Guidelines for Sanitation Management in Asia and Africa

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List of Abbreviations

AAWSSA	Addis Ababa Water Supply and Sewerage Authority
ADF	African Development Fund
APHA	American Public Health Association
BNR	Biological Nutrient Removal
BOD	Biochemical Oxygen Demand
BOT	Build, Operate and Transfer
CAAC	Catchments Area Advisory Committees
CAS	Conventional Activated Sludge
CBO	Community Based Organization
COD	Chemical Oxygen Demand
CSG	Community Support Group
CSO	Combined Sewer Overflows
EIA	Environmental Impact Assessment
EPA	Environmental Protection Authority
EPB	Environment Protection Bureau
ERSWEC	Economic Recovery Strategy for Wealth and Employment Creation
ESRDF	Ethiopian Social Rehabilitation and Development Fund
ESTs	Environmentally Sound Technologies
KEBS	Kenya Bureau of Standards
KWAHO	Kenya Water for Health Organization
MDGs	Millenium Development Goals
MEWASS	Meru Water and Sewerage Services
MOH	Ministry of Health
MONRE	Ministry for Natural Resources and Environment
MOSTE	Ministry of Science, Technology and Environment
MOWR	Ministry of Water Resources
MPND	Ministry of Planning and National Development
MWI	Ministry of Water and Irrigation
NCC	Nairobi City Council
NCWSC	Nairobi City Water and Sewerage Company

NEMA	National Environment Management Authority
NGO	Non-governmental Organization
NPDES	National Pollutant Discharge Elimination System
NPS	Non Point Source
NWCPC	National Water Conservation & Pipeline Corporation
NWRMS	National Water Resources Management Strategy
NWSC	Nairobi Water and Sewerage Company
NWSS	National Water Services Strategy
ODA	Official Development Assistance
PPA	Participatory Poverty Assessment
PPIAF	Public-Private Infrastructure Advisory Facility
PPP	Purchasing Power Parity
PRSP	Kenya's Poverty Reduction Strategy Paper
PRSPs	Poverty Reduction Strategy Papers
RBC	Rotating Biological Contactors
SBRs	Sequencing Batch Reactors
SDPRP	Sustainable Development and Poverty Reduction Paper
SEPA	State Environmental Protection Administration
SPC	Statistical Process Control
SS	Suspended Solids
SSPs	Small Scale Providers
STW	Sewage Treatment Works
SWPA	State Environmental Protection Administration
TSS	Total Suspended Solids
TVIEs	Township and Village Industrial Enterprises
UN-HABITAT	United Nations Human Settlements Program
UNCHS	United Nations Centre for Human Settlements
UNEP	United Nations Environment Program
UNICEF	United Nations Children's Fund
UV	Ultraviolet
WAB	Establishment of the Water Appeals Board
WEHAB	Water, Energy, Health, Agriculture and Biodiversity
WHO	World Health Organization
WPCS	Water Pollution Control Section

WRDF	Water Resource Development Fund
WRMA	Water Resources Management Authority
WRMP	Water Resource Management Policy
WRUA	Water Resource Users Associations
WS	Waste Stabilization
WSBs	Water ServiceS Board
WSDP	Water Sector Development Programme
WSP	Water and Sanitation Program
WSPs	Water Services Providers
WSRB	Water Services Regulatory Board
WSS	Water and Sanitation Serviced
WSSD	World Summit on Sustainable Development
WSSDP	Water Supply and Sewerage Development Programme
WSTF	Establishment of the Water Services Trust Fund
WUAs	Water User Associations water user associations

1 Introduction

Preamble

"Guideline for sanitation management in Asia and Africa" is the first comprehensive report on the sanitation management in Asia and Africa. This report presents information on the status, policies, regulations and actions (including master plan) in the Asia and Africa for sanitation (wastewater) management. Recently, it has been estimated that more than half of the world population live in Asia and Africa. In these regions, sanitation (wastewater) management including wastewater treatment (WWT) facilities (sewer lines and sewage treatment plants) is one of the major health hazard sources in most of the urban and rural areas. Water quality is deteriorating in many places because of the lack of access to improved sanitation. Some cities in the developing world treat only 10 % of their sewage, while some 2.4 billion people do not have adequate sanitation. As a result, many people are facing enormous health crises and subsequently about 6,000 children die everyday.

In the case of Asia, especially the Asia-pacific region, this is home to more than half the world population. According to the report of Water and Sanitation in the World's Cities, the water coverage of urban dwellers without 'improved' provision in Asia is 7 % with 98 million in 2000 and the sanitation coverage of that is 22 % with 297 million. In the case of Africa, approximately 15 % of urban dwellers in Africa do not have access to adequate water supply with 44 million and the sanitation coverage of urban dwellers is 16 % with 46 million [1]. Sanitation (wastewater) is very closely linked to good health and human survival. The proper management of sanitation, however, also has a pivotal role in generating economic growth and reducing poverty, achieving food security, improving environmental health conditions and protecting ecosystems. Several attempts have been made by countries in Asia and Africa regions to address the problems caused by improper sanitation management. However, as yet, no significant progress has been achieved.

Purpose

In general, the term 'sanitation' is understood as the services and facilities required in ensuring a healthy, user friendly, and convenient management of human wastes at the personal level, i.e., in and around the household [2]. According to the Concise Oxford Dictionary, "sanitation" refers to all conditions that affect health, especially with regard to dirt and infection and specifically to the drainage and disposal of sewage and refuse from houses. In this report, the term 'sanitation' is defined as the water originated from wastewater including domestic, industrial, and sewage.

The purpose of this proposed project is to develop guidelines for the sanitation management in Asia and Africa by assessing, reviewing, and analyzing the present situation of wastewater pollution for urban and rural areas and the existing sanitation management policies and strategies in these regions. All procedures of this research are described in Figure 1.

