wastewater flows therefore pollution levels in the Gomti river remain high.

The GoAP phase II is aimed at intercepting and treating the remaining wastewater flows discharging into the Gomti river. The following major facilities have been sanctioned for implementation, which include a 345 mld treatment plant at Kakraha, trunk sewer, pumping stations and interception facility at nalas to collect and carry the sewage to the STP.

- Interception and diversion works for nalas
- Rehabilitation of existing sewers and laying of new sewers
- Kukrail rising main from bypass road to MPS at Guari
- Rising main from MPS at Guari to STP at Kakraha
- MPS at Guari
- Rehabilitation of SPS
- STP (UASB and post treatment facility at Kakraha)

3.3.3 Overview of the Master Plan

The sewerage system for Lucknow is planned in four different districts in the Sewerage Master Plan. The following table presents the sewerage districts proposed in the Master Plan. These districts are planned to conform to the topography and existing sewerage system in Lucknow. The characteristics of various sewerage districts, having their own sewage treatment works are described below.

Table 3.5 Sewerage District s Proposed in Master Plan and District-wise Sewage Treatment Plant for 2030 (Lucknow)

District I	Western part of city. The sewage generated from this district drains into existing FAB technology Daulatganj STP.
District II	Southern part of city, south of Sarda Canal. The sewerage generated from this district will be treated in the proposed Khwajapur STP.
District III	City core, Trans Gomti area. The sewage generated from this district will drain into sanctioned Guari MPS for treatment in the sanctioned Kakraha STP. Kakraha STP will also receive a part of wastewater from District IV via existing Cis side interceptor sewer pumping stations until year 2015.
District IV	City core, Cis Gomti area. A part of sewage generated from this district will be intercepted by proposed relief trunk sewer to discharge into proposed Martin Purwa MPS and then to proposed Mastemau STP.

Treatment Plant	District	Status	2003 (mld)	2030 (mld)	Process	Effluent discharge
Daulatganj STP	I	E/A	42	56	FAB	Gomti river
Hardoi Rd LDA Colony	I	P	-	14	FAB	Gomti river
Khwajapur STP	II	P	-	135	UASB++	Irrigation and Sai river
Kakraha STP	III	S	-	345	UASB	Irrigation and Gomti river
Mastemau STP	IV	P	-	305	UASB++	Irrigation and Gomti river
Total			42	855	-	-

E: Existing, A: Augment, S: Sanctioned, P: Proposed, ++ post-treatment

3.3.4 Recommendations

Major interventions are necessary to reduce river pollution and improve sanitation to all the population and to cope with its future growth. The following recommendations are identified in this report:

1) *Rehabilitate main trunk sewers*: This intervention is required to reduce the amounts of wastewater that overflow to surface drains and to reduce the risk of a catastrophic failure. In addition to cleaning and repair of the system it will be necessary to survey the whole system and to store record drawings and data in a readily accessible form (preferably GIS based) to facilitate maintenance and future planning.

2) *Rehabilitate existing pumping stations*: pumping equipment is getting old and is poorly maintained. Pumps and diesel generators should be updated, and operation should be automated. Significant institutional capacity building and reorganisation will be required to ensure sustainable operation and maintenance of the pump stations with emphasis on continuous and reliable operation of diesel generators during power interruptions.

3) *Increase treatment plant and sewer conveyance capacity*: The existing treatment plant at Daulatganj is at present fully utilised. Part of the sewage generated on the Cis and Trans Gomti side of the river is collected in sewers but these are conveyed to the river. Remaining wastewater flow is discharged to drains that flow to the river. New treatment plants and a scheme to intercept all wastewater flows are urgently required to reduce pollutant loads to Gomti river. This

intervention includes: rehabilitation of pump stations, rehabilitation of trunk sewers and lateral sewers in the city district, removing connection of branch sewers to nalas, construction of new nala tappings and increasing the number of household connections to branch sewers.

4) *Extend the secondary sewerage system*: This intervention is required to improve sanitary conditions in the areas of the city that are without sewers. Eventually sewerage should be provided in all urban areas where densities exceed 120 persons per hectare. Conventional waterborne sewerage should only be extended to areas where water supply systems provide a minimum of 135 lpcd.

5) *Implement regulations, collection and treatment systems for on-site sanitation*: Peripheral areas where population densities are less than 120 persons per hectare should be provided with proper on-site sanitation systems. This intervention is also required to improve sanitary conditions and reduce the amount of pathogens in the environment. Systems for collecting and treating septage are required.

Reducing the pollutant loads to water resources and improving the living environment for residents of Lucknow are important issues that can only be addressed by appropriate sanitation and sewerage interventions. These long-term goals can be met by 2030 if sufficient resources are allocated to the construction of sewage treatment plants and wastewater collection systems.

As shown in Figure 3.1 there is at present a large gap between existing treatment capacity and wastewater load. Therefore there is an urgent need to augment and install treatment plants and trunk sewers. These urgent projects should be carried out as Stage I, within 5 to 10 years of adopting the sewerage master plan i.e. 2010 to 2015.

After 2015, the emphasis will be on providing branch sewers and connecting households to the collection system in order to increase the amount of wastewater diverted to treatment plants. As shown in Figure 3.2, the largest component of the cost during Stage I is for trunk sewers and pumping station (excluding branch sewer). At Stage II the largest cost component becomes for branch sewers. Treatment plants are a relatively small part of the overall cost. The total estimated costs are presented in Table 3.6.

Table 3.6 Preliminary Project Costs for Master Plan for Lucknow City

Base year : 2003

Item	Cost (Rs. million)		
	Stage I -2015	Stage II 2016-2030	Total
Trunk sewers (including manholes)	1,361.05	2,567.86	3,928.91
Branch sewers	2,738.50	7,640.26	10,378.76
Pumping stations	1,729.94	1,214.84	2,944.78
Rising mains	65.72	180.38	246.10
Treatment plants	364.40	1,020.00	1,384.40
Replacement of M/E assets	0.00	154.81	154.81
Sub-total	**6,259.61**	**12,778.15**	**19,037.76**
Physical Contingency (20%)	1,251.92	2,555.63	3,807.55
Cost of detailed engineering (15%)	938.94	1,916.72	2,855.66
Cost of project administration (10%) (1)	625.96	1,277.81	1,903.77
Land acquisition	438.00	196.00	634.00
Sub-total	**3,254.82**	**5,946.16**	**9,200.98**
Grand total	**9,514.43**	**18,724.31**	**28,238.74**
Direct Cost (including land acquisition)	6,697.61	12,974.15	19,671.76
House connections	1,353.15	3,459.54	4,812.69

Note (1): 4% preparation + 6% administration during construction

3.3.5 Selection of Priority Projects for Feasibility Study

Priority projects are defined as projects that should be implemented as soon as possible (before 2015) to achieve pollution reduction targets. These projects include diversion of all drains that have been identified as a source of pollution by UPJN. Priority projects have been included in the scope of the Feasibility Study.

Projects that have already been sanctioned by NRCD are not identified as priority projects because it is assumed they will be fully implemented in the near future.

Priority projects: selected for detailed investigations in Feasibility Study are listed as follows:

1) Feasibility of proposed trunk sewers, and pump stations. Confirm and survey proposed alignments, confirm topography, location and invert levels of connecting lateral sewers. Confirm catchment area, projected flow, determine size of pipes and develop profile drawings. If necessary adjust conceptual trunk sewer layout based on topographic surveys. Confirm site of proposed pumping stations and develop preliminary designs.

2) Field survey of existing pumping station: CGPS to determine the physical condition of existing mechanical, electrical equipment, rising mains and sumps. Identify repair or replacement needs. Determine future flows, required size of replacement pumps, sumps and new rising mains if required.

3) Inspect condition of existing TG and CG trunk sewers and prepare a plan with costs for rehabilitation.

4) Feasibility of Mastemau treatment plant for District IV. Confirm and survey site, method of treatment, method of disposal for effluent and sludge. Develop preliminary design for STP including influent pumping station. Investigate feasibility of discharging to irrigation or wetlands.

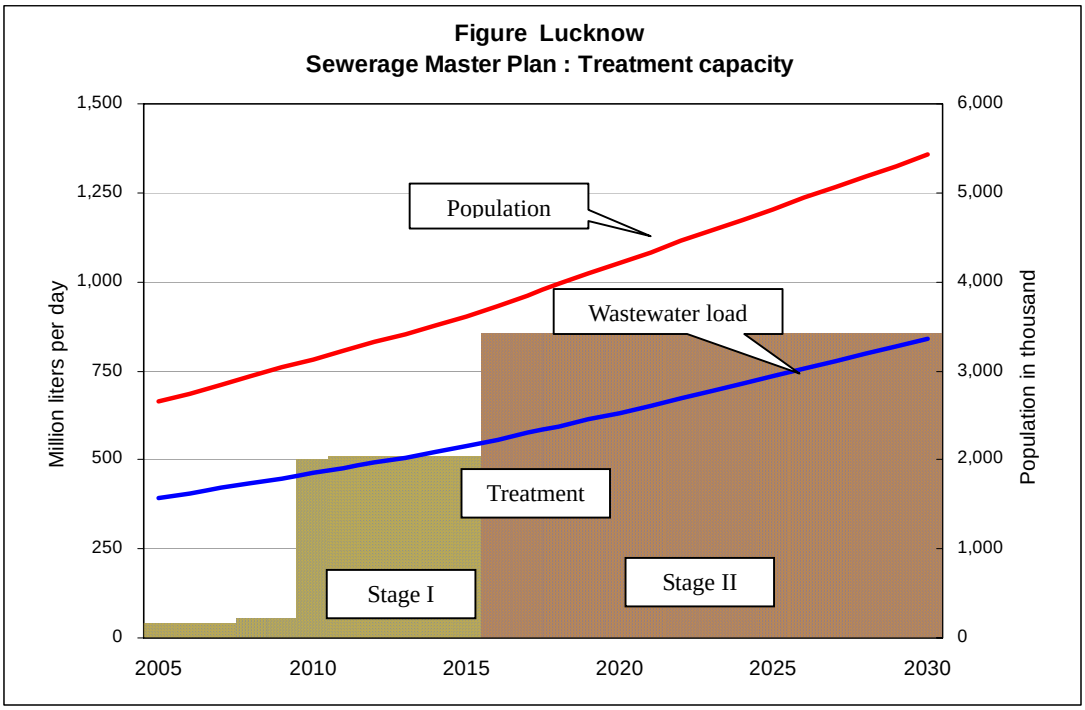


Figure 3.1 Proposed Treatment Capacity for Lucknow City

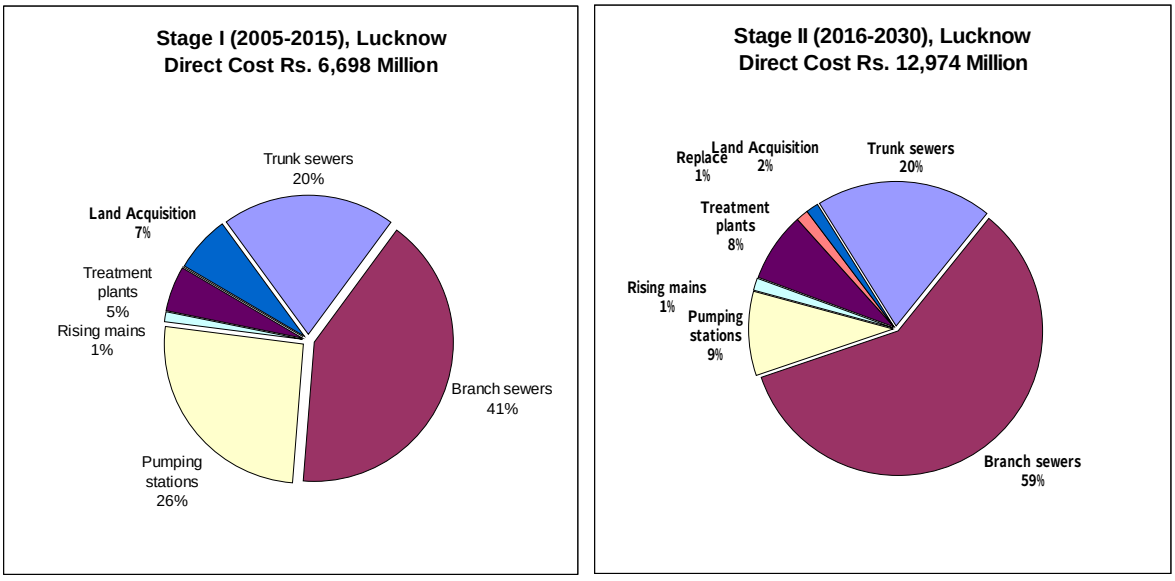
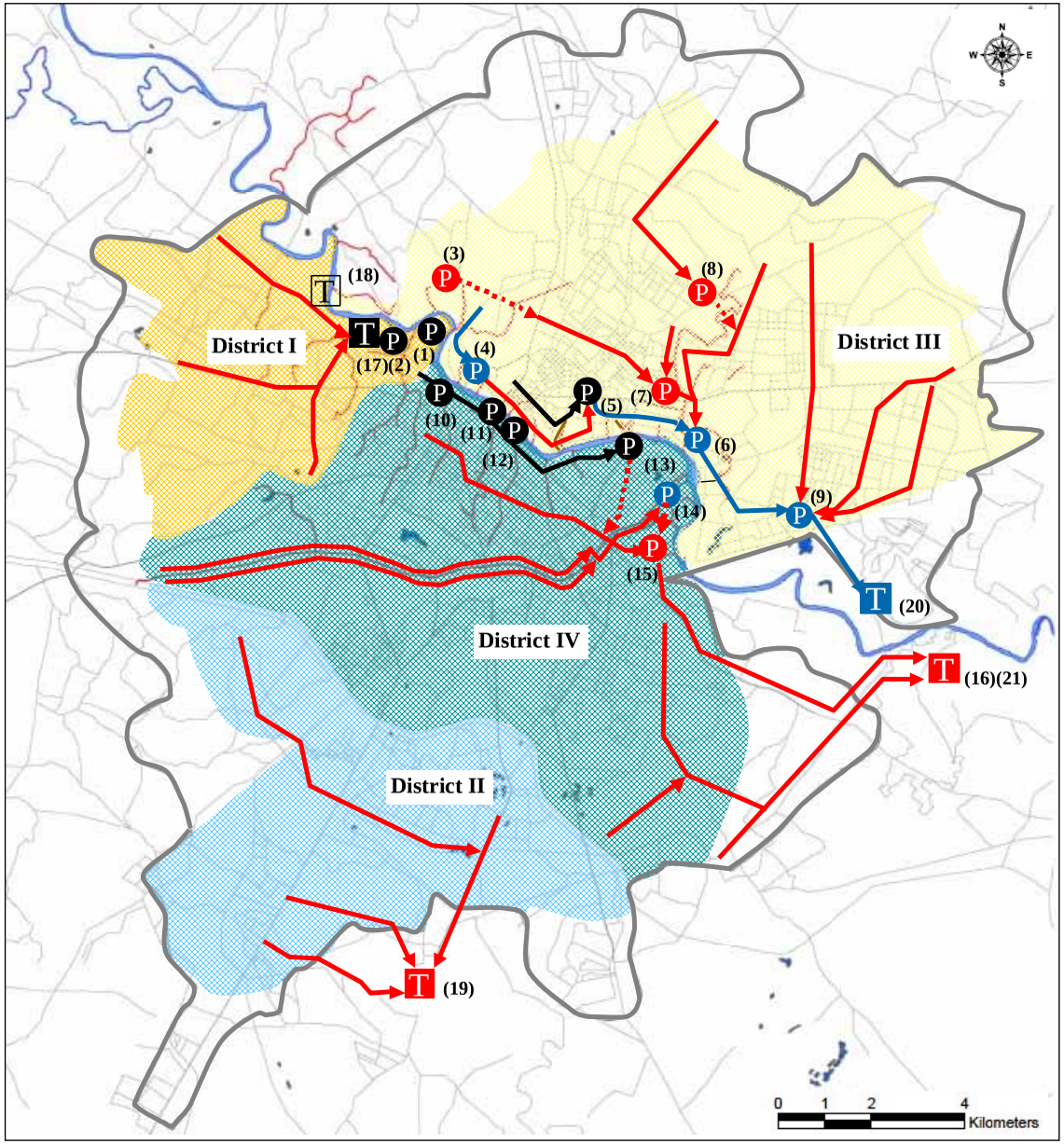