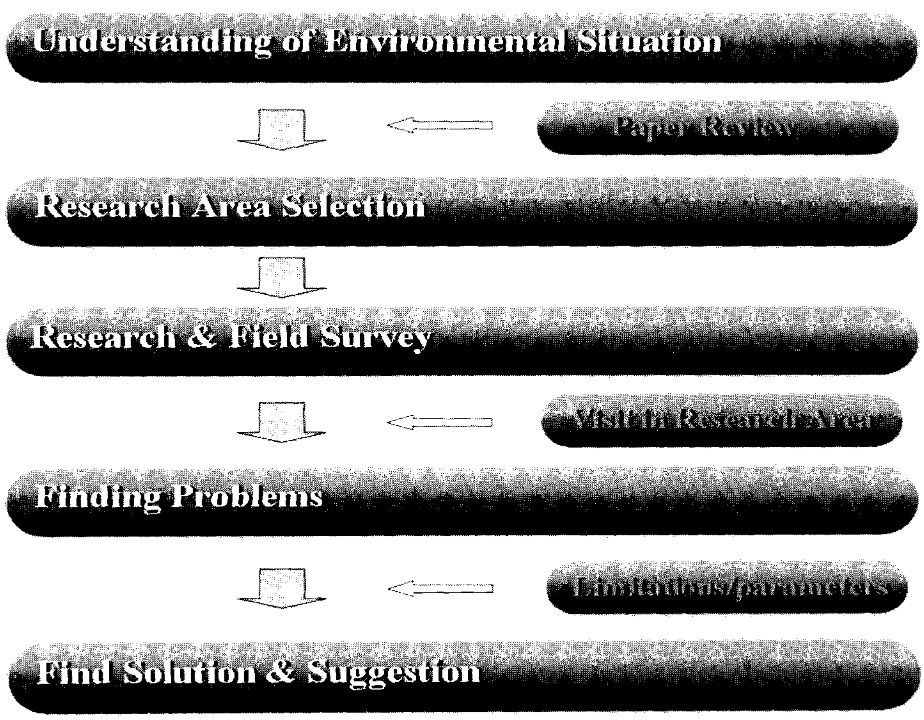


Figure 1.1 Procedures of this research

This report is designed to be a reference manual for articulating the various elements of the evolving sanitation management outlined in developing countries. These elements are as follows:

- Analysis and evaluation of the status of sanitation management in research areas.
- Approach to develop the strategic framework for sanitation management.
- Development of matrix for the available technology selection.

It is expected that the new strategic framework for sanitation management in Asia and Africa is the first comprehensive solution on the overall sanitation management in developing countries.

Water-related Challenges

Water is one of the most important natural resources that are essential to the human life. Water is closely related with health, well-being and development. The abundance of water means healthy life and development whereas the lack of water means poor health and poverty. Every year, more than 5 million people die worldwide as a result of poor water quality and more than half of the victims are children. The lack of water will seriously undermine food production, environmental conservation and economic development. On the other hand, Water demand increases to meet the growing needs for agricultural production and industrial expansion.

A series of global conferences, meetings and events focusing on freshwater resources and sustainable development have taken place over the past three decades. Through these meeting and events, an extensive knowledge base on water-related issues has been built. Major decisions and recommendations have been made, most recently in the framework of the Millenium Development Goals (MDGs) and World Summit on Sustainable Development (WSSD) goals and targets. Yet most water problems remain. The increasing freshwater demands of an expanding global population continue to outstrip the investment and infrastructure needed to accomplish the goals, particularly in developing countries. Stronger and more concerted efforts are clearly required on the part of governments, UN agencies and other water stakeholders to overcome the primary constraints to implementing the recommended actions in a timely and effective manner.

Implementation of the various recommendations on water supply and sanitation that have come out of international conferences and meetings over the last 20 years has been extremely slow. The fact remains that the state of the world's water is still fragile and its sustainable use and management has been far from satisfactory. The overall progress has been uneven: industrial countries, in particular, have not gone enough in helping the developing world come out of the poverty trap. Despite the slow progress, however, over the past 10 years some 900 million people have gained access to water supplies and 985 million to sanitation.

Recent Data on Water Supply and Sanitation Worldwide

Access to the improved water supply and sanitation is absolutely crucial to human health while the availability of a reliable water supply and sanitation infrastructure helps protect water resources from overexploitation and pollution. During 1990-2000, the percentage of the world population with access to improved water supply and sanitation rose from 78 to 82 % and 51 to 61 % respectively according to the WHO/UNICEF 2003. However, despite the progress achieved, in 2000, about 2.4 billion people still lacked access to improved sanitation and 1.1 billion people lacked access to safe drinking water respectively [3].

Access to sanitation services in rural areas is even more problematic: only 31 % of rural inhabitants in developing regions (compared to 73 % of urban dwellers) are estimated to have access to any type of improved sanitation. Some 2 out of 2.6 billion people currently without access to improved sanitation live in rural areas. On the other hand, since almost all the future population will take place in cities of the developing world, new sanitation approaches for urban areas are urgently needed. The status of sanitation is particularly serious in informal settlements, where the coverage is extremely low and the untreated human waste is contaminating the water supply and the environment with severe impacts on human health.

2 Understanding Status of Environmental Management in Asia and Africa

2.1 Asia

Asia (Figure 2.1) is one of the areas with huge population, and recently, concerns over environmental issues in this part of the world have been raised. In this report, China and Vietnam in Asia are selected as research areas. This is because these two countries have rapidly growing economies in Asia and their environmental issues including sanitation have been considered as serious following a series of industrial development and lack of infrastructure in water supply and sewerage. More so, the environmental gap between urban and rural areas has become increasingly wider and it is thus urgent to understand this phenomenon and find a solution.

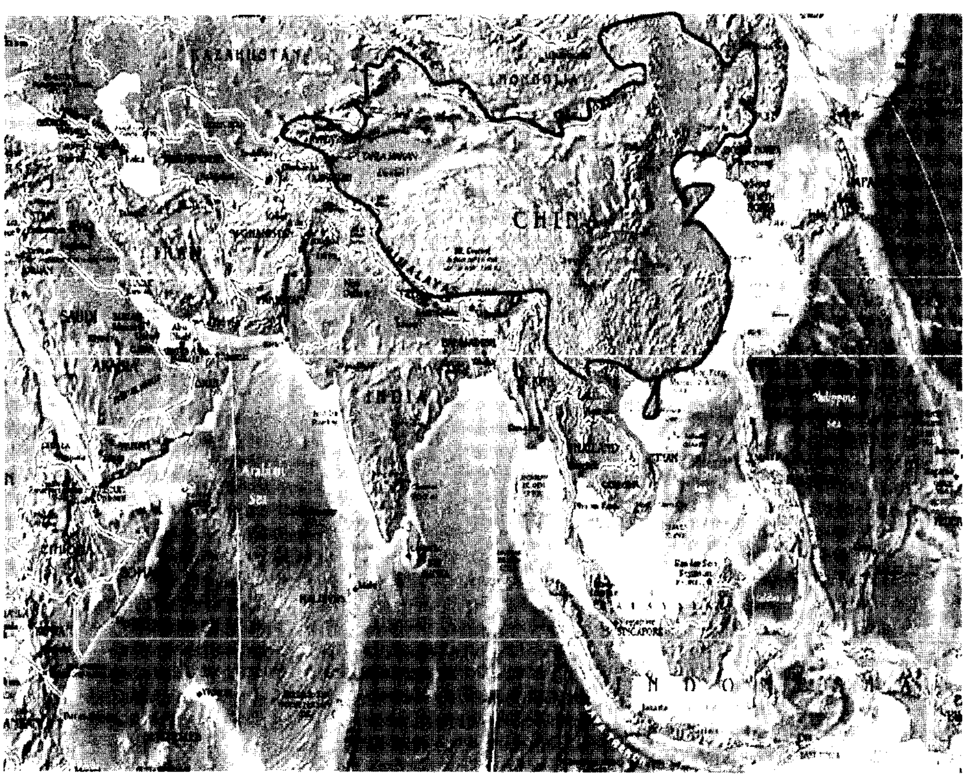


Figure 2.1 Map of Asia

Water Supply for Asia

The percentage of people worldwide with access to the improved water supply was risen from 77 % in 1990 to 83 % in 2002. About 1.09 billion more people were served over the decade (655 and 436 million in urban and rural areas, respectively). These figures can be considered as representatives of the global situation since over 93 % of the world population was taken into consideration in these statistics.

Between 1990 and 2002, 193 million more people gained access to drinking water supply in Eastern Asia (147 and 46 million in urban and rural areas). Considering the rapid demographic growth in this part of the world (there were 149 million more people in 2002 than in 1990), the percentage of population served was only increased by 6 %. In urban settings, the coverage was in fact decreased by 6 %. In comparison, 412 million more people gained access to drinking water supply in South-Central Asia between 1990 and 2002. The most noticeable increase was in rural areas with a 16 % increase (+ 282 million), whereas in urban settings the increase was 4 % (+ 131 million).

During the same period, 99 million more people gained access to drinking water supply in Southeastern Asia. However, no progress was made in terms of urban coverage due to the increase of population (+ 82 million), whereas in rural areas, the percentage of population served was improved by 5 %, mainly due to the small increase in population in these areas (+ 13 million). On the other hand, 49 million more people gained access to the drinking water supply in Western Asia between 1990 and 2002, representing an overall increase of 5 % and most of the progress in terms of coverage were made in rural areas (+ 9 % or + 12 million). Despite a small 1 % increase in urban settings, 36 million more people still gained access to the drinking water supply. Most of the efforts to serve people with the improved water supply were made in urban areas with 97 million more people served between 1990 and 2002. These efforts, however, were only sufficient to keep up with the increase of urban dwellers (+ 95 million).

Sanitation for Asia

In 2004, the Joint Monitoring Program for Water Supply and Sanitation issued a review of progress in meeting the access targets in water and sanitation. The percentage of people worldwide with the access to improved sanitation facilities was risen from 49 % in 1990 to 58 % in 2002, and the progress was achieved both within urban (with 608 million more people served) and rural settings (440 million more people served). These figures can be considered as fairly representative of the global situation since over 88 % of the world population is taken into consideration.

Despite such progress, however, there were still over 2.6 billion people who lacked access to the improved sanitation (cf. The previous estimate was 2.4 billion). To meet the target of halving the proportion of people without access by 2015, considering the population growth, the additional 1.9 billion people will need to be served - 1 billion in urban areas and 900 million in rural areas. Furthermore, if the trend between 1990 and 2002 continues, the world would miss the sanitation target by more than 500 million people. Close to 2.4 billion people would still be without the improved sanitation in 2015, almost as many as there are today.

Eastern Asia has seen an important progress in terms of percentage of population served: the regional coverage increasing by 21 %. This corresponds to 331 million more people with access to the improved sanitation during 1990's, with more than half in rural areas (+ 188 million). Urbanization in this region is important with 181 million more people in 2002 than in 1990 and the rural population decreased by 32 million.

Southern Asia has seen a good progress in terms of percentage of population served: the coverage increased by 17 %. This corresponds to 310 million more people with access to the improved sanitation between 1990 and 2002. Progress was made both in urban areas, with a 12 % increase (+ 121 million) and rural settings with 17 % more people that have gained access to improved sanitation (+ 190 million).

Southeastern Asia has seen good progress in terms of percentage of population served: the coverage increased by 13 %. This corresponds to 119 million more people with the access to improved sanitation over those 12 years (1990-2002). There was a 12 % increase in the coverage in urban areas (+ 82 million) and a 10 % coverage improvement in rural areas (+ 37 million people).

Western Asia hasn't seen any progress in terms of percentage of population served at regional level: the coverage slightly decreased, by 3 %, in rural areas. Nevertheless, 38 million more people with access to the improved sanitation between 1990 and 2002, and the progress was made for people with house connections, especially in urban settings (+ 10 %). Most efforts to serve people with the adequate sanitation have been made in urban areas with 87 million more people connected during the period. These efforts, however, were not sufficient enough to keep up with the increase of urban dwellers (+ 95 million).

2.1.1 Eastern Asia: China

1) General Information

China possesses the 6th largest water resource in the world, with an annual freshwater renewal of 2,800 billion m^3. But the uneven distribution has led to severe shortages in certain areas. Moreover, because of China's large population, water resource per capita is only 2,400 m^3, one fourth of the world's average, making China one of those 13 countries whose water availability per person is the lowest. According to the international standard, the warning level for severe water shortage is 2,000 m^3 per person. If 1,000 m^3 per person is calculated as the basic requirement, the water availabilities per person in 9 provinces in China is only 500 m^3. Approximately 400 out of those 600 established cities are short of water, while 130 of them face a severe shortage problem. The urban water shortage in China is 6 billion m^3 annually or 16 million m^3 daily [4].