Figure 3.2 Estimated Cost of Sewerage, Breakdown of Direct Construction Cost



Legend

- Municipal Boundary
- Sewer
- Rising Main
- (P) Pump Station
- T Treatment Plant

Black : Existing Facility
Blue : Sanctioned Facility
Red : Proposed Facility

	Pumping Station	District	Status	Remarks
1	Sarkata Nala SPS	I	E	
2	Nagaria Nala SPS	I	E	
3	Lunia Purwa SPS	III	P	
4	Mohan Meakin SPS	III	S	
5	Trans Gomti SPS	III	E/R	
6	Kukrail No.1 SPS	III	S	
7	Kukrail No.2 SPS	III	P	
8	Kukrail No.3 SPS	III	P	
9	Guari MPS	III	S	
10	Pata Nala SPS	IV	E	
11	Wazirganj Nala SPS	IV	E	
12	Ghasiyari Mandi SPS	IV	E	
13	Cis Gomti SPS	IV	E/R	
14	GH Canal SPS	IV	S	
15	Martin Purwa MPS	IV	P	
16	TSPS at Mastemau STP	IV	P	

	Treatment Plant	District	Status	Capacity (mld)	Remarks
17	Daulatganj STP (FAB)	I	E/A	56	Average flow
18	LDA colony STP (FAB)	I	(P) (LDA)	14	
19	Khwajapur STP (UASB + AL)	II	P	135	
20	Kakraha STP (UASB)	III	S	345	
21	Mastemau STP (UASB + AL)	IV	P	305	
Total				855	

E: Existing
S: Sanctioned
P: Proposed
R: Rehabilitation
A: Augmentation
D: Decommision

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PROJECT	LOCATION	Figure 3.3
THE STUDY ON WATER QUALITY MANAGEMENT PLAN FOR GANGA RIVER IN THE REPUBLIC OF INDIA	Lucknow City	Proposed Sewerage System in 2030 (Lucknow)

3.4 SEWERAGE MASTER PLAN FOR KANPUR CITY

3.4.1 General

The methodology of this study has been to determine the least cost approach for meeting Kanpur city's sewerage and pollution control needs. This has involved the consideration of existing infrastructure and proposals by UPJN for GAP-II, alternative service coverages, alternative technologies, and alternative wastewater treatment and disposal methods. A summary of relevant population, water supply and wastewater data is presented in Table 3.7.

Kanpur city's population is projected to double from 2.8 million in 2003 to 5.6 million by 2030. At present the total domestic wastewater load is about 395 mld vs. an installed treatment capacity of 171 mld. The amount of wastewater collected and diverted to treatment is on average 79 mld, and represents less than 20% of the total amount generated. Remaining wastewater is discharged to Ganga and Pandu river through open drains and used for irrigation without treatment. The Pandu river is a tributary to the Ganga with its confluence at approximately 25 km downstream of Kanpur.

Water supply and sanitation services are inadequate for Kanpur’s present population. The installed raw water treatment capacity is 380 mld, while the total production from all sources is 502 mld, corresponding to an estimated 182 lpcd. Water supply is intermittent, and adverse sanitation conditions (including defecation in the open) cause increasing hazards to public health.

The sewer infrastructure is old, and poorly maintained. Many of the existing trunk sewers do not have sufficient hydraulic capacity for projected wastewater loads.

The West District has experienced rapid population growth and development of new colonies. At present population is about 335,800 but there is no formal water supply or sewerage in the area. UPJN is implementing improvements to the water supply system. A barrage on the Ganga is being constructed to secure up to 1,600 mld of raw water for the city. A new water treatment plant and distribution system is at present being implemented to augment supply to the area by 200 mld.

Similarly, water supply improvements have been implemented in the south under the Indo-Dutch project to increase capacity by 42 mld. The amount of wastewater generated in these areas can therefore be expected to increase significantly in the coming years.

Table 3.7 Project Data Sheet for Kanpur City

(1) Population

	2003	2015	2030
Municipal	2,819,827	4,342,031	5,629,081
Outside municipal boundary	0	0	0
Total	2,819,827	4,342,031	5,629,081

(2) Water Supply

		2003	2015	2030
Population served by municipal system		2,733,800	4,000,000	5,629,081
Demand (UPJN estimated)	mld	589	1,067	1,534
Water supply treatment capacity				
Existing	mld	350	350	350
Proposed	mld	28	778	1,337
Total	mld	378	1,128	1,687
Water sources				
Municipal-river	mld	350	1,128	1,678
Municipal-well	mld	112	112	112
Private	mld	40	40	40
Other	mld	0	7	7
Total	mld	502	1,287	1,837

(3) Wastewater

		2003	2015	2030
Population in sewer service area		1,848,335	2,983,898	5,629,081
Population connected to sewer		677,264	1,686,470	4,210,800
Percentage of total population		24%	39%	75%
Wastewater return rate per capita	lpcd	140	145	155
Total wastewater generated	mld	395	630	873
Amount intercepted	mld	259	433	873
Treatment capacity				
Existing	mld	171	171	171
Sanctioned	mld		200	200
Proposed	mld		179	519
Total	mld	171	550	890

3.4.2 Existing and Sanctioned Sewerage Facilities

(1) Existing Facilities

The city of Kanpur's domestic sewage facilities include a collection system and two wastewater treatment plants at Jajmau:

- 5 mld pilot UASB
- 130 mld ASP

The collection system covers about 30 % of the city area and most of this is within the old, densely populated centre core. The total amount of wastewater measured in drains and at the STPs in 1997 was about 370 mld of which 160 mld was intercepted under GAP-I. At present, average inflow to the treatment plants is 79 mld, only about 20 % of the total wastewater generated.

A separate collection system serves the tannery industries located in the Jajmau area conveyed by pumping stations directly to the 36 mld UASB. Originally designed for 9 mld, it now collects approximately 13 mld of tannery wastewater. This mixed with about 27 mld domestic wastewater before treatment in the combined treatment plant.

- 36mld UASB (Combined Effluent Treatment Plant: CETP)

(2) Sanctioned Facilities

GAP-II is aimed at intercepting and diverting the remaining flows of about 210 mld to wastewater facilities being constructed south of the city under Indo-Dutch assistance. The following works have been sanctioned under GAP phase II and are at present under construction:

- Tapping Sisamau nala that discharges about 120 mld of domestic wastewater to Ganga
- Tapping of COD nala, Ganda nala and Halwa Khanda nala that discharge about 50 mld of domestic wastewater to Pandu river which ultimately meet Ganga river at about 25 km downstream of Kanpur.
- Relieving sewers, about 8 km
- Intermediate pumping stations at Munshi Purwa and Rakhimandi to pump about 180 mld
- Trunk sewer along COD nala to proposed treatment plant
- Land acquisition for proposed STP at Bingawan

Projects not yet sanctioned but in the process of sanction are as follows:

- 200 mld UASB STP at Bingawan

3.4.3 Overview of the Master Plan

The sewerage system for Kanpur is planned in four different districts (five zones) in the Sewerage Master Plan. The following table presents the sewerage districts proposed in the Master Plan. These districts are planned to conform to the topography and existing sewerage system in Kanpur. The characteristics of various sewerage districts, having their own sewage treatment works are described below.

Table 3.8 Sewage District Proposed in Master Plan and District-wise Sewage Treatment Plant for 2030 (Kanpur)

District I (Central)	Central part of city core including old city area. The sewage generated from this district drains into existing Jajmau Main Pumping Station, then pumped to existing Jajmau STP located in District I (East). In this district, four pumping stations were commissioned for nala interception and diversion and one pumping station is proposed in this Master Plan.
District I (East)	Eastern part of city core, including cantonment. The sewage generated from this district is conveyed to Jajmau STP same as District I (Central). New trunk sewer is proposed to convey domestic wastewater generated in tannery zone contaminated by tannery industrial wastewater to UASB unit of Jajmau STP separately from domestic wastewater from District I (Central).
District II	Southern part of the city. The sewage generated from this district is to be treated at proposed Bingawan STP. Also sewage generated from a part of city core area is to be diverted via Rakhi Mandi SPS and Munshi Purwa MPS and treated at Bingawan STP.
District III	Western part of the city, newly developing area. The sewage generated from this district to be conveyed to proposed Panki Pumping Station then to proposed Panka STP, effluent to discharge into Pandu river, a tributary of Ganga river.
District IV	Southeastern part of city, undeveloped area. Currently no formal sewerage system exists.

Treatment Plant	District	Status	2003 (mld)	2030 (mld)	Process	Effluent discharge
Jajmau (tannery)	I	E/A	36	52	UASB	Ganga river
Jajmau (domestic)	I	E/A	130	183	ASP	Irrigation and Ganga river
Jajmau (domestic)	I	E	5	5	UASB	Irrigation and Ganga river
Bingawan STP	II	PS/A	-	365	UASB++	Irrigation and Pandu river
Panka STP	III	P	-	200	UASB++	Irrigation and Pandu river
Karankhera STP	IV	P	-	85	UASB++	Irrigation and Ganga river
Total	-	-	171	890	-	-

E: Existing, A: Augment, PS: in process of Sanction, P: Proposed, ++ post-treatment

3.4.4 Recommendations

Major interventions are necessary to reduce river pollution and improve sanitation to all the population and to cope with its future growth. The following recommendations are identified in this report:

1) ***Rehabilitate main trunk sewers*:** This intervention is required to reduce the amount of wastewater that overflow to surface drains and to reduce the risk of a catastrophic failure. In addition to cleaning and repair of the system it will be necessary to survey the whole system and to store record drawings and data in a readily accessible form (preferably GIS based) to facilitate maintenance and future planning.

2) ***Rehabilitate existing pumping stations*:** Pumping equipment is getting old and is poorly maintained. Pumps and diesel generators should be updated, and operation should be automated. The installed capacity at Jajmau pumping station should be increased to improve standby capacity and prevent overflows during peak flow periods. Significant institutional capacity building and reorganisation will be required to ensure sustainable operation and maintenance of the pumping stations with emphasis on continuous and reliable operation of diesel generators during power interruptions.

3) ***Increase the amount of wastewater conveyed to Jajmau treatment plants*:** The existing treatment plant at Jajmau is at present not fully utilised. This intervention is required to reduce pollutant loads to Ganga river and maximise the existing investment in treatment capacity. This intervention includes: rehabilitation of nala tapping pumping stations, rehabilitation of trunk sewers and lateral sewers in the city district, removing connection of branch sewers to nalas, and increasing the number of household connections to branch sewers.

4) ***Implement a separate domestic wastewater collection system in the Jajmau Tannery cluster*:** At present tannery wastewater is finding its way into the domestic wastewater stream and upsetting the activated sludge treatment process. The domestic wastewater collection system from the tannery cluster must be physically separated from other domestic wastewater systems. This can be achieved by installing a separate service collector connected directly to the UASB. Other minor modifications at the treatment plant site may also be required to fully isolate the tannery wastewater stream. The result will be improved performance of Jajmau activated sludge plant and therefore reduction in pollutant loads.

5) ***Install forced aeration in final polishing pond at Jajmau UASB*:** This intervention will reduce the levels of BOD and sulphides, which at present greatly exceed discharge criteria in NRCD standards.

6) ***Provide trunk sewer facilities and treatment plant in West District*:** This intervention is required to improve sanitary conditions and reduce pollutant load. The district is experiencing rapid development and population growth. New water supply projects are being implemented and the amount of wastewater will increase significantly.

7) ***Implement regulations, collection and treatment systems for on-site sanitation*:** Peripheral areas where population densities are less than 120 persons per hectare should be provided with proper on-site sanitation systems. This intervention is also required to improve sanitary conditions and reduce the amount of pathogens in the environment. Systems for collecting and treating septage are required.

Reducing the pollutant loads to water resources and improving the living environment for residents of Kanpur are important issues that can only be addressed by appropriate sanitation and sewerage interventions. These long-term goals can be met by 2030 if sufficient resources are allocated to the construction of sewage treatment plants and wastewater collection systems.

As shown in Figure 3.4, there is at present a large gap between existing treatment capacity and wastewater load. Therefore there is an urgent need to augment treatment plants and trunk sewers. These urgent projects should be carried out as Stage I, within 5 to 10 years of adopting the sewerage master plan i.e. 2010 to 2015.

After 2015 the emphasis will be on providing branch sewers and connecting households to the collection system in order to increase the amount of wastewater diverted to treatment plants. As shown in Figure 3.5, the largest component of the cost during stage I is for trunk sewers and pumping stations. At Stage II, the largest cost component becomes for branch sewers. Treatment plants contribute relatively small part of the overall cost. The total estimated costs are as presented in table below:

Table 3.9 Project Costs for Master Plan for Kanpur City

Base year : 2003

Item	Cost (Rs. million)		
	Stage I -2015	Stage II 2016-2030	Total
Trunk sewers (including manholes)	873.96	3,609.19	4,483.15
Branch sewers	695.48	6,653.07	7,348.54
Pumping stations	1,100.80	893.5	1,994.30
Rising mains	20.17	76.47	96.64
Treatment plants	489.00	1,065.00	1,554.00
Replacement of M/E assets	0.00	299.06	299.06
Sub-total	**3,179.41**	**12,596.29**	**15,775.70**
Physical Contingency (20%)	635.88	2,519.26	3,155.14
Cost of detailed engineering (15%)	476.91	1,889.43	2,366.35
Cost of project administration (10%) (1)	317.94	1,259.63	1,577.57
Land acquisition	288.00	419.20	707.20
Sub-total	**1,718.73**	**6,087.52**	**7,806.26**
Grand total	**4,898.14**	**18,683.81**	**23,581.96**
Direct Cost (including land acquisition)	3,467.41	13,015.49	16,482.90
House connections	830.00	2,840.28	3,670.28

Note (1): 4% preparation + 6% administration during construction

3.4.5 Selection of Priority Projects for Feasibility Study

Priority projects are defined as projects that should be implemented as soon as possible (before 2015) to achieve pollution reduction targets. These projects include diversion of all drains that have been identified as a source of pollution by UPJN. Priority projects have been included in the scope of the Feasibility Study.

Projects that have already been sanctioned by NRCD are not identified as priority projects because it is assumed they will be fully implemented in the near future. Also countermeasures to improve industrial treatment are not included in the scope of works.

Priority projects (listed in order of priority):

1) Develop a plan and identify the cost for inspection of existing trunk sewers and the 90” outfall sewer to Jajmau.

2) Feasibility study to isolate the domestic wastewater collection system in the Jajmau tannery area and treat it at the UASB along with industrial wastewater (to protect the activated sludge process).

3) Feasibility of augmenting the treatment capacity at Jajmau activated sludge treatment plant.