For the last 20 years, China has transformed itself from a rural economy into an industrial giant, averaging over 8 % annual growth of GDP. Unfortunately, this rapid growth has taken a significant toll on its natural resource base as well, particularly water resources. Their depletion has been accompanied by deteriorating water quality, resulted of contamination by untreated industrial wastes (usually related to old technology) and domestic sewage, leakage from outdated waste-treatment/disposal systems, and contamination from agricultural fertilizers and pesticides. These problems have been exacerbated by a low level of treatment technology and by the unwillingness to comply with pollution control laws and regulations.

Compared to the year 2002, the pollution of freshwater in China was lessened in 2003 [5], even though the situations were still serious. In 2003, for the water quality of 407 monitoring sections for the seven main river systems [6], 38.1 % belonged to Class Ⅰ to Ⅲ, 32.2 % Class Ⅳ and Ⅴ, and 29.7 % worse than Class Ⅴ (Table 2.1). For these 118 national monitoring sections of seven main water system, 53.4 % belonged to Class Ⅰ-Ⅲ, 37.3 % Class Ⅳ-Ⅴ, 9.3 % worse than Class Ⅴ. The water quality of mainstreams are generally better than those of bayous.

Table 2.1 Environmental quality standard for surface water in China (Unit: mg/L)

		I	II	III	IV	V
1	pH	6 - 9				
2	Dissolved Oxygen ≥	Saturation rate 90% (or 7.5)	6	5	3	2
3	COD_{Mn} ≤	2	4	6	10	15
4	COD ≤	15	15	20	30	40
5	BOD_5 ≤	3	3	4	6	10
6	NH_3-N ≤	0.015	0.5	1.0	1.5	2.0
7	TP ≤ (lake、reservoir)	0.02 (0.01)	0.1 (0.025)	0.2 (0.05)	0.3 (0.1)	0.4 (0.2)
8	TN ≤	0.2	0.5	1.0	1.5	2.0
9	Cu ≤	0.01	1.0	1.0	1.0	1.0
10	Zn ≤	0.05	1.0	1.0	2.0	2.0
11	F^- ≤	1.0	1.0	1.0	1.5	1.5
12	Se ≤	0.01	0.01	0.01	0.02	0.02
13	As ≤	0.05	0.05	0.05	0.1	0.1
14	Hg ≤	0.00005	0.00005	0.0001	0.001	0.001
15	Cd ≤	0.001	0.005	0.005	0.005	0.01
16	Cr^{6+} ≤	0.01	0.05	0.05	0.05	0.1
17	Sn ≤	0.01	0.01	0.05	0.05	0.1
18	Cyanide ≤	0.005	0.05	0.2	0.2	0.2
19	Volatile Hydroxy-benzene ≤	0.002	0.002	0.005	0.01	0.1
20	oil ≤	0.05	0.05	0.05	0.5	1.0
21	Standard Anionics ≤	0.2	0.2	0.2	0.3	0.3
22	Sulfide ≤	0.05	0.1	0.2	0.5	1.0
23	Fecal Coliform (number/L)≤	200	2,000	10,000	20,000	40,000

Note)

I ——Mainly for origins of rivers and national natural protection zones

II——Mainly as first-degree protection zone of drinking water sources, and habitat of endangered hydro bios.

III——Mainly as second–degree protection zone of drinking water sources, fishery, and swimming

IV——Mainly for industrial use and entertainment use without contact by human odies

V——Mainly for agricultural use and landscape purpose

Water Quality of Main River Systems

In 2003, according to the integrated pollution index, the descending order of water pollution of seven main river systems is Haihe River, Liaohe River, Yellow River, Huaihe River, Songhuajiang River, Yangtse River, and Zhujiang River (Figure 2.2). Compared to the previous year, the pollution of Haihe River, Liao River, and Huaihe River was slightly reduced while the pollution of Songhuajiang River, Zhujiang River, and Yellow River became worse. The main contaminants in the main seven river systems were oil, Biological Oxygen Demand(BOD), ammonia and nitrogen, permanganate value, volatile hydroxybenzene, etc. (Table 2.2).

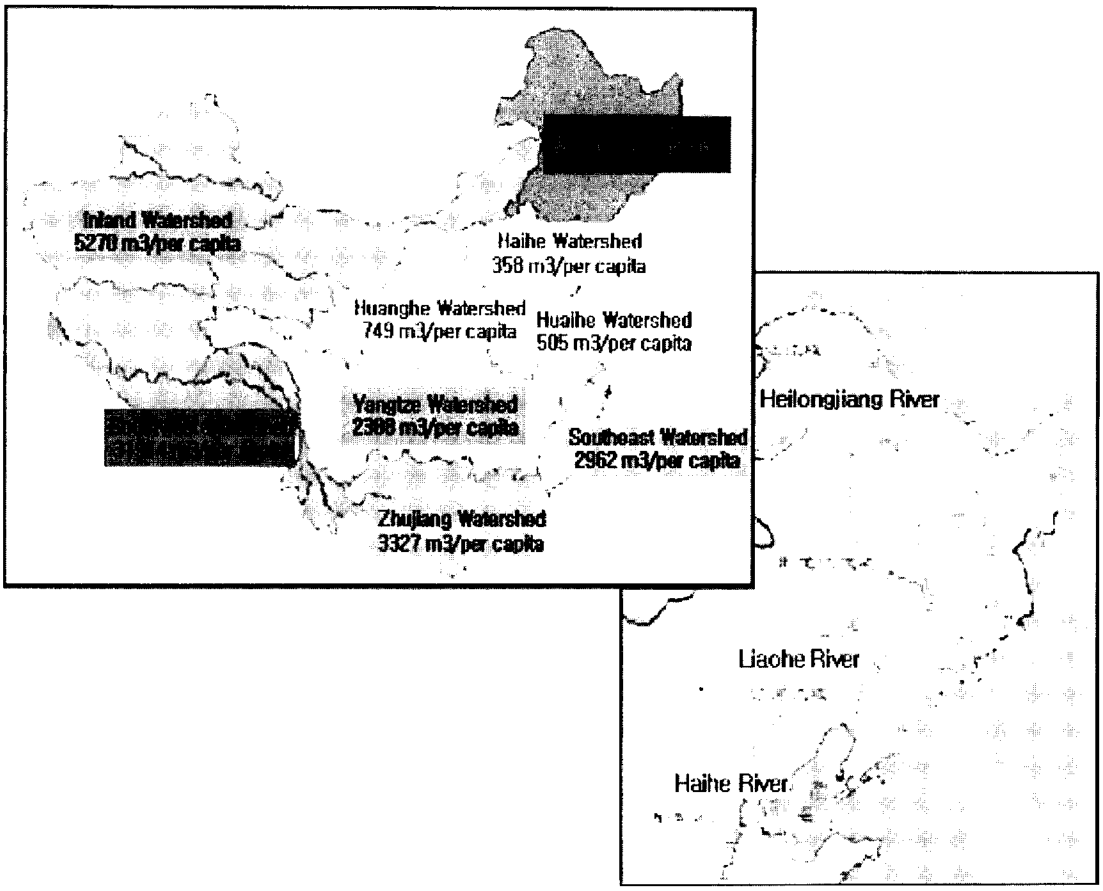


Figure 2.2 Map of watershed in China (Source: [7])

On the other hand, the water quality of inland rivers are relatively good (Table 2.3), better in most rivers in 2003 than in 2002. In 2003, for the 28 key lakes and reservoirs, only 1 of them belonged to Class II (3.6 %), 6 Class III (21.4 %), 7 Class IV (25.0 %), 4 Class V (14.3 %), and 10 worse than Class V (35.7 %) (Table 2.4).

Table 2.2 Water quality & main pollutants of seven main river systems in China (2003)

Name of river system	# of national monitoring sections	WQ (I-III), %	WQ (IV-V), %	WQ (worse than V), %	Main pollutants
Yangtse River	103	71.8	17.5	10.7	Oil, ammonia & nitrogen
Yellow River	44	15.9	45.4	38.7	Oil, ammonia & nitrogen, permanganate value
Zhujiang River	33	81.8	12.1	6.1	Volatile hydroxybenzene, ammonia & nitrogen , oil
Songhuajiang River	41	7.7	74.4	17.9	Oil, ammonia & nitrogen, permanganate value
Huaihe River	86	18.6	41.9	39.5	Ammonia & nitrogen, oil, BOD
Haihe River	65	21.5	24.6	53.9	Ammonia & nitrogen, BOD, oil
Liao River	37	29.7	29.7	40.6	BOD, oil, Volatile hydroxybenzene

Source: [8]

Table 2.3 Water quality of inland rivers in China (2003)

Name of river system	# of rivers/ # of national monitoring sections	WQ (I-III), %	WQ (IV-V), %	WQ (worse than V), %	Main pollutants
Rivers in Zhejiang and Fujian	18/30	63.3	36.7	0	Volatile hydroxybenzene, ammonia & nitrogen , oil
Rivers in the southwest	10/17	58.8	29.4	11.8	Pb、permanganate value
Inland rivers	7/19	84.2	15.8	0	Oil
Three George Reservoir	1/6	100			
Water Quality of South-North Water Project (East part)	1/12	8.3	41.7	50.0	Ammonia & nitrogen, permanganate value, oil

Source: [8]

Table 2.4 Water quality & eutrophication of key lakes in China (2003)

Name of lakes	# of monitoring sites	WQ (I-III), %	WQ (IV-V), %	WQ (worse than V), %	Main pollutants	Degree of eutro-phication
Taihu lake	21	0	28.6	71.4	TN, TP	Light
Rivers Connected to Taihu lake	89	9.0	48.3	42.7	NH_3-N, TP, BOD	
Dianchi lake	NA	0	0	100	TN, TP	Server
Rivers around Dianchi lake	8	0	50	50	NH_3-N、BOD	
Chaohu lake				100	TN, TP	Medium
Rivers around Chaohu lake	12	33.3	16.7	50	NH_3-N	

Source: [8]

Water Quality of Underground Water

Water quality of underground water changes very little because of its slow recycle rate [6]. However, there still remains a trend of deterioration. Point and non-point pollutions widely exist in most cities and districts. Situations become more serious in districts with rapid industrialization and high population density. The main contamination indicators are degree of mineralization, total rigidity, nitrate, nitrite, NH_3-N, iron, manganese, chloride, sulfate, pH, fluoride, and hydroxybenzene etc. Pollution of iron, manganese, and "3-nirtogen" are severe all over the country while those of degree of mineralization, total rigidity, and nitrate are serious situation in North, East, middle-South, North-west of China.

Water Quality of Drinking Water

In 2003, water quality of drinking water sources in 47 key cities was relatively good. Thirty-one of them met the national drinking water standards with the rate of more than 80 % and 22 of those with the rate of 100 %. Eight cities were shown the standard-meeting rate between 50 % and 79.9 %, and the remainder met the standard with the rate of less than 50 %. In China, however, approximately 700 million people (one-half of the total) consume drinking water not meeting the minimum drinking water quality standards. More than half of the cities, moreover, are experiencing severe water supply shortages. Rapid industrial and agricultural growth together with noncompliance with water pollution regulations, laws, and programs, and without adequate water treatment facilities, means surface water and groundwater pollutions becoming increasingly severe. The situation becomes even more serious in rural China due to the immature sanitation facilities.

2) Environmental Concern

Data analysis shows that as the economy has been rapidly developing for the past few years (1998-2003), the industrial wastewater discharge basically follows a tempered increasing trend. The amount of domestic wastewater is growing faster than the industrial wastewater and already accounted for 53.8 % of the overall wastewater in 2003. However, the COD (chemical oxygen demand) emission was slightly reduced in general (Table 2.5). The industrial COD emission was declined rapidly, while the domestic wastewater increased annually. The standard-meeting rate of industrial wastewater was increased from 67 % in 1998 to 89.2 % in 2003 due to the introduction of integrated wastewater management approach.