4) Field surveys to confirm alignment, and invert levels of trunk sewers that need to be replaced.

Determine the feasibility of installing a parallel pipe or develop a plan for replacement in the same alignment.

5) Field surveys for the following existing pumping stations:

   - Nawab ganj
   - Muir mill
   - Parmat
   - Guptarghat
   - Jajmau
   - Lakhanpur

   Determine physical condition of existing mechanical, electrical equipment, rising mains and sumps. Identify repair or replacement needs. Confirm catchment areas (existing and future). Determine future flows, required size of replacement pumps and rising mains if required.

6) Field surveys for new pumping station to intercept and divert Bhagwatdas ghat nala in Central District, confirm catchment areas (existing and future). Determine future flows, required size of civil structures, pumping plants and rising mains.

7) Feasibility of Panka treatment plant for West District. Confirm and survey site, method of treatment, method of disposal for effluent and sludge. Develop preliminary design for STP including influent pumping station.

8) Feasibility of Panka outfall sewer, Panki pumping station and main North-South trunk sewers. Confirm and survey proposed alignments, confirm size of pipes, develop profile drawings. Determine feasibility of crossing under Pandu river with gravity sewer; identify river cross section, flood levels and scouring depth. If necessary adjust conceptual trunk sewer layout based on topographic surveys. Develop preliminary designs for proposed pumping stations.

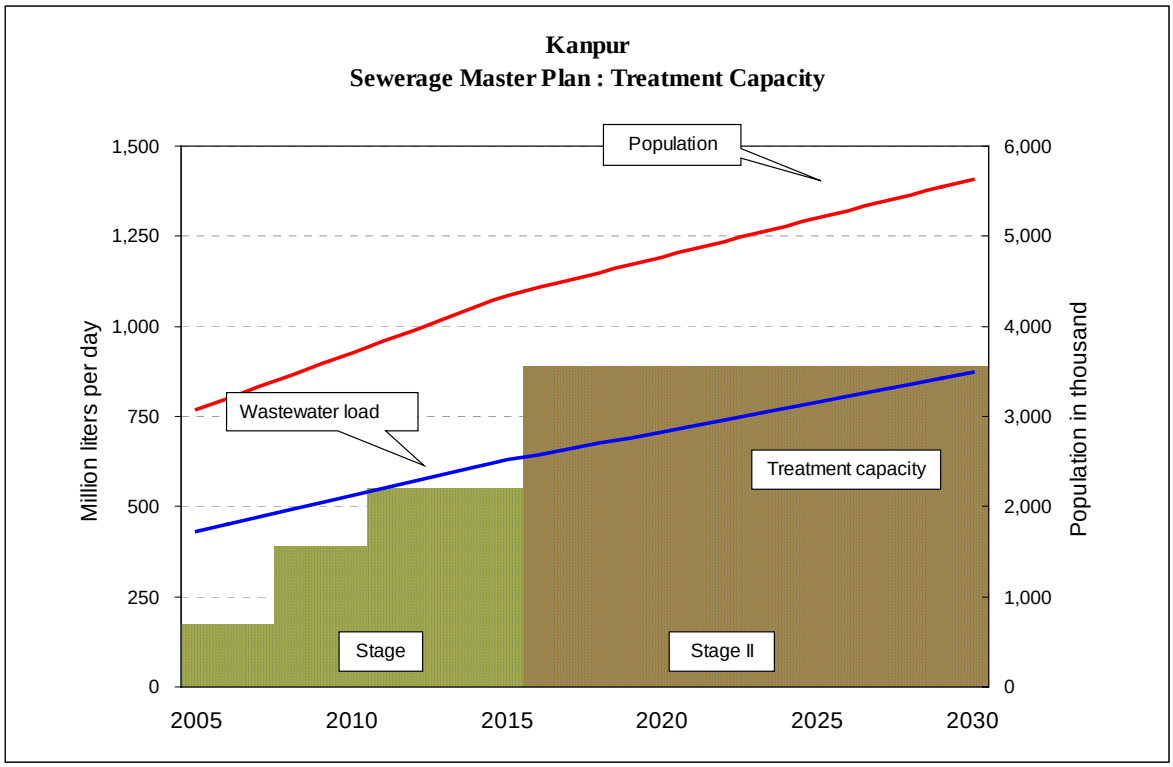


Figure 3.4 Proposed Treatment Capacity for Kanpur City

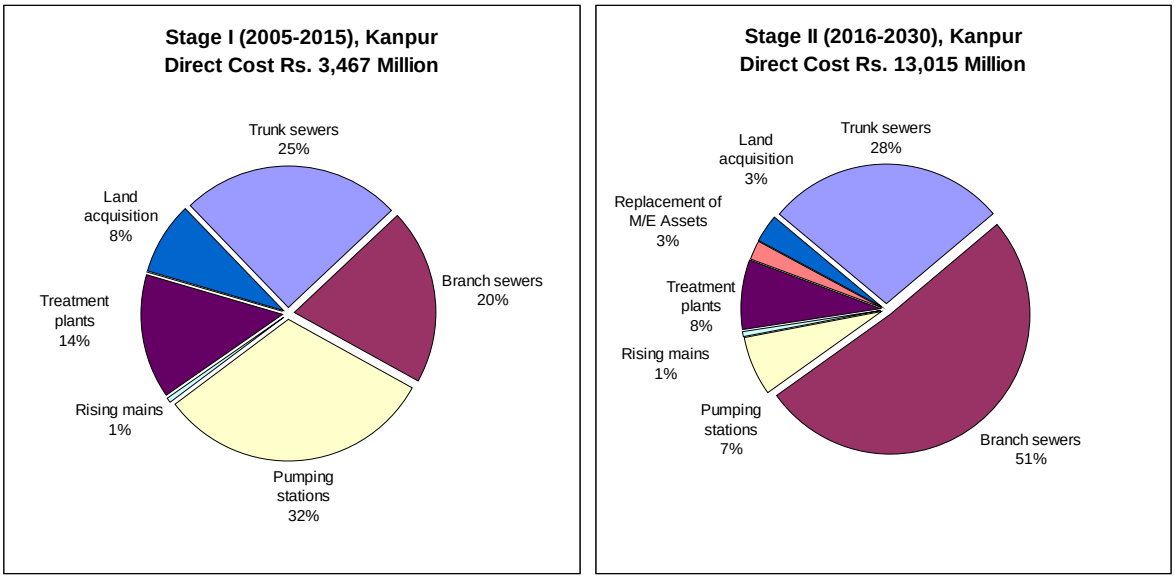
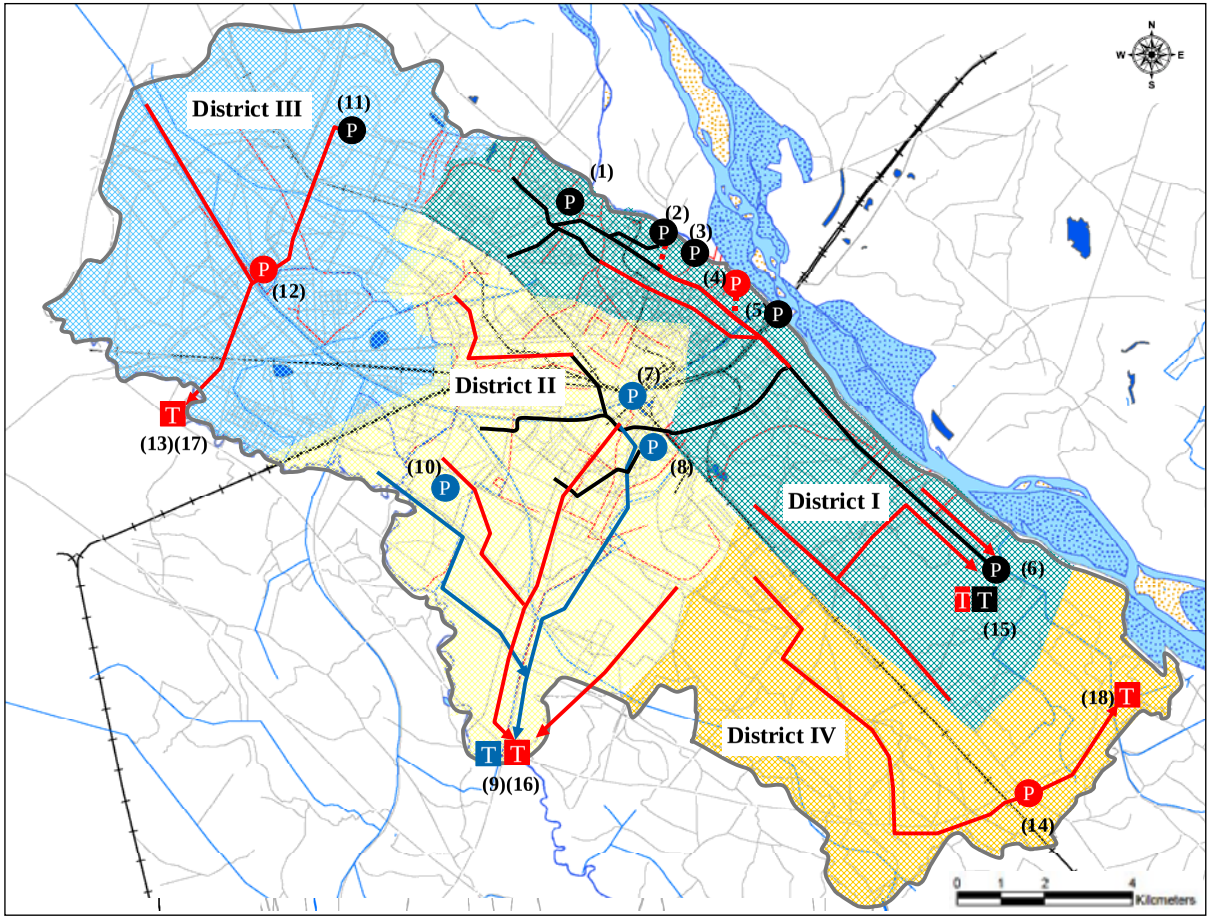


Figure 3.5 Estimated Cost of Sewerage, Breakdown of Direct Construction Cost (Kanpur)



Legend

- Municipal Boundary
- Sewer
- Rising Main
- Pump Station
- Treatment Plant

Black : Existing Facility
Blue : Sanctioned Facility
Red : Proposed Facility

	Pumping Station	District	Status	Remarks
1	Nawabganj SPS	I	E/R	
2	Parmat SPS	I	E/R	
3	Muirmill SPS	I	E/R	
4	Bhagwatdas ghat SPS	I	P	
5	Guptarghat SPS	I	E/R	
6	Jajmau SPS	I	E/R	
7	Rakhimandi SPS	II	S	
8	Munshipurwa SPS	II	S	
9	MPS at Bingawan STP	II	S/A	
10	Ganda Nala SPS	II	S	
11	Lakhanpur SPS	III	E/R	
12	Panki SPS	III	P	
13	MPS at Panka STP	III	P	
14	Ruman SPS	IV	P	

	Treatment Plant	District	Status	Capacity (mld)	Remarks
15	Jajmau STP (ASP)	I	E/A	183	Average flow
	Jajmau STP (UASB)	I	E/A	52	
	Jajmau STP (UASB)	I	E	5	
16	Bingawan STP (UASB + AL)	II	PS/A	365	
17	Panka STP (UASB + AL)	III	P	200	
18	Karankera STP (UASB + AL)	IV	P	85	
Total				890	

E: Existing
S: Sanctioned
P: Proposed
R: Rehabilitation
A: Augmentation
D: Decommision
PS: in Process of Sanction

JAPAN INTERNATIONAL COOPERATION AGENCY TOKYO ENGINEERING CONSULTANTS CO., LTD. CTI ENGINEERING INTERNATIONAL CO., LTD.	PROJECT THE STUDY ON WATER QUALITY MANAGEMENT PLAN FOR GANGA RIVER IN THE REPUBLIC OF INDIA	LOCATION Kanpur City	Figure 3.6 Proposed Sewerage System in 2030 (Kanpur)

3.5 SEWERAGE MASTER PLAN FOR ALLAHABAD

3.5.1 General

The methodology of this study has been to determine the least cost approach for meeting Allahabad city's sewerage and pollution control needs. This has involved the consideration of existing infrastructure and proposals by UPJN for GAP-II, alternative service coverages, alternative technologies, and alternative wastewater treatment and disposal methods.

Allahabad city's population is projected to double from 1.1 million in 2003 to 2.08 million by 2030. A summary of relevant population, water supply and wastewater data is presented in Table 3.10.

At present the total domestic wastewater load is about 226 mld vs. an installed treatment capacity of 60 mld. The amount of wastewater collected and diverted to treatment is on average 66 mld. Remaining wastewater is discharged to Ganga and Yamuna rivers through open drains. The Yamuna river joins the Ganga river at the Sangam confluence, a site that has great spiritual significance for the Hindu faithful. It is used daily for ritualistic bathing and by the multitudes during perennial Mela including the Kumbh Mela which sees the assembly of millions of pilgrims every 12 years. UPJN is at present implementing the construction of a 29 mld sewage treatment plant using FAB technology to treat flows at the tail end of Salori nala which discharges at upstream of the Sangam.

Water supply and sanitation services are inadequate for Allahabad’s present population. The installed raw water treatment capacity is 130 mld, while the total production from all sources is 271 mld, corresponding to 207 lpcd. Water supply is intermittent, and adverse sanitation conditions (including defecation in the open) cause increasing hazards to public health.

The sewer infrastructure is old, and poorly maintained. Many of the existing trunk sewers do not have sufficient hydraulic capacity for projected wastewater loads. Growth is occurring to the west around Lukerganj between Ghaghar nala and Sasur Khaderi river. Growth is also occurring to the north in the Rajapur and Salori nala catchments and south across the Yamuna river. Given the geographical constraints and difficulties in crossing the two rivers it could not be possible to consolidate collection and treatment to centralized facilities. A number of smaller decentralized schemes are proposed under the present Master Plan.

Table 3.10 Project Data Sheet, Allahabad

(1) Population

		2003	2015	2030
Municipal		1,039,429	1,390,856	1,913,712
Outside municipal boundary		51,382	85,662	143,721
Floating		10,394	13,909	19,137
Total		1,101,205	1,490,427	2,076,570

(2) Water Supply

		2003	2015	2030
Population served by municipal system		1,049,800	1,404,700	1,932,850
Demand	mld	210	290	402
Water supply treatment capacity				
Existing	mld	130	130	140
Proposed	mld		10	
Total	mld	130	140	140
Water source				
Municipal-river	mld	80	140	140
Municipal-wells	mld	137	137	137
Private	mld	54	54	54
Other	mld	-	-	-
Total	mld	271	331	331

(3) Wastewater

		2003	2015	2030
Total population		1,101,205	1,490,427	2,076,570
Population in sewer service area		308,340	596,170	1,661,300
Population connected to sewer		200,494	454,885	1,530,827
Percentage of connected population		18 %	31 %	74 %
Wastewater return rate per capita	lpcd	205	175	155
Total wastewater generation	mld	226	261	322
Amount intercepted	mld	60	226	322
Treatment capacity				
Existing	mld	60	60	60
Sanctioned	mld		29	29
Proposed	mld		160	251
Total	mld	60	249	340

3.5.2 Existing and Sanctioned Sewerage Facilities

(1) Existing Facilities

The city of Allahabad's sewage facilities include collection system and a sewage treatment plant at Naini:

- Gaughat pumping station
- Daraganj sewer and pumping station
- Tapping of Mumfordganj nala
- Tapping of Chachar nala
- Partial tapping of Ghaghar nala
- 60 mld sewage treatment plant at Naini

Project activity in GAP-I intercepted and treated only 30% of wastewater flows therefore pollution levels in the Ganga and Yamuna rivers remain high.