Table 2.5 Wastewater and COD emission in China (1998-2003)

Year	Emission of wastewater (x 100 million m^3)			Emission of COD (x 10,000 m^3)		
	Total	Industry	Domestic	Total	Industry	Domestic
1998	395.3	200.5	194.8	1,495.6	800.6	695.0
1999	401.1	197.3	203.8	1,388.9	691.7	697.2
2000	415.2	194.2	220.9	1,445.0	704.5	740.5
2001	432.9	202.6	230.3	1,404.8	607.5	797.3
2002	439.5	207.2	232.3	1,366.9	584.0	782.9
2003	460.0	214.4	247.6	1,333.6	511.9	821.7
Growth rate (%)	4.6	2.5	6.6	-2.4	-12.3	5.0

Source: [4], [5], [6]

The industrial economy volumes in China were hiked from 3,915 billions in 1998 to 6,178 billions (RMB) in 2003, and the proportions of pollution intensive industries such as chemical production and textile became even bigger, with both leading to heavy pressures on water environment. However, the pollution intensities of each industry kept decreasing because of the enforcements of national and regional regulations and the improvements of industrial technical levels, resulting in the industrial COD discharge declined for those years surveyed.

2.1.2 Southern Asia: Vietnam

1) General Information

Together with industrialization, the urbanization process in Vietnam has been preceded rather rapidly. In 1990, there were only 500 large and small urban centers, which have grown to 623 at present. These are 4 cities directly dependent on the central government (Hanoi, Hai Phong, Ho Chi Minh City, and Da Nang) and 82 cities and towns belonging to the provinces, and 537 small towns belonging to the districts. According to the Statistical Year Book, Hanoi 2000, the percentage of urban population was changed during 1980-1999 and its forecasted number for the year 2020 is shown in Figure 2.3. The urbanization has led to an increase in the number of both official and unofficial migrants from the rural to the urban area. This creates a pressure on housing and urban environmental sanitation.

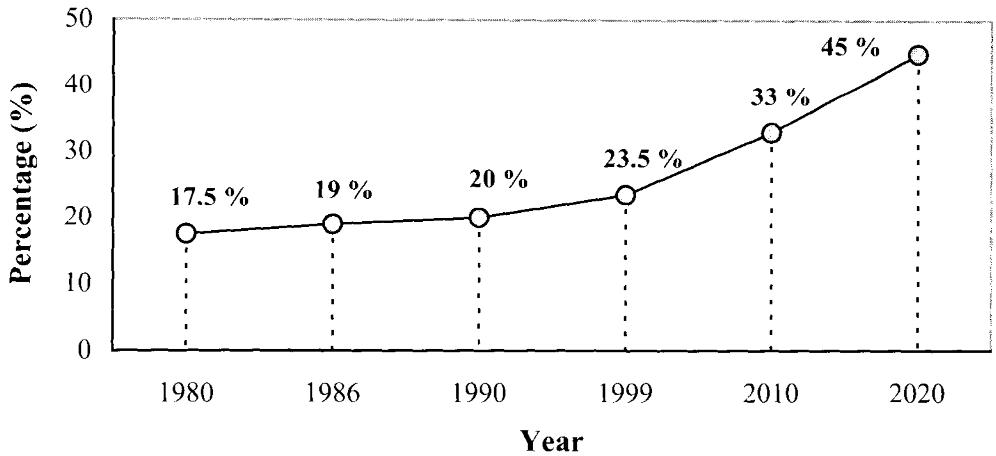


Figure 2.3 Increase of urban population in Vietnam (1998-2020)

At the beginning of 1990, the capacity of water treatment plants was 1,871,000 m^3/d. The total length of pipeline network with the minimum diameter of 100 mm was 4,000 km and its coverage was 57 % (equivalent to 7.4 million inhabitants) with the average water consumption of 55 L per capita per day. Due to the fact that most of the treatment plants had backward technology, the pipeline network was old so the actual capacity was achieved about 70 % the designed capacity. The average leakage rate and loss was over 50 %. As a result, the effect of fixed assets is low and the water shortage was a common phenomenon in urban areas. Up to the year 2000, the concentrated water supply system has been constructed with the ratios of 100 % in cities and provincial towns and about 45 % in small towns. For the entire country, there are about 200 water treatment plants with the total capacity of 2.7 million m^3/d, supplying the supply the clean water to more than 60 % citizens with an average consumption standard of 60 L – 80 L per capita per day. Despite the capacity increased by about 800,000 m^3/d. However, even this increasing figure was unable to meet the demand with the growth of population in the cities (it had increased by over 5.0 million inhabitants since 1989 to 1999 in comparison with the total of 18.0 million inhabitants in 1999).

The typical drainage system in urban areas of Vietnam nowadays is the combined one that drains domestic and industrial wastewaters and storm water. Most of them had been constructed for about 100 years, with the main responsibility of storm water drainage. They had not been maintained and repaired frequently so they had been degrading a lot. The additional construction had been implemented unsystematically, and not in compliance with the sustained plan, so it could not satisfy the requirement of the development of the cities. All drainage systems in urban areas had been formed after the French domination period with the responsibility of inner drainage (ancient area) and had been developed over the years. In the 1954-1975 period, during the Vietnam War, the North was badly ruined and subsequently the drainage system had been constructed mainly at the southern urban areas. There are only 10 out of 61 cities and towns in with the drainage systems at the total length of about 1,000 km. In such big cities as Hanoi, Ho Chi Minh, and Hai Phong, the coverage is only 0.2 m per capita whereas 0.04-0.06 m per capita in smaller cities (cf. the standard of 2.0 m per capita in developed countries).

Water Quality of Main River Systems

There are 15 river basins larger than 2,000 km^2, 9 of which are considered major rivers. These nine major basins are the Bang Giang - Ky Cung, Red River/Thai Binh, Ma, Ca, Thu Bon, Kone, Ba, Dong Nai and the Mekong Delta. The drainage system in urban areas of Vietnam has an important relationship with the exploitation and use of surface water resources such as lakes, irrigations, rivers, and coastal areas. As the place to receive, keep, and drain for the city, they contribute to treat the wastewater in the combined drainage system by naturally cleaning themselves. The storm-water from combined drainage system is discharged along with sludge and rubbish, and the untreated wastewater with large rubbish, organic substances, and heavy metals severely pollutes the water resources. The canals and irrigations in the city in fact have become parts of the drainage system. Ponds also become wastewater keepers. That is why the water quality in the channels, irrigations, ponds and lakes is not so different from the wastewater quality *(Note: Figure 2.4 is quoted from the seminar of Kwater by Nguyen Duy Du, Asian Institute of Technology).*