(2) Sanctioned Facilities

GAP-II is aimed at intercepting and diverting the remaining flows discharging into Ganga and Yamuna rivers. The following works have been proposed by UPJN for GAP-II:

Sanctioned projects:

- Tapping Salori nala and pumping station
- 29 mld Salori STP with land acquisition for future 101 mld STP

3.5.3 Overview of the Master Plan

The sewerage system for Allahabad is planned in seven different districts in the Sewerage Master Plan (M/P). The following table presents the sewerage districts proposed in the M/P. These districts are planned to conform to the topography and existing sewerage system in Allahabad. The characteristics of various sewerage districts, having own sewage treatment works are described below.

Table 3.11 Sewerage Districts Proposed in Master Plan and District-wise Sewage Treatment Plant for 2030 (Allahabad)

District A	Central part of city core including old city area. The sewage generated from this district drains into existing Gaughat Main Pumping Station, then conveyed to existing Naini STP across Yamuna river.
District B	Western part of city core. The sewage generated from this district to be conveyed to proposed Ghaghar nala Main Pumping Station, then to proposed Numaya Dahi STP. Wastewater intercepted at the tail of Ghaghar nala to be diverted to Numaya Dahi STP.
District C	Northern part of city core, Salori nala basin. The sewage generated from this district drain into Salori nala. Wastewater of Salori nala is to be intercepted and treated at sanctioned FAB technology Salori STP.
District D	Central and eastern part of city core. The sewage generated from this district to be conveyed to Mumfordganj Main Pumping Station then to proposed Rajapur STP to be located on right bank of Ganga river.
District E	Kodara area, newly developing area. Two relatively large nalas flow through this district. Two small STPs at out fall of Kodara nala and Ponghat nala are proposed at the end of these nalas to intercept and treat the wastewater.
District F	Phaphamau area, newly developing area, left bank of Ganga river. A small STP has been proposed in the Master Plan for this area.
District G	Naini area, newly developing area, right bank of Yamuna river. Naini STP for District A is located in this district that is proposed to be augmented. Another STP at Mawaiya is proposed in the Master Plan.

Treatment Plant	District	Status	2003 (mld)	2030 (mld)	Process	Effluent discharge
Naini STP	A	E/A	60	80	ASP	Irrigation and Ganga river
Numaya Dahi STP	B	P	-	50	WSP	Irrigation and Yamuna river
Salori STP	C	S/A	-	35	FAB	Ganga river
Rajapur STP	D	P	-	80	UASB++	Ganga river
Kodara STP	E	P	-	30	UASB++	Irrigation and Ganga river
Ponghat STP	E	P	-	10	WSP	Irrigation and Ganga river
Phaphamau STP	F	P	-	10	WSP	Ganga river
Mawaiya STP	G	P	-	45	UASB++	Ganga river Downstream of the Sangam
Total	-	-	60	340	-	-

E: Existing, A: Augment, S: Sanctioned, P: Proposed, ++: Post Treatment

3.5.4 Recommendations

Major sewerage interventions are necessary to reduce river pollution and improve sanitation to all the

population and to cope with its future growth. The following recommendations are identified in this report:

1) ***Rehabilitate main trunk sewers in District A*** : This intervention is required to reduce the amounts of wastewater that overflow to surface drains and to reduce the risk of a catastrophic failure. In addition to cleaning and repair of the system it will be necessary to survey the whole system and to store record drawings and data in a readily accessible form (preferably GIS based) to facilitate maintenance and future planning.

2) ***Rehabilitate existing pumping stations***: Pumping equipment is getting old and is poorly maintained. Pumps and diesel generators should be updated, and operation should be automated. The installed capacity at Gaughat, Alopibagh, and Lukerganj pump stations should be increased to improve standby capacity and prevent overflows during peak flow periods. Significant institutional capacity building and reorganisation will be required to ensure sustainable operation and maintenance of the pump stations with emphasis on continuous and reliable operation of diesel generators during power interruptions.

3) ***Increase the amount of wastewater conveyed to Naini treatment plants***: The existing treatment plant at Naini has provision for expansion to 80 mld. This intervention is required to reduce pollutant loads to Ganga river and maximise the existing investment. This intervention includes: rehabilitation of Gaughat pump station and rising mains to Naini STP.

4) ***Provide new trunk sewer facilities and treatment plants to serve large population centres****:* This intervention is required to improve sanitary conditions in densely populated areas and reduce pollutant loads. Several districts are experiencing rapid development and population growth. New water supply projects are being implemented and the amount of wastewater will increase significantly. Present sewage treatment capacity is insufficient to meet the projected sewage load therefore new treatment plants are required.

5) ***Implement regulations, collection and treatment systems for on-site sanitation*****:** Peripheral areas where population densities are less than 120 persons per hectare should be provided with proper on-site sanitation systems. This intervention is also required to improve sanitary conditions and reduce the amount of pathogens in the environment. Systems for collecting and treating septage are required.

Reducing the pollutant loads to water resources and improving the living environment for residents of Allahabad are important issues that can only be addressed by appropriate sanitation and sewerage interventions. These long-term goals can be met by 2030 if sufficient resources are allocated to the construction of sewage treatment plants and wastewater collection systems.

As shown in Figure 3.7, there is at present a large gap between existing treatment capacity and wastewater load. Therefore, there is an urgent need to augment treatment plants and trunk sewers.

These urgent projects should be carried out as Stage I, within 5 to 10 years of adopting the sewerage master plan i.e. 2010 to 2015.

After 2015, the emphasis will be on providing branch sewers and connecting households to the collection system in order to increase the amount of wastewater diverted to the treatment plants. As shown in Figure 3.8, the largest component of the cost during Stage I is for treatment plants, trunk sewers and pumping stations. At Stage II the largest cost component becomes for branch sewers. In Stage II, Treatment plants contribute relatively small part of the overall cost. The total estimated costs are presented in table below:

Table 3.12 Project Costs for Master Plan for Allahabad City

Base year : 2003

Item	Cost (Rs. million)		
	Stage I -2015	**Stage II 2016-2030**	**Total**
Trunk sewers (including manholes)	672.89	919.36	1,592.25
Branch sewers	221.08	1,942.42	2,163.50
Pumping stations	478.60	113.90	592.50
Rising mains	218.82	0.00	218.82
Treatment plants	820.00	268.60	1,088.60
Replacement of M/E assets	0.00	86.40	86.40
Sub-total	**2,411.39**	**3,330.68**	**5,742.07**
Physical Contingency (20%)	482.28	666.13	1,148.41
Cost of detailed engineering (15%)	361.70	499.60	861.31
Cost of project administration (10%) (1)	241.14	333.08	574.21
Land acquisition	507.20	113.20	620.40
Sub-total	**1,592.32**	**1,612.01**	**3,204.33**
Grand total	**4,003.71**	**4,942.69**	**8,946.40**
Direct Cost (including land acquisition)	2,918.59	3,443.88	6,362.47
House connections	220.08	1,393.36	1,613.44

Note (1): 4% preparation + 6% administration during construction

3.5.5 Selection of Priority Projects for Feasibility Study

Priority projects are defined as projects that should be implemented as soon as possible (before 2015) to achieve pollution reduction targets. These projects include diversion of all drains that have been identified as a source of pollution by UPJN. The following priority projects have been included in the scope of the Feasibility Study. Projects that have already been sanctioned by NRCD are not identified as priority projects because it is assumed they will be fully implemented in the near future.

(1) District A

- Augmentation of Naini STP from 60 to 80 mld
- Rehabilitation of Gaughat MPS and Chachar nala SPS
- Rehabilitation of existing trunk sewers and installation of new trunk sewers

(2) District B

- Rehabilitation of Lukerganj SPS
- Construction of Ghaghar nala SPS
- Construction of new Numaya Dahi STP
- Installation of new trunk sewer
- Installation of rising main to STP

(3) District D

- Construction of Rajapur STP
- Rehabilitation of Alopibagh and Morigate PS
- Rehabilitation of existing trunk sewers and installation of new trunk sewers and rising main
- Construction of Rajapur nala tapping facility and SPS

(4) District E

- Construction of Kodara nala tapping facility and STP
- Construction of Ponghat nala tapping facility and STP

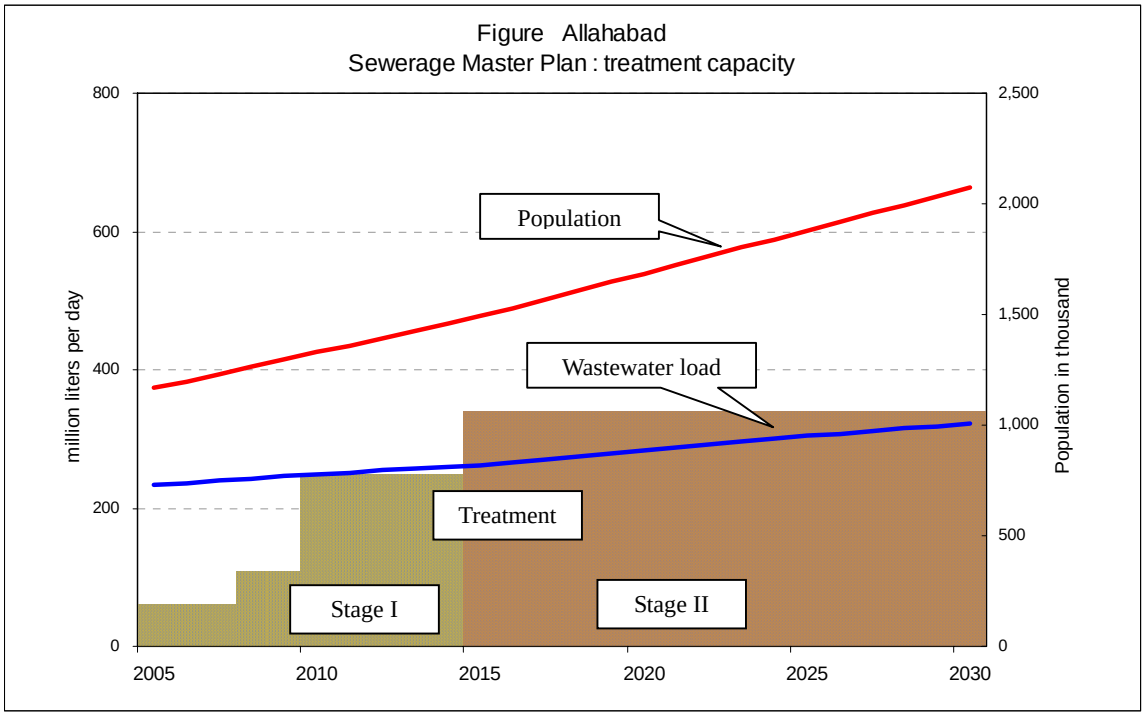


Figure 3.7 Proposed Treatment Capacity for Allahabad City

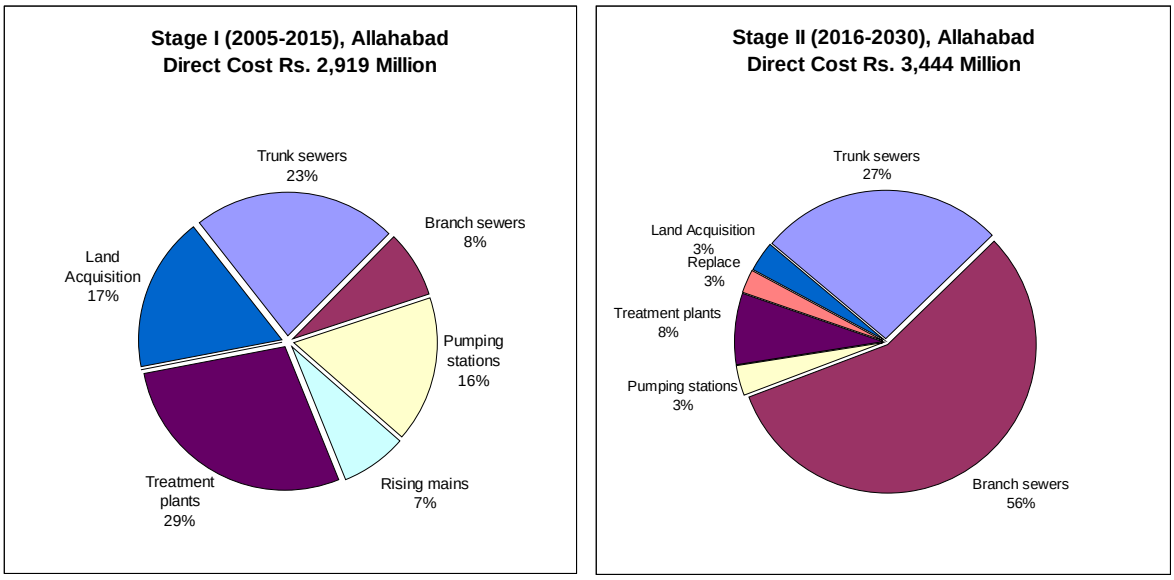
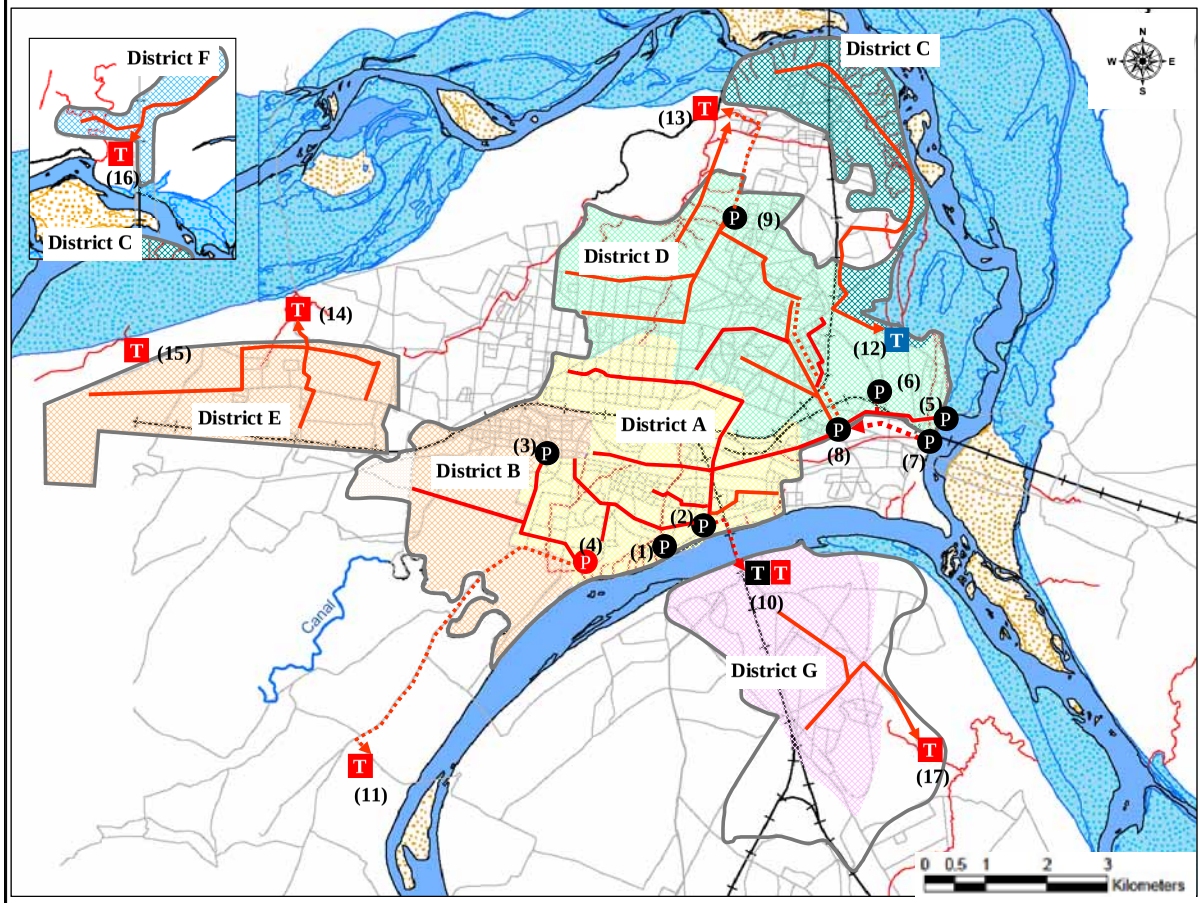