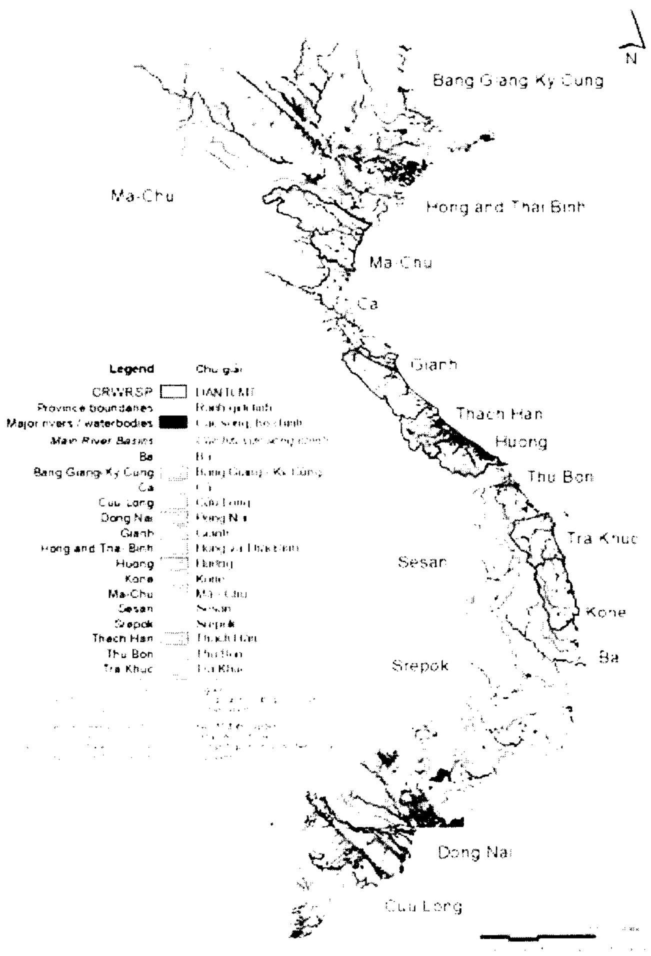


Figure 2.4 Map of main river in Vietnam

In Northern areas, some river portions flowing through the urban and industrial zones or professional villages appear to have a deteriorated quality. Those surveyed rivers do not reach the A level in Vietnamese regulations. The part of Hong River at Lao Cai

Province shows 3-5 times higher in BOD, COD and coliform figures. The part of Hong River at Viet Tri is severely polluted, especially in dry season; comparison to the Vietnamese regulations, it exceeds 2.37 times in COD, 3.83 times in BOD, and 1.4 times in NO_2, especially at Viet Tri Bridge 4-20 times in NO_2. Cau River (Thai Nguyen) is also badly polluted because of industrial activities. The part flowing through the town shows high contents of BOD, COD but low content of DO, and sometimes H_2S reaches 5.8-12 mg/L, NO_2 exceeding the A level 5-10 times and NH_4 exceeding the A level 2. At Huong Waterfall, BOD exceeds the A level 2.38-3.25 times, while at Loang River estuary receiving wastewater from Gia Sang Laminating Steel, BOD exceeds 7.55 times. At the part of Thuong River at Bac Giang, the excess of BOD is 2.68 times, COD 1.85 times, NO_2 70-200 times, compared to the Vietnamese regulations. The measured COD and BOD in Tam Bac River (Hai Phong) were in the same increasing trend in 1995 through 1997.

Rivers in the Middle areas are often short, with high slope and good quality in both upstream and downstream, becoming the usual water resource. However, such down streams as Vinh Phuoc River (Dong Ha), Huong River (Hue), Tuy Loan River (Da Nang), and Tra Khuc River (Quang Ngai) are mostly polluted because of urban and industrial wastewater being used. Rivers in Southeast area are more polluted than rivers in North and Middle areas: water from Dong Nai River in Hoa An, Cat lai, Phuoc Khanh, and Dong Tranh has oil content of 0.3-0.4 mg/L, while the regulation for A - level water must not contain oil. In case of Sai Gon River, the BOD and COD at Phu Cuong Brigde exceed the Vietnamese Standard 2-4 times, and the content of nutrient substances such as nitrogen excess regulations many times, especially at Nha Rong Port. The content of coliforms exceed 50-100 times, and oil and some heavy metals like Pb, Hg, Cr, and Cd are found in several places.

Wastewater containing lots of organics and nutrient substances discharged into rivers and lakes results in eutrophication fact. The concentration of the polluted substances in urban irrigations such as sediment, BOD, COD, nitrogen, and NH_3 is clearly high, belonging to the location of wastewater discharge. Drainage river is also polluted by such heavy metals as Pb, Hg, and Cr, and such toxic substances as phenol and cyanide, and this polluted trend is rapidly increasing. The organic pollution by BOD in channels and irrigations in Hanoi and Ho Chi Minh City is shown in Figure 2.5. The inner urban drainage rivers such as Set River, To Lich River, Lu River (in Hanoi), Doi canal, Tau Hu, Nhieu Loc – Thi Nghe (in Ho Chi Minh City) are becoming more and more polluted.

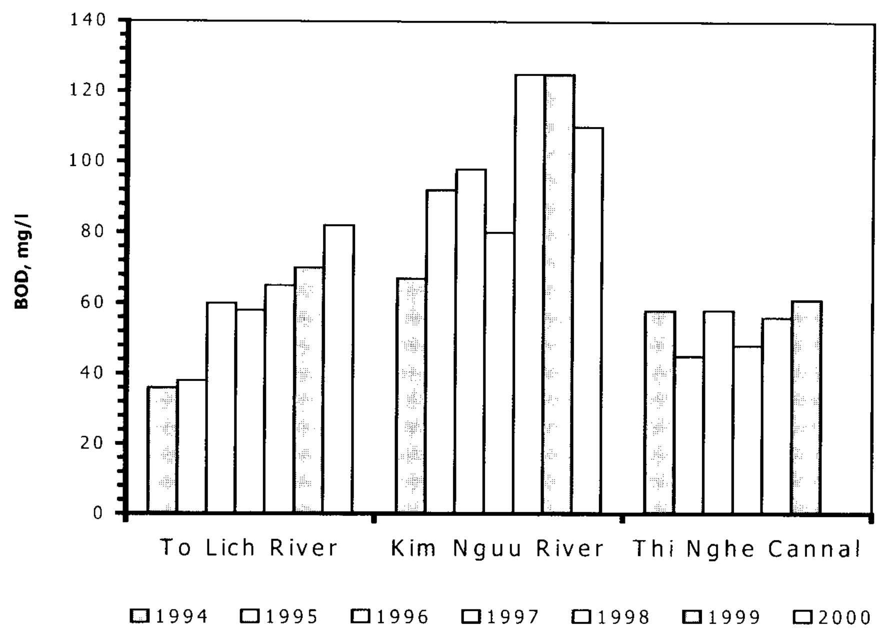


Figure 2.5 BOD change in water systems of Vietnam (1994-2000)