Figure 3.8 Estimated Cost of Sewerage, Breakdown of Direct Construction Cost (Allahabad)



Legend

- Municipal Boundary
- Sewer
- Rising Main
- Pump Station
- Treatment Plant

Black : Existing Facility
Blue : Sanctioned Facility
Red : Proposed Facility

	Pumping Station	District	Status	Remarks
1	Chachar nala SPS	A	E/R	
2	Gaughat SPS	A	E/R	
3	Lukerganj SPS	B	E/R	
4	Ghaghar nala SPS	B	P	
5	Daraganj SPS	D	E/R	
6	Allahpur SPS	D	E/R/A	
7	Morigate SPS	D	E/R	
8	Alopibagh SPS	D	E/R/A	
9	Mumfordganj SPS	D	E/R/A	

	Treatment Plant	District	Status	Capacity (mld)	Remarks
10	Naini STP (ASP)	A	E/A	80	Average flow
11	Numaya Dahi STP (WSP)	B	P	50	
12	Salori STP (FAB)	C	S/A	35	
13	Rajapur STP (UASB + AL)	D	P	80	
14	Kodara STP (UASB + AL)	E	P	30	
15	Ponghat STP (WSP)	E	P	10	
16	Phaphamau STP (WSP)	F	P	10	
17	Mawaiya STP (UASB + AL)	G	P	45	
Total				340	

E: Existing
S: Sanctioned
P: Proposed
R: Rehabilitation
A: Augmentation
D: Decommision

JAPAN INTERNATIONAL COOPERATION AGENCY TOKYO ENGINEERING CONSULTANTS CO., LTD. CTI ENGINEERING INTERNATIONAL CO., LTD.	PROJECT THE STUDY ON WATER QUALITY MANAGEMENT PLAN FOR GANGA RIVER IN THE REPUBLIC OF INDIA	LOCATION Allahabad City	Figure 3.9 Proposed Sewerage System in 2030 (Allahabad)

3.6 SEWERAGE MASTER PLAN FOR VARANASI

3.6.1 General

The methodology of this study has been to determine the least cost approach for meeting Varanasi city's sewerage and water pollution control needs. This has involved the consideration of existing infrastructure and proposals by UPJN for GAP-II, alternative service coverages, alternative technologies, and alternative wastewater treatment and disposal methods.

Water supply and sanitation services are inadequate for Varanasi's present population. Sewer infrastructure is old, and poorly maintained. Water supply is intermittent, and adverse sanitation conditions (including defecation in the open) cause increasing hazards to public health.

A summary of relevant population, water supply and wastewater data is presented in Table 3.13. Varanasi city's population is projected to double from 1.34 million in 2003 to 2.82 million by 2030. At present total wastewater load is about 289 mld vs. installed treatment capacity of 88 mld (80 mld at Dinapur and 8 mld at Bhagwanpur). The amount of wastewater collected and diverted to treatment is only 30 % of the total amount generated. Remaining 70 % of the wastewater is discharged into Varuna river and Ganga river through open drains.

Table 3.13 Project Data Sheet, Varanasi

(1) Population

	2003	2015	2030
Municipal	1,157,510	1,627,540	2,220,700
Outside municipal boundary	126,989	268,518	491,350
Floating	57,874	81,378	111,036
Total	1,342,373	1,977,436	2,823,086

(2) Water Supply

		2003	2015	2030
Population served by municipal system		1,215,480	1,708,900	2,823,086
Demand	mld	232	336	490
Water supply treatment capacity				
Existing	mld	310	310	310
Proposed	mld		200	200
Total	mld	310	510	510
Water source				
Municipal-river	mld	123	510	510
Municipal-wells	mld	143	143	143
Private	mld	67	67	67
Other	mld	7	7	7
Total	mld	340	727	727

(3) Wastewater

		2003	2015	2030
Total population		1,342,373	1,977,436	2,823,086
Population in sewer service area		976,223	1,371,717	2,708,520
Population connected to sewer		435,525	988,718	2,117,315
Percentage of connected population		32%	50%	75%
Wastewater return rate per capita	lpcd	215	185	155
Total wastewater generation	mld	289	366	438
Amount intercepted	mld	210	272	420
Treatment capacity				
Existing	mld	88	88	80
Sanctioned	mld		37	37
Proposed	mld		200	313
Total	mld	88	325	430

3.6.2 Existing and Sanctioned Sewerage Facilities

(1) Existing Sewerage Facilities

The following are major exiting sewerage facilities that were completed by Jal Nigam under GAP-I:

- Five Ghat pumping stations: located along the left bank of the Ganga river.
- Assi main pumping station and rising main to Bhagwanpur
- Konia main pumping station and rising main to Dinapur STP
- Diversion of main trunk sewer to Konia main pumping station
- Sewage treatment works:

  - Dinapur STP: 80 mld
  - Bhagwanpur: 8 mld
  - DLW STP: 12 mld

(2) Sanctioned Facilities

GAP-II is aimed at intercepting and diverting the remaining flows discharging into Ganga and Varuna rivers. The following works have been proposed by UPJN for GAP-II and sanctioned:

- Increase pumping capacity at Harishchandra ghat and Trilochan ghat SPS
- Provide new Ghat interceptor sewers to Trilochan ghat SPS
- Provide new pump station to intercept flows at Nagwa drain.
- New 37 mld STP at Ramna to treat flow intercepted at Nagwa
- Relieving trunk sewer in sub-central district

3.6.3 Overview of the Master Plan

The sewerage system for Varanasi is planned in four different districts in the Sewerage Master Plan (M/P). The following table presents the sewerage districts proposed in the M/P. These districts are planned to conform to the topography and existing sewerage system in Varanasi. The characteristics of various sewerage districts having their own sewage treatment works are described below.

Table 3.14 Sewage District Proposed in Master Plan and District-wise Sewage Treatment Plant for 2030 (Varanasi)

District I	City centre conveying 80 mld of sewage through the existing outfall sewer to Konia MPS and existing activated sludge treatment plant at Dinapur.
District II	Subcentral and Trans-Varuna zone to convey approximately 200 mld to a proposed STP at Sathwa (UASB with post treatment). Wastewater to be diverted away from the city district to relieve flows in the outfall sewer to Konia MPS
District III	South, Assi nala catchment, conveying 8 mld of sewage to Bhagwanpur STP and the balance of the wastewater generated to be conveyed to a sanctioned facultative waste stabilization pond at Ramna.
District IV	Lohta District to convey 50 mld of sewage to a proposed STP near Varuna river (UASB followed by aerated lagoons).

Treatment Plant	District	Status	2003 (mld)	2030 (mld)	Process	Effluent discharge
Dinapur STP	I	E/R	80	80	ASP	Irrigation and Ganga river
Sathwa STP	II	P	-	225	UASB++	Irrigation and Ganga river
Bhagwanpur STP	III	E/R	8	0	ASP	Ganga river
Ramna STP	III	S/A	-	75	WSP	Irrigation and Ganga river
Lohta STP	IV	P	-	50	UASB++	Ganga river through Varuna river
Total	-	-	88	430	-	-

E: Existing, A: Augment, S: Sanctioned, P: Proposed, R: Rehabilitation, ++: Post Treatment

3.6.4 Recommendations

Major interventions are necessary to reduce river pollution and improve sanitation to all the population and to cope with its future growth. The following recommendations are identified in this report:

1) ***Rehabilitate main trunk sewer***: This intervention is required to reduce the amount of wastewater that overflow to surface drains and to reduce the risk of a catastrophic failure. In addition to cleaning and repair of the system it will be necessary to survey the whole system and to store record drawings and data in a readily accessible form to facilitate maintenance and planning.

2) ***Rehabilitate Ghat pumping stations***: pumping equipment is old and poorly maintained. Pumps and diesel generators should be updated, and operation should be automated. Capacity at Harishchandra ghat and Trilochan ghat pump stations should be increased to prevent overflows during peak periods. Significant institutional capacity building and reorganisation will be required to ensure sustainable operation and maintenance of the pump stations with emphasis on continuous and reliable operation of diesel generators during power interruptions.

3) ***Intercept all drains along the Varuna river and divert to treatment***: This intervention is required to reduce pollutant loads to Ganga and Varuna rivers. This intervention includes: interceptor sewer along the left and right bank of the Varuna, nala tapping arrangements, 150 mld pumping station at Chaukaghat and 200 mld treatment plant at Sathwa.

4) ***Eliminate bypass overflows at Konia MPS***: Augmentation of Dinapur STP is not cost-effective. Flows in excess of 80 mld should be diverted to the sub-central district and treated at the new STP in Sathwa. Konia MPS requires the addition of a fourth line of low lift and high lift pumps to improve standby capacity at peak flow conditions. The diversion gate on Rajghat outfall sewer must be rehabilitated and closed to prevent overflows to Ganga river. Operation of the gate must be automated to allow opening in case of emergencies. A low level overflow is required at Konia MPS to prevent surcharging of the main trunk sewer when the screw pumps stop.

5) ***Intercept Assi/Nagwa nala and divert to treatment***: This intervention is required to protect the water supply intake and the bathing ghats. This intervention includes: interceptor sewer along the left and right bank of Assi nala, Nagwa MPS (GAP-II – sanctioned 37 mld) and Ramna STP (GAP-II – sanctioned 37 mld).

6) ***Install disinfection facilities at Dinapur and Bhagwanpur STP***: This intervention will reduce the levels of faecal coliforms in order to meet effluent criteria. In the case of Bhagwanpur this intervention will reduce the risk of contaminating the raw water supply and bathing ghats located downstream.

7) ***Extend the secondary sewerage system***: This intervention is required to improve sanitary conditions in the areas of the city that are without sewers. Eventually sewerage should be provided in all urban areas where densities exceed 120 persons per hectare. Conventional waterborne sewerage should only be extended to areas where water supply systems provide a minimum of 135 lpcd. Small bore sewerage systems should be considered where water supply services are not adequate, for example in trans-Varuna district.

8) ***Implement regulations, collection and treatment systems for on-site sanitation***: Peripheral areas where population densities are less than 120 persons per hectare should be provided with proper on-site sanitation systems. This intervention is also required to improve sanitary conditions and reduce the amount of pathogens in the environment. Systems for collecting and treating septage are required.

As shown in Figure 3.10, there is at present a large gap between existing treatment capacity and wastewater load. Therefore, there is an urgent need to provide treatment plants and trunk sewers. These urgent projects should be carried out as Stage I, within 5 to 10 years of adopting the sewerage master plan i.e. 2010 to 2015.

After 2015, the emphasis will be on providing branch sewers and connecting households to the collection system in order to increase the amount of wastewater diverted to treatment plants.

As shown in Figure 3.11, the largest component of the cost during Stage I is for trunk sewers. At Stage II the largest cost component becomes for branch sewers. Treatment plants are contributing a relatively small part of the overall cost. The total estimated direct costs are as follows:

Table 3.15 Project Costs for Master Plan for Varanasi City

Base year : 2003

Item	Cost (Rs. million)		
	Stage I -2015	Stage II 2016-2030	Total
Trunk sewers (including manholes)	1,749.04	825.04	2,574.08
Branch sewers	413.70	2,110.26	2,523.96
Pumping stations	818.50	380.10	1,198.60
Rising mains	56.43	9.86	66.29
Treatment plants	613.20	285.80	899.00
Rehabilitation of Old Trunk Sewer	612.47	0.00	612.47
Replacement of M/E assets	0.00	86.40	86.40
Sub-total	**4,263.34**	**3,697.46**	**7,960.80**
Physical Contingency (20%)	852.67	739.49	1,592.16
Cost of detailed engineering (15%)	639.50	554.62	1,194.12
Cost of project administration (10%) (1)	426.33	369.75	796.08
Land acquisition	324.00	272.00	596.00
Sub-total	**2,242.50**	**1,935.86**	**4,178.36**
Grand total	**6,505.84**	**5,633.32**	**12,139.16**
Direct Cost(land ac)	4,587.34	3,969.46	8,556.80
House Connection	326.03	990.28	1,316.31

Note (1): 4% preparation + 6% administration during construction

3.6.5 Selection of Priority Projects for Feasibility Study

Priority projects are defined as projects that should be implemented as soon as possible (before 2015) to achieve pollution reduction targets. These projects include diversion of all drains that have been identified as a source of pollution by UPJN. The following priority projects have been included in the scope of the Feasibility Study. Projects that have already been sanctioned by NRCD are not identified as priority projects because it is assumed they will be fully implemented in the near future.

i) Rehabilitation of ghat pumping stations (District I)

ii) Rehabilitation of existing treatment plant and pumping stations (District I and II)

- Rehabilitation of Dinapur STP and Konia PS
- Rehabilitation of old trunk sewer
- Installation of relief trunk sewer (downstream component sanctioned)
- Installation of rising main from Chaukaghat MPS
- Installation of Chaukaghat MPS and Sathwa STP

iii) Measure for sub-central area (District II)

- Installation of relief trunk sewer (Upstream component: downstream has been sanctioned)
- Installation of Varuna interceptor of right bank
- Installation of lateral trunk sewers

iv) Measure for trans-Varuna area (District II)

- Installation of Varuna Interceptor of Left Bank
- Installation of lateral trunk sewers

v) Measures for Assi nala catchment (District III)

- Installation of Assi nala interceptor on both banks
- Installation of outfall trunk sewer to Ramna STP (sanctioned)
- Installation of Nagwa PS (sanctioned)

- Installation of Ramna STP (sanctioned)
- Rehabilitation of Bhagwanpur STP
- Installation of lateral trunk sewers

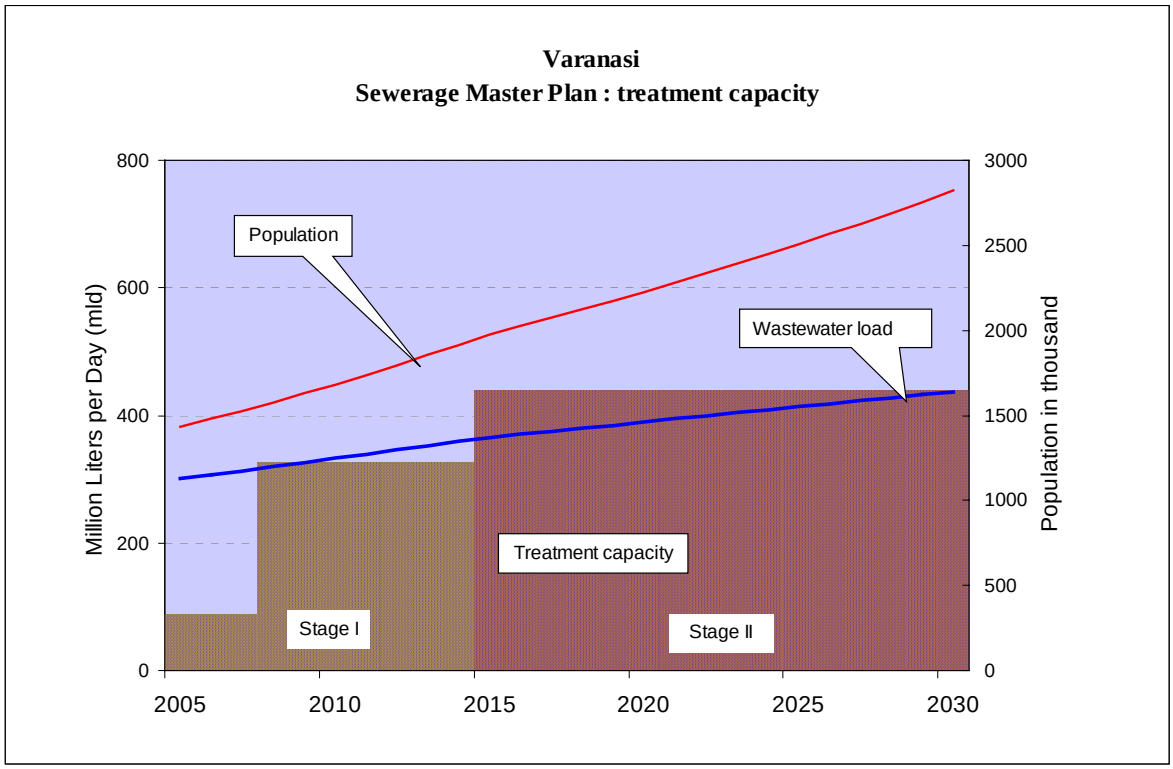


Figure 3.10 Proposed Treatment Capacity for Varanasi City

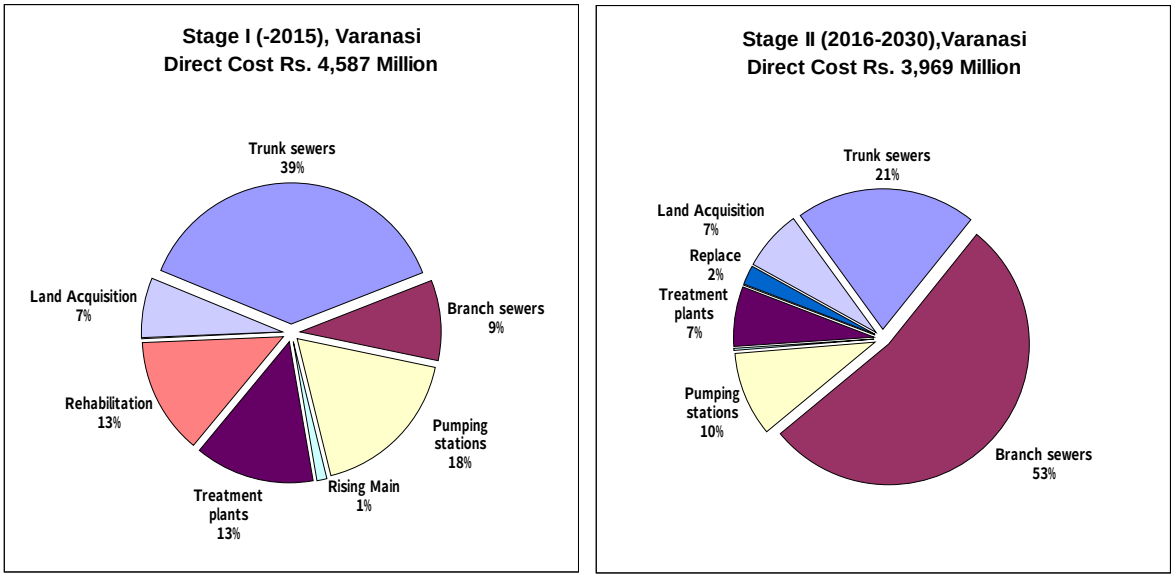
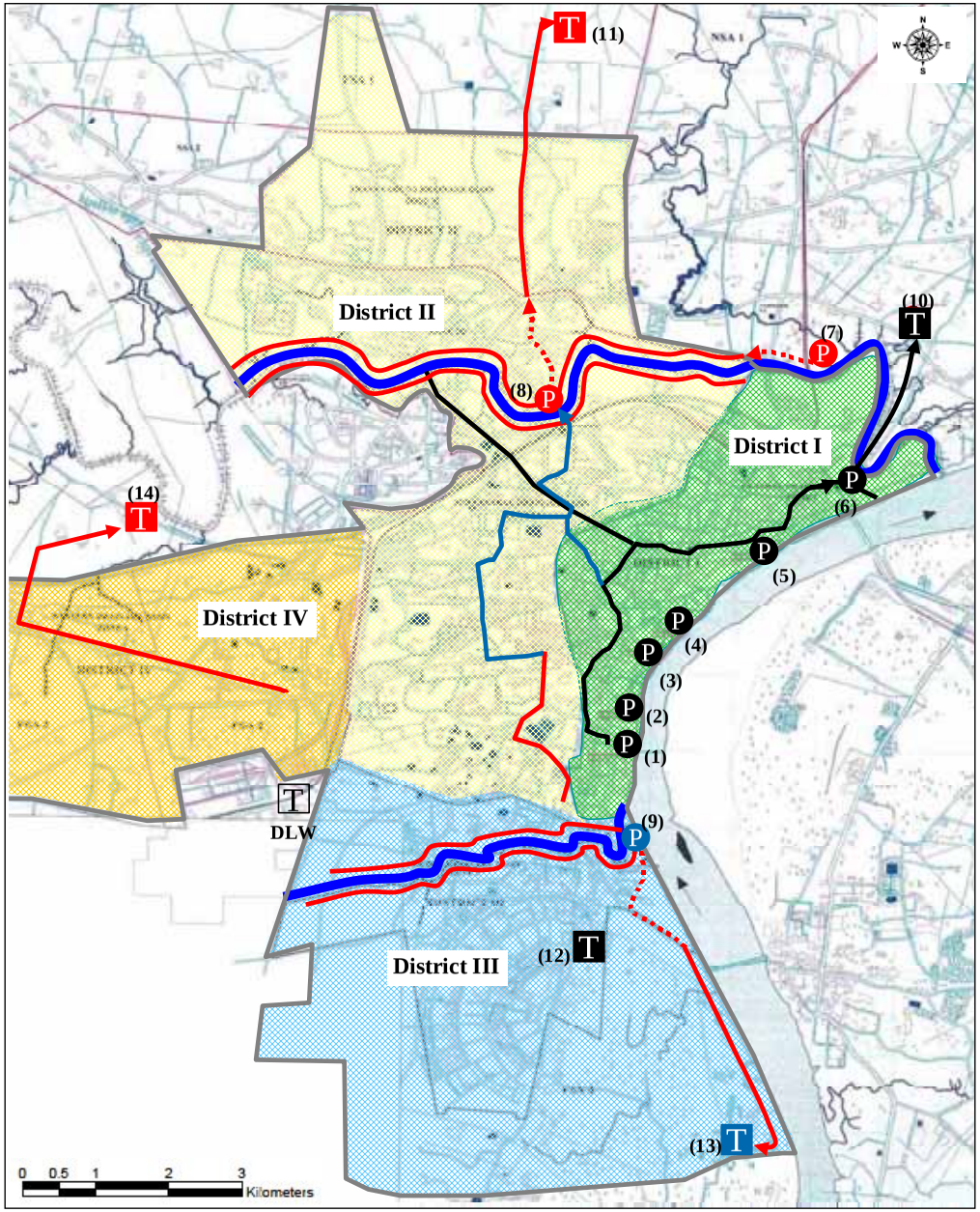


Figure 3.11 Estimated Cost of Sewerage, Breakdown of Direct Construction Cost (Varanasi)



Legend

- Municipal Boundary
- Sewer
- Rising Main
- Pump Station
- Treatment Plant

Black : Existing Facility
Blue : Sanctioned Facility
Red : Proposed Facility

	Pumping Station	District	Status	Remarks
1	Harischandra SPS	I	E/R/A	
2	Mansarovar SPS	I	E/R	
3	Dr. RP SPS	I	E/R	
4	Jalesan SPS	I	E/R	
5	Trilochan SPS	I	E/R/A	
6	Konia SPS	I	E/R	
7	Naroka nala SPS	II	P	
8	Chaukaghat SPS	II	P	
9	Nagwa SPS	III	S/A	

	Treatment Plant	District	Status	Capacity (mld)	Remarks
10	Dinapur STP (ASP)	I	E/R	80	
11	Sathwa STP (UASB + AL)	II	P	225	
12	Bagwanpur STP (ASP)	III	E/R/D	8 / 0	Average flow
13	Ramna STP (WSP)	III	S/A	75	
14	Lohta STP (UASB + AL)	IV	P	50	
Total				430	

E: Existing
S: Sanctioned
P: Proposed
R: Rehabilitation
A: Augmentation
D: Decommision

JAPAN INTERNATIONAL COOPERATION AGENCY TOKYO ENGINEERING CONSULTANTS CO., LTD. CTI ENGINEERING INTERNATIONAL CO., LTD.	PROJECT THE STUDY ON WATER QUALITY MANAGEMENT PLAN FOR GANGA RIVER IN THE REPUBLIC OF INDIA	LOCATION Varanasi City	Figure 3.12 Proposed Sewerage System in 2030 (Varanasi)

3.7 NON-SEWERAGE SCHEME PLAN FOR PROJECT CITIES

3.7.1 General

The non-sewerage schemes are proposed as sanitary, hygienic and aesthetic improvements projects rather than pollution reduction projects because their contributions to the river pollution are not significant compared to sewerage components. The plan of non-sewerage schemes consists of low cost sanitation program and measures for improving sanitary and hygienic condition of the ghat areas. Ghat sanitary improvement measures include low cost sanitation program in ghat area and constructed dhobi ghat program, recommendations on solid waste management, crematoria and cattle wallowing.

3.7.2 Low Cost Sanitation Program For Slum

Open defecation and urination are rampant in the project cities, especially in slum communities and banks of the rivers and nalas, which directly and indirectly pollute the water bodies and cause deterioration of water quality of the rivers and unsanitary conditions.

The objectives of low cost sanitation program are to reduce non-point pollution and improve hygienic and sanitary conditions in the cities, especially in slum communities.

Existing Low Cost Sanitation (LCS) programs, most of which have adopted a supply-driven approach, show disappointing results: i.e. poor operation and maintenance of facility, low usage rate, etc. To provide LCS, it is recommended that new sanitation facilities should be planned and implemented based on demand and needs of the users. The demand-driven LCS program is proposed to provide appropriate sanitation mode. The proposed LCS program consists of two steps;

1) Implementation of pilot project to develop a right process for sustainable LCS
2) Implementation of the full scale project, if the pilot project succeeds

3.7.3 Ghat Sanitary Improvement Plan

The ghat area is unhygienic due to open defecation and urination, throwing of half-burnt/un-burnt dead bodies, laundry activities, cattle wallowing, throwing of offerings, dumping of solid waste, discharge of untreated sewage, etc. The pollution contribution from these activities except untreated sewage discharge is rather insignificant. Measures to tackle untreated sewage are planned in Sewerage Master Plan. The main objective of the Non-sewerage plan for ghat area is to improve hygienic and sanitary conditions and reduce non-point pollution.

3.7.4 LCS Program at Ghats

The current number of Community Toilet Complexes (CTCs) in ghat area is insufficient and open defecation and urination is rampant due to lack of toilet facilities and public awareness. Appropriate number of CTCs at suitable places is required. The planning and implementing procedure is same as the LCS program in slum community.

3.7.5 Constructed Dhobi Ghat Program

To improve the unsanitary condition caused by cloth washing activities at bathing ghats, traditional dhobi ghats shall be moved to inland area with appropriate wastewater treatment mode. The usage rate of existing inland facilities is not satisfactory due to inappropriate location, poor maintenance and improper provision of the facility. It is recommended that the facility should be planned and constructed based on demand and needs of the users. The demand-driven Constructed Dhobi Ghat Program is proposed to provide appropriate laundry facility for dhobis. The proposed program is composed of;

1) Implementation of pilot project to develop a right process for sustainable Constructed Dhobi Ghat
2) Implementation of the full scale project, if the pilot project succeeds

3.7.6 Recommendations on Sanitary Improvement in Ghat Area

(1) Solid Waste Management

Dumping of solid waste in ghat area is rampant. Solid waste management is one of the key issues to improve sanitary condition of the ghat area. However, this issue is not specific in only ghat area but also in the whole city area and, therefore, should be considered in the part of improvement of solid waste management in the whole city. The recommendations for improvement of solid waste management for the whole city are described in Volume III-7. The following measures should be considered for ghat area;

1) Installation of dustbins and garbage boxes
2) Enhance hygiene and environmental education
3) Appropriate solid waste management by public and private initiative, Nagar Nigam and CBO or NGO involvement for cleaning and collection of solid waste

(2) Cremation

Electric and improved wood crematoria have not been very popular and acceptable by the Hindu people so far. It is recommended that new electric and improved wood cremation facilities be not constructed, unless awareness and acceptance of existing facilities are enhanced and the usage rate is increased. In this stage, awareness programmes to enhance the use of electric and improved crematoria are recommended.

(3) Cattle Wallowing

The cattle owners would move their cattle to another place, if the facility such as ponds and Kunds for cattle wallowing is provided nearby their place of activities. The location of such facilities should be decided, if available, in cooperation with local governments and cattle owners. It is also necessary to increase awareness of cattle owners through public awareness campaign. There is currently no organised system and association to control and manage cattle wallowing, thus such monitoring system should be organised.

3.8 INITIAL ENVIRONMENTAL EXAMINATION (IEE) FOR MASTER PLAN PROJECT

The Ministry of Environment and Forests (MoEF) enforced the notification in January 1994 and amended it in May 1997, April 1997, January 2000, December 2000, August 2001 and November 2001 for conducting Environmental Impact Assessment (EIA) studies which are obligatory for the establishment of certain categories of industries specified in Schedule I. The Schedule I industries include 30 categories. The appraisal committees comprising experts, Governmental official and non-government organisations (NGOs) were set up by the MoEF to scrutinise various EIAs prepared for the establishment of such industries and projects. The appraisal committees would accord an environmental clearance to the project in consultation with MoEF after scrutinising the EIA report for the proposed project. Sewerage project is not included in these industries and does not require EIA study according to the Notification.

An Initial Environmental Examination (IEE) for the proposed project components in the Master Plan for the four cities was carried out by JICA Study Team based on a JICA guideline, to briefly identify the impacts of the facilities proposed in the Sewerage Master Plans on natural and social environment. The important environmental issues are identified and the impacts are ranked as (A) strong impact, (B) medium impact, (C) not fully known, and no major impact during the construction and operation stage.

The result of IEE (preliminary scoping matrix and impact identification) is presented in the table below.

The major impacts identified for the proposed facilities are related to construction and operation of sewage treatment plants as given in the table below.

Table 3.16 Major Impact Identified for Proposed Facilities and their Spatial and Time Range

Impact items	Phase	Spatial range	Time range	Range/ affected people
1. Land acquisition for construction of STP	Construction	Agricultural field	Long term	Farmers
2. Income loss of agriculture due to construction of STP in agricultural field	Construction	(Social issue)	Long term	Farmers
3. Landscape and land use change	Construction	Agricultural field	Long term	Nearby villagers
4. Sludge disposal from STP	Operation	Disposal sites	Long term	Disposal sites
5. Contamination of surface water and groundwater by discharging treated effluent and seepage from STP	Operation	River, irrigation canal and groundwater	Long term	Nearby villagers
6. Contamination of soil through application of treated water and dried sludge	Operation	Agricultural field	Long term	Farmers

The proposed projects are, however, in general, environmental mitigation projects by providing sewerage system to properly dispose of municipal sewage. Therefore, the projects themselves have preferable environmental impacts on the water environment and the public health of the residents.

Table 3.17 Scoping Matrix for Project Components
Preliminary Environmental Impacts Identified for the Proposed Project (Lucknow, Kanpur, Allahabad and Varanasi)

Development Scheme \ Environmental Elements		Social Environment									Natural Environment								Pollution					
		Resettlement	Economic Activity	Traffic/Public Facilities	Split of Communities	Cultural Properties	Water Right/Right of Common	Public Health Condition	Solid Waste	Hazard	Topography and Geology	Soil Erosion	Groundwater	Hydrological Situation	Coastal Zone	Flora and Fauna	Local Meteorology	Landscape	Air Pollution	Water Pollution	Soil Contamination	Noise and Vibration	Ground Subsidence	Odour
Sewage Treatment Plant	**C**	B/C	B/C	C					C									B/C				C		
	O							C	C				B/C	C						B/C	B/C	C		C
Pumping Station	**C**	C		C																		C		
	O							C	C													C		
Installation of Main Trunk Sewer	**C**		C	C																		C		
	O																							
Rehabilitation of Existing Trunk sewer	**C**		C	C				C												C		C		C
	O																							

Remarks:

C: Indicates construction (rehabilitation) stage. **O**: Indicates operation stage.
A: Indicates that the development scheme is foreseen to have strong impact on the environmental element.
B: Indicates that the development scheme is foreseen to have some impact on the environmental element.
C: Indicates that the development scheme is foreseen to have minor impact on the environmental element
Balnk: indicates no impact

3.9 PUBLIC PARTICIPATION AND AWARENESS PROGRAMME (SOCIAL CONSIDERATION AND HYGIENE EDUCATION PLAN)

Social consideration and hygiene education plan is intended to acquire cooperation from the various stakeholders on the proposed projects. Particularly, until sewer connections are provided when direct link between benefit of sewerage and sewerage charge is tangible, the project benefit is difficult to be seen for the stakeholders. The proposed projects will surely improve river water quality but not consider the hygiene and sanitary improvement to greater extent. Therefore, public understanding for the projects is strongly required and necessitates the social consideration and hygiene education.

3.9.1 Issues to be considered

The followings issues are identified for preparing effective social consideration and hygiene education plans on a sustainable implementation of sewerage and non-sewerage schemes.

- Lack of a suitable plan and definition on public enlightenment and education on hygiene and sanitation and public participation for river water management projects.

- Lack of clear multi-sectoral cooperation systems for public enlightenment and education on hygiene and sanitation among related ministries, local authorities, private entities, NGOs, CBOs and communities.

- Lack of budgets, basic data, research and development for methodology for public enlightenment and education on hygiene and sanitation and Public Participation activities.

3.9.2 Basic Recognitions

- Human Health and Urban River Environment

Based on present situation of communicable diseases in UP and public opinions identified in the public awareness survey and the community workshops, the human health has priority over ‘urban river environment’ in the preparation order of a hygiene education plan.

- Definition of Hygiene Education

Definition of “hygiene education” handled by the study is given as follows:

- Actions to heighten public awareness on consciousness and notion on health & sanitation.
- Actions to heighten mutual understanding between communities and authorities concerned.
- Actions to heighten recognition of burden sharing for operation and maintenance.
- Actions to heighten public awareness on urban river environment.

3.9.3 Organisations and Approaches

(1) Actors

Appropriate cooperative systems shall be set up to utilise expertise and disciplinarians of related Ministries, Local Government Bodies, NGOs/CBOs and communities, which are considered as actors for implementing related activities on Public Participation and Awareness (PP/PA) based on the hygiene education concept.

(2) Multi-Sectoral Cooperation

1) Effective and flexible implementation

For an effective and a flexible implementation of the multi-sectoral cooperation, the following coordination is necessary.

- To create specific functions or offices for handling hygiene education in each sector, especially in NRCD for urban river water pollution for the future plans and programmes proposed by the JICA Study.
- To coordinate lateral communication among actors
- To open related information to each other

2) Specific functions/offices in NRCD

The proposed organisational arrangements of *'Suggested Institutional Framework for YAP II'* and *'Proposed National Public Participation & Coordination Cell'* are well considered for PP/PA activities under the YAP II. Furthermore, the arrangements could be upgraded as a specific organisational section of NRCD. However, the following expertise and disciplinary should be in any event incorporated into those arrangements

- Public Health and Environmental Sanitation
- Public Education
- Environmental Education as a whole

3) Multilateral cooperation scheme

In order to incorporate those expertise and disciplinary mentioned above into the new function of NRCD, therefore, a multilateral cooperation scheme should be established among NRCD, other relevant department of Ministry of Environment & Forests, Ministry of Human Resource Development, and Ministry of Health & Family Welfare.

(3) Approaches

1) Top-Down Approach & Participatory Approach

In principle, the approach of "top-down" should be introduced to actions of public awareness on 'hygiene education' if mutual trust between authorities and communities is sufficiently satisfied. Meanwhile, a positive participation of the private sector including communities, civil societies and individuals in the related activities is very much important. This participatory approach can be called 'Public Participation'.

2) Public Participation as an Approach

The 'Public Participation' is clarified in the JICA study as follows:

- When communities of the four cities may participate in some form in the projects, and then opinion, intentions and ideas of the communities such as improvement goals of degrees of environmental sanitation and health, the service levels, levels of willingness to pay, urban river cleanliness and so on, are expected to be reflected on these projects.

3.9.4 Basic Concept of Hygiene Education Plan

(1) Stepwise Planning

A stepwise four-terms plan on hygiene education for the four cities of Lucknow, Kanpur, Allahabad and Varanasi between 2004 and 2015 has been proposed and a basic concept of the plan is shown in

Table 3.18 and illustrated in Figure 3.13.

Table 3.18 Stepwise Plan on Hygiene Education

	Terms	Main Awareness to be heightened	Core Themes
1.	Short-Term	To heighten public awareness on consciousness/notion on health & Sanitation	Personal Health and Sanitation (personal issues)
2.	Medium-Term	To heighten mutual understanding between communities and authorities concerned.	Community Issues and Public Participation
3.	Mid and long Term	To heighten recognition of burden sharing for operation and maintenance.	Cost sharing and Willingness to Pay (Urban Issues)
4.	Long-Term	To heighten public awareness on urban river environment	Environmentally Friendly Urban River

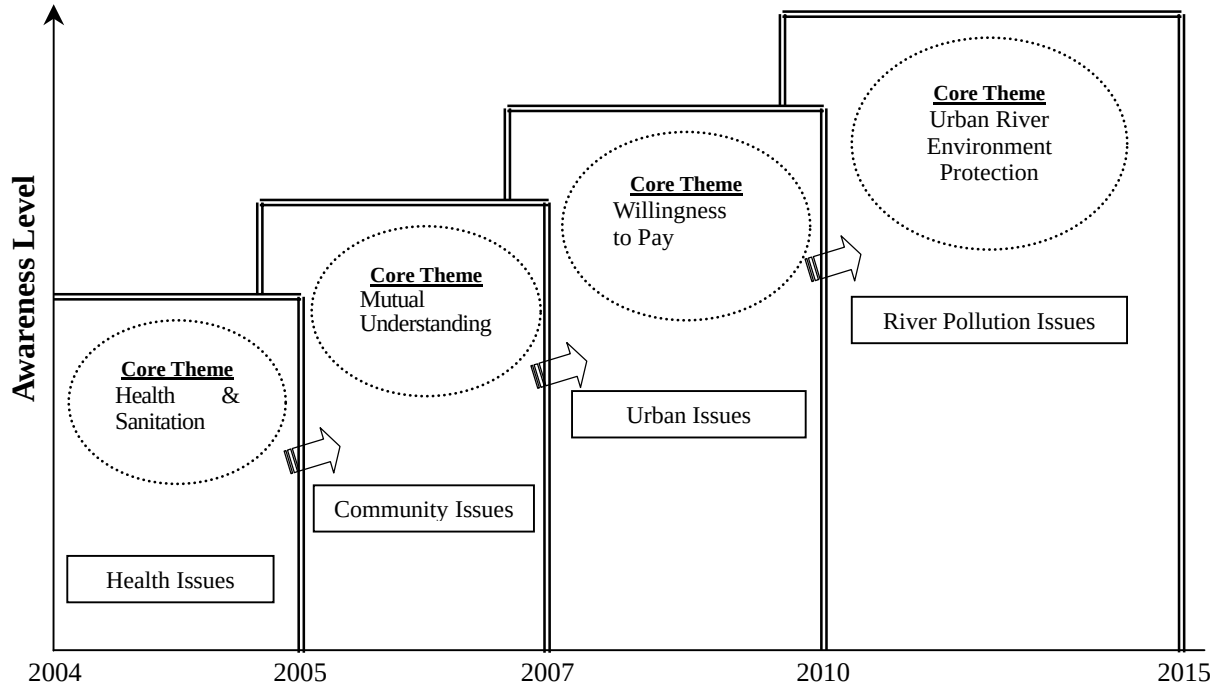


Figure 3.13 Awareness Level of the People

(2) Effort Level and Specific Actions

To attain each target in the stepwise plan of hygiene education, an effort level to be attained by all actors has been illustrated in Figure 3.14.

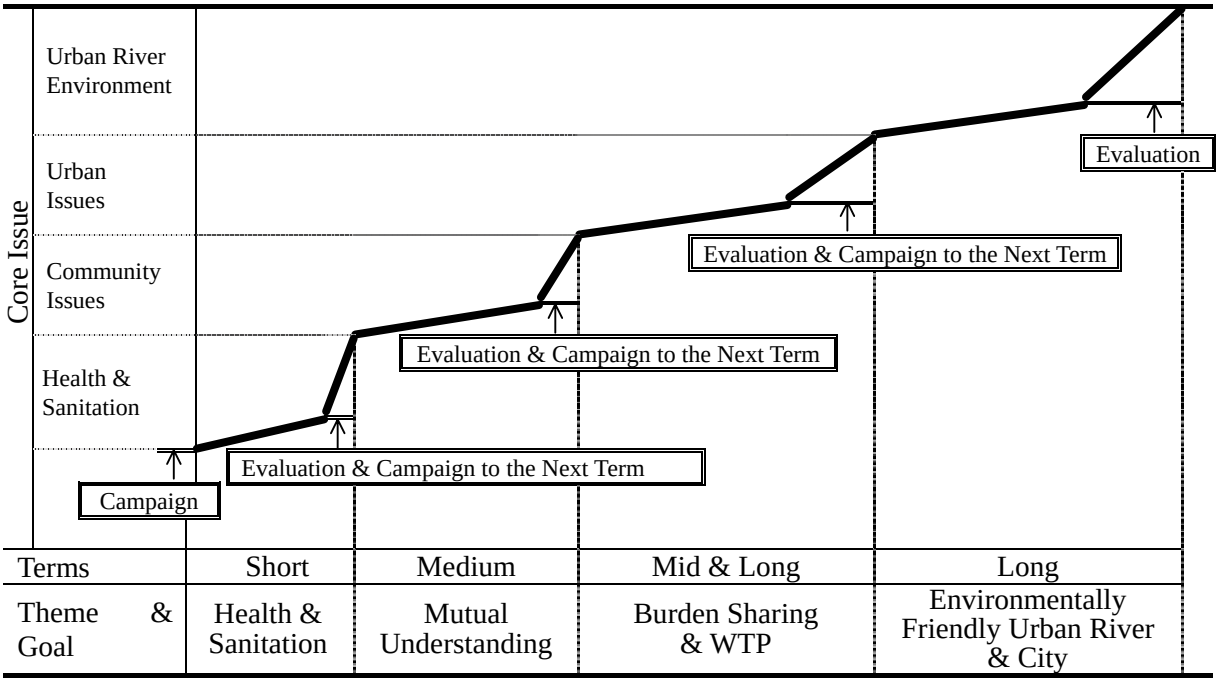


Figure 3.14 Effort Level and Specific Actions

3.9.5 Preparation of Action Plans

Reasonable action plans for such activities are necessary for respective cities of the study area.

For the planning of the actions, several critical points to be considered are identified as follows.

- The actions to be taken shall concurrently implement with sewerage/non-sewerage plans.
- Objectives of the actions and Core theme
- Degree of Participation
- Activities to be implemented
- Target Groups
- Women's Cooperation and Enhancement of Children Awareness
- Languages to be used
- Mutual cooperation among the four cities

Based on the above identification, basic idea of draft action plans on the related activities has been considered for each municipality concurrently with Master Plans of sewerage/non-sewerage schemes that have been proposed by the JICA Study Team.

3.10 RECOMMENDATIONS ON SOLID WASTE MANAGEMENT

The objectives of this sub-study on solid waste management (SWM) are to identify influence of solid waste in the four cities of Lucknow, Kanpur, Allahabad and Varanasi on water quality of Ganga river and to make recommendations to improve the current solid waste management system.

The following are survey observations on solid waste management in the four cities:

1) A total of 89 nalas were investigated to estimate the location and the amount of solid waste dumping in and along nalas. A total of 1,301 solid waste dumping sites were identified in and along the nalas. It is estimated that some 202,000 cubic meters, i.e. 70,000 tons of solid waste is dumped around and into nalas. Of the total volume, solid waste dumped in and along nalas in Allahabad, i.e. 153,000 cubic meters is the largest of four cities and is almost six to fifteen times amount of the other cities while the waste in Varanasi, i.e. 10,000 cubic meters is the smallest.

2) Most solid waste in and along nalas comes from residential waste and its major components are kitchen waste, wrapping paper, plastic bags, etc. Since the residents use nalas to dispose their rubbish in their daily life, almost all places where a bridge is built over the nalas and nalas is flowing in front of or behind houses are utilised as dumping sites.

3) Domestic wastewater is stagnant in many street gutters and small drainage canals or nalas because they are buried by solid waste.

4) Domestic waste is discarded in open spaces since the waste is not collected regularly. Waste is dumped into vacant plots and road shoulders. Although roads are swept in the early morning, they are littered with waste in the same afternoon. Since solid waste is irregularly collected, secondary collection depots are littered with waste. Street animals, such as cows, pigs, goats and dogs, eat domestic waste at primary and secondary collection points, and nalas, and this contributes to reduce the amount of waste to be managed.

5) Large volume of solid waste is disposed into nalas and sewers, which damages sewerage facility and impede appropriate operation and maintenance.

6) All machinery and equipment for the secondary collection are old and some of these cannot be used. Scrap-and-build vehicles are remarkable but almost no material for maintenance is available at workshops.

7) All final disposal sites are located in lowland areas or at places adjacent to rivers and adopt open dumping system without adequate leachate treatment system. The carrying in and dumping of solid waste is not well managed because the boundary of final disposal sites is unclear. Approach roads are unclear, and no or little heavy machinery for placement and compaction is available at final disposal sites.

8) Not so many scavengers were identified at disposal sites because they collect solid waste at primary and secondary collection sites and road litter. Materials collected are mainly plastic shopping bags, rags and glass. Estimated earning from the collected valuable material of a scavenger at disposal sites is Rs. 30 to 50 /day.

Generally, water quality degradation caused by solid waste dumping in and along nalas is minimal compared with a large volume of the untreated domestic wastewater that finds the way to the rivers. From the sanitation point of view, however, it is important to remove solid waste from the living places of residents, such as wastes on roads, gutters and vacant plots, earlier at the primary stage of

solid waste management.

To avoid solid waste dumping in and around nalas and street gutters and mitigate the adverse impact of solid waste dumping on river water quality it is required to keep solid waste out from secondary and primary collection depots appropriately. For this purpose, it is indispensable for sweepers for primary collection depots to transport solid waste to secondary collection depots precisely and regularly, and then solid waste must be carried to final disposal sites without long retention of waste at the secondary depots. The following actions should be carried out to meet this requirement in the first place:

1) Increase of sweepers and their education
2) Improvement in handcarts and collection tools
3) Facility maintenance of secondary collection depots and sweeping of surrounding areas
4) Increase of open dumper trucks
5) Recruitment of loading staff and their education

Currently, some solid waste management plan is available in these four cities but they are not a full-dress master plans. This study therefore recommends that full-scale solid waste management master plans for the four cities be formulated. In formulating solid waste management master plans, the social and economic conditions with a long-term foresight should be considered. In addition, action plans proposed in the Master Plan should be carefully considered step by step and precisely carried out in accordance with financial affordability of each city. In the master plans, capacity building of city officers for solid waste management should be enhanced to carry out the master plan appropriately.

3.11 GIS/ DATA MANAGEMENT/ APPLICATION DEVELOPMENT

3.11.1 GIS Mapping, Analysis and Database Development

The Study on Water Quality Management for the Ganga river basin covers a vast geographic extent. The study area is encompassed between the latitudes of 21.5 deg. North and 31.5 deg North, and the longitudes of 73 deg. East to 89 deg. East. Within this expanse, the defined Ganga river basin for the study measures approximately 857,650 sq. km.

With the help of the GIS and the accompanying database application, it is intended to assimilate study relevant information into a uniform format, enabling systematic data extraction, analysis and mapping to support the different aspects of the study. Of primary focus within the entire work is the assimilation, mapping, and analytical support for the water quality assessment, modelling, and decision support for management plan formulation.

The GIS and database support efforts were directed at two scales:

1) The river basin
2) The most polluted section of the Ganga river covering the cities of Lucknow, Kanpur, Allahabad, and Varanasi.

- River Basin GIS

At the river basin level, the efforts were directed towards collecting broad scale data for the entire basin. These efforts were complicated by the inclusion of border/ restricted areas as a result of which the acquisition and use of Survey of India (SOI) maps was not readily feasible. Available SOI maps in addition to maps from Central Pollution Control Board (CPCB) and National Thematic Mapping Organisation (NATMO) were used as the initial data source to develop an understanding of the region and formulate a seamless GIS database for the study.

The water resources map provided the first river basin wide data source for the Study Team, supplementing the drainage (river and major tributaries) maps from CPCB. Land use coverage for the river basin data is based on information derived from interpretation of WiFS (188 m pixel resolution) satellite data.

Basic information for the Study Team on demographic data in association with administrative boundaries to the district level and locations of urban areas within the basin were used to prepare analyses of proximity and relative importance for pollution loading into the river. A detailed distance based calculation was generated for all 238 large urban centres identified in the study area of the Ganga river basin.

Through an interactive process of mapping monitoring locations of water quality and water flow, from documented sources, information provided by CPCB and CWC, and through repeated interactions with experts from these agencies, the maps representing these locations were accurately established.

Based on the detailed mapping of the river systems through the entire basins, and based on the modelling efforts planned for the study, the 26 sub-basins defined by CPCB were re-delineated as 38 sub-basin. On the basis of these sub-basins, the entire GIS information was analysed and computed for the modelling support. This information, in conjunction with basin wide water quality data and water flow information was used to develop the requisite data and analysis framework for the study.

- City Level GIS

The four cities in this study are Lucknow, Kanpur, Allahabad, and Varanasi. Information for these four cities was developed from Satellite Imagery (LISS and PAN data was blended together to provide multi-spectral 5.8 metre resolution imagery) acquired for National Remote Sensing Agency interpreted with the help of available 1:50,000 and 1:25,000 scale SOI topographic maps. The maps were enhanced by and attributed using the help of the SOI maps, tourist maps, and third-party digital data. This information was verified against SOI maps and through field observations of the team, where possible.

While the satellite imagery base maps and GIS data cover a vast extent, detailed mapping of the major roads and existing sewerage facilities was conducted for the urbanized extents of each city. This detailed mapping covered approximately 200 sq. km. each for Lucknow and Varanasi, 300 sq. km for Allahabad, and 400 sq.km. for Kanpur.

Careful mapping of the information on sewerage systems, nalas, and associated information of capacity, flow, and water quality was created from information provided to the Study Team from UP Jal Nigam and UP Nagar Nigam offices from each of the cities. The information was supplemented from field observations of the study team and was consolidated into the correctly geo-referenced based maps developed. This information provided the basis for establishing spatially accurate information analysis for the four city region as well as developing the water quality modelling efforts at this scale.

3.11.2 City Level Mapping and Sewerage Master Plan Development Support

The GIS database developed under the earlier stage of this study was relocated and deployed at the Lucknow office set up by the Study Team. During this stage of the work a greater emphasis was placed on two parallel activities:

- Population Analysis and Development Distribution
- Sewerage System Master Plan Development

(1) Population Analysis and Distribution

The city level analysis of the existing demographic distribution and projections for future population growth and distribution were supported by the use of GIS. The ward maps of each city were obtained from the respective Nagar Nigam offices, digitised, and associated with the census data made available from the Census Department office in Lucknow. These municipal extents were overlaid on the satellite imagery to assess the relationship between the demographic distribution and the urban landscape.

Using satellite imagery and visual interpretation maps derived from the same, growth directions beyond the city were analysed and peri-urban areas of growth were demarcated which have been included in the study area for each city.

(2) Sewerage Master-Plan Development

The GIS base maps were updated with existing sewerage facilities and drainage features to establish more accurate base maps for the sewerage master-plan development efforts. Using the limited topographical information and field observations, catchments and sub-catchment maps were also developed for each city.

The master-planning efforts used these maps in combination with demographic analysis and growth distribution to plan and locate the major features of treatment facilities and trunk sewers. Iterative re-design of the master plan and analysis using GIS was carried out for each city and the intermediate and final plans documented using GIS.

3.11.3 Web Site Development

A study web site has been developed for this study. This provides basic information about the project to the public. A secure, login section to this web-site has also been developed where project maps developed in the GIS are being uploaded. This will make the maps available to permitted users for viewing, download and printing.

Information on on-going events and planned events will also be provided through this web site.

Figure: Update Home Page of Web Site
http://www.gangajicastudy.com/

3.12 INSTITUTIONAL DEVELOPMENT PROGRAMME

3.12.1 Current Institutional Set-up

The issue of protecting the river pollution falls under the directive of National River Conservation Directorate (NRCD) under the Ministry of Environment and Forests. NRCD has been entrusted with the charge of implementing the river action plans.

On the other hand, the following implementing organisations have been key players for construction, rehabilitation, implementation and operation/ maintenance.

a) Nagar Nigam (Municipal Corporation)	Responsible for surface drains (Construction and O & M)
b) Jal Sansthan (Municipal Water and Sewerage Corporation)	Responsible for sewerage facilities, pumping stations, trunk sewers, (O & M only) and branch sewers construction and O&M
c) Municipal Development Authority	Responsible for construction and O & M of sewerage and drainage facilities on their development areas, located in the urban area inside or outside Municipal area, until the developed area including drainage & sewerage will be transferred to Nagar Nigam
d) UP State Jal Nigam (State Water and Sewerage Corporation)	Responsible for construction of sewerage systems for the city, as well as interception, diversion and treatment facilities which are directly linked with river water quality improvement

The constructed facilities by the UP Jal Nigam are being operated and maintained by UP Jal Nigam itself, for the time being, although it tries to transfer them to Nagar Nigam or Jal Sansthan.

Therefore, UP Jal Nigam is expected to continue, for the time being, as the implementing agency as well as O & M agency. However, after various study we propose the responsibility changes as below for the mid- and long-term basis.

3.12.2 Proposed Institutional Set-up

Institutional alignment, in its broad sense, includes cultural, socio-economic and legal frameworks, organisations and their operational, financial and human resources. The institutional development program covers these issues of the study and intends to present a comprehensive guidance to pursue a sustainable undertaking of the project.

Original requirements for the institutional development program were to set up the city level organisations, which are able to operate and maintain the sewerage and other sanitation facilities properly. In review of the present city office (*Nagar Nigam* and *Jal Sansthan*) and results so far attained under the capacity building projects within the city offices, it is learned that city offices are not capable to raise revenues sufficient for operation of sewerage services or provision of other services under the current local administration set up. City requires transfer of legal jurisdiction and responsibility: and operational, human and financial resources from the State Government. Shift of framework is necessary. This transfer, if implemented, will be in accordance with the National policy of decentralization, devolution and delegation.

Up to now, only “operation and maintenance of facilities” has been focused. It, however, has to be reminded that sewerage and sanitation service, along with other services such as water supply and solid waste disposal, is a public infrastructure service to be provided by the municipality. Now, “sustainable operation and maintenance of the facilities” should be perceived as “sound development of the public services.” The public infrastructure services as such have the common set of objective, principles and guidelines proved elsewhere in the world.

To devise such sound public infrastructure service provider in the municipal office structure, a comprehensive Institutional Development Program (IDP) is proposed. It is also proposed to establish an independent IDP Unit to be created in the UP Department of Urban Development to formulate and implement capacity building in the city offices and local administrative reform to bring about the sound public service providers in cities. It is also suggested that the proposed "Public Service Training Centre" and the IDP Consultant, both of which may be invited by a bilateral assistance programmes, may assist and enhance the efforts of the IDP Unit.

3.13 ECONOMIC AND FINANCIAL ANALYSIS

3.13.1 Economic Evaluation

Economic benefits of the proposed project are identified as follows:

1) Increment of willingness to pay (WTP) for improvement of water quality of the river Ganga estimated by Contingency Valuation Method (CVM)
2) Increment of WTP for improvement of sewerage and sewage treatment systems estimated by CVM
3) Saving of medical expenditure due to decrease of suffering rate of water borne diseases derived from the improvement of water environment
4) Increase in saving due to decrease of suffering rate of water borne diseases also derived from the improvement of water environment, and
5) Contribution to regional economy derived from incremental increase of bathing population at the Ghats along the river Ganga.

Following table shows their estimated unit values.

Table 3.19 Estimated Unit Economic Value of the Proposed Project

As of 2003 Price Level

City	WTP for Improvement of Water Quality of the River Ganga	WTP for Sewage Treatment Services	Incremental Saving of Medical Expenses due to Decrease of Suffering Rate of Water Borne Diseases		Incremental Saving of Salaries/Wages due to Decrease of Suffering Rate of Water Borne Diseases		Contribution to Local Economy Derived from Bathing Population	
			Outpatient	Inpatient	Outpatient	Inpatient	From Regular Users	From Occasional Users
	(Rs./annum per household)						(Rs./annum per person)	
Lucknow	326	1,820	10	125	4	11	-	-
Kanpur	326	1,152	10	130	2	7	-	-
Allahabad	326	512	10	128	3	10	16,425	54,750
Varanasi	326	1,080	12	150	3	9	16,425	54,750

Based on these unit economic benefits and economic costs adjusted from financial costs, an annual cash stream of economic costs and benefits is developed and economic indicators of Net Present Value (NPV) of the Project, Economic Internal Rate of Return (EIRR) and Benefits to Costs (B/C) are estimated as shown in the table below. The projects for Lucknow and Varanasi have more than 5 % of EIRR. The EIRR of the proposed project for Varanasi is quite high as much as 14 % and the project will generate quite large economic benefits, reflecting enhanced economic activities by improvement of water quality of the Ganga and thanks to large bathing population.

Table 3.20 Economic Evaluation for Four Cities (Base Case)

Index	Lucknow	Kanpur	Allahabad	Varanasi
NPV (10%)	-3,026	-2,994	-2,040	5,444
EIRR	6.1%	Negative	Negative	14.2%
B/C	0.70	0.61	0.42	1.8

Note; a discount rate of 10 % is applied to estimate NPV and B/C.

In Master Plan, implementation of public participation and awareness (PP/PA) activities for these projects is planned. Through these activities, WTP for improvement of river water quality is expected to be enhanced. If PP/PA activities enhance the existing WTP by following percentage the project would be economically feasible for Kanpur and Allahabad.

Table 3.21 Enhanced Percentage of Existing WTP to Ensure Economic Feasibility

Index	Kanpur	Allahabad
EIRR 5 %	9 %	20 %
EIRR 10 %	70 %	64 %

It is recommended that the EIRR should be at least 5 % for this kind of projects to establish public utilities of basic human needs.

To obtain at least 5 % of EIRR, the WTP for improvement of river water quality and sewerage service is required to be enhanced by 10 to 20 percent for Kanpur and Allahabad through PP/PA activities.

3.13.2 Financial Evaluation

The current connection rates of household to existing sewerage system are estimated to be about 20-40 % in the four cities. Average annual payment for sanitation service including sewer charge/tax for the four cities is summarised in the following table. The payment for sanitation accounts for about 1.0 to 2.0 % of household income.

City	Household income (Rs./household/annum)	Average annual payment for sanitation service (Rs./household/annum)	Percentage of sanitation payment of total expenditure
Lucknow	184,900	3,046	1.6 %
Kanpur	110,000	2,212	2.0 %
Allahabad	131,000	1,376	1.0 %
Varanasi	125,916	1,857	1.5 %

Source: Volume III-6.

Currently, Jal Sansthans of the four cities collect sewer charge/tax to recover some part of operation & maintenance (O&M) costs of sewerage system. The current collection rate of sewerage charge/tax for the four cities is preliminarily estimated at 75 % of the total bills issued.

Financial evaluation of the project for the 4 cities is conducted under the following conditions:

- Construction, O&M and replacement costs are used as financial cost
- Estimated average annual household expenditure for sanitation is used as financial benefit
- 75 % of sewer charge/tax collection rate
- The discount rate applied for NPV and B/C is 10 %.

The result of financial analysis is summarised in the table below:

Table 3.22 Financial Evaluation for Four Cities

Index	Lucknow	Kanpur	Allahabad	Varanasi
NPV (10%) in million Rs.	- 6,907	- 5,876	- 1,950	- 6,510
FIRR	Not possible to calculate			
B/C (10 %)	0.61	0.65	0.46	0.20

Generally, sewerage projects cannot be financially feasible if all the costs including capital and O&M are to be recovered from user charges. To make sewerage projects viable, usually, government subsidy is required, especially for the capital cost and such subsidy can be justified because of the nature of the sewerage projects that contribute to public health and improve the environment. The evaluation shows that such case is true of the proposed projects for the four cities. Therefore, financial viability of the proposed projects are evaluated assuming the capital cost is paid by government grant and O&M costs

are to be recovered by user charges in principle.

More detailed financial analysis and evaluation are conducted for the proposed priority projects in the Feasibility Study (F/S) Report based on the detailed financial data and information. In addition to the evaluation, effective measures to improve current financial situation to operate and maintain the proposed sewerage system are recommended.