Water Quality of Lakes

Figure 2.6 shows the change of BOD in some typical urban lakes, including Bay Mau Lake (Hanoi), An Bien (Hai phong), Goong (Vinh), and Tinh Tam (Hue) according to the Hanoi University. Urbanization is the main reason for the change in water quality of urban rivers and lakes. Almost all the lakes have not reached the surface water B standard issued by TCVN 5942-1995 in such criteria as BOD, COD, nitrogen, NH_3, and coliform. West Lake (in Hanoi) is a big natural lake, but its water quality has been deteriorated due to the improper control and management. Urban lakes (e.g., Goong in Vinh City) receive mostly storm-water and a small portion of wastewater that is increasing recently. One of the main reasons raising the level of organic substances in the lake is such nutrient elements as phosphoric and nitrogen from storm water, causing eutrophication. For those 12 lakes in Hanoi studied, the ammonia-nitrogen in their water is shown higher than 1.0 mg/L, especially 5.0 mg/L in Thien Quang and Giang Vo Lakes, and PO_4 exceeds 0.35 mg/L. These elements make the density and mass of living alga become large. In West lake water, the average density of alga is 7-12 millions cells/m^3 and the mass of living organisms is 3-4 g/m^3 whereas in Thanh Cong Lake, these figures might be from hundreds to thousands cells per m^3 and 15-88 g/m^3, respectively.

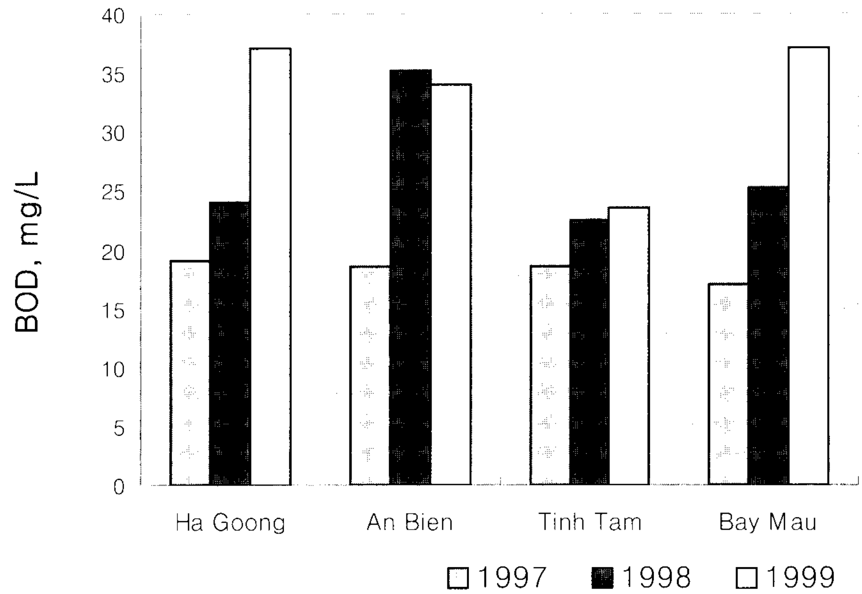


Figure 2.6 BOD change in lakes of Vietnam (1997-1999)

2) Environmental Concern

In June 1996, there were only 16 industrial zones (12 industrial and 4 export processing zones). By now, however, the number has been increased to 62, and more industrial zones, 3 export processing zones, and a high technology zone are distributed in 27 of the 61 provinces and cities. Of these, 15 zones are based on available enterprises already in operation, 31 on small-scale enterprises, and 20 new modern industrial zones. Only 22 industrial zones have completed construction of the infrastructure, while only 5 zones have central common effluent treatment plants in operation.

The old industries installed before 1975 are mostly medium and small-scale industries, and distributed throughout the country. Their production technologies are outdated, causing pollutions of air and water environments and discharging solid wastes into the surrounding areas. According to the current estimates, only 20 % of those old industrial enterprises have renovated and modernized their production technologies. Around 90 % of the old enterprises do not have any wastewater treatment system and most of the old industrial zones do not have a central wastewater treatment plant (WWTP). Therefore, the industrial wastewater is only treated superficially, and then discharged directly into surface water sources, causing grave pollution in some rivers.

Almost all new industries were installed after the national plan on environment and sustainable development was adopted in 1991, and the Law on Environmental Protection was promulgated in 1994. Therefore, such pollution control measures as cleaner production adoption and environmental impact assessment have been applied for those industries after the initial stages of their establishments. However, the environmental impact is individually assessed only for each project. The assessment of the cumulative impacts made by several projects invested in the same area is still neglected. For example, Thi Vai River (Dong Nai province) is seriously polluted, resulted from the cumulative impacts made by many projects operating in the river basin.

Although much attention has been paid to the improvement and expansion of urban infrastructure for the last several years, the transportation, water supply, and drainage systems in urban centers of Vietnam are still poor and deficient. Both domestic and industrial wastewaters as well as storm water share the same drainage, and the common wastewater treatment facilities are not available. Therefore, wastewater is treated only superficially and then discharged directly into rivers and lake, causing serious pollution of surface water environment. During rainy seasons, the drainage system is unable to keep up with the volume of water flow, leading to inundation in many urban centers. The percentage of urban population accessing the potable water supply nationwide averages out at only 47 % and 53 % in 1995 and 1998 respectively. The urban roads are narrow and of low quality, resulting in traffic jams during rush hours, particularly in large cities.

The surface water environment in urban centers is polluted, even with some places being heavily polluted due to the direct discharge of untreated wastewater into the waterways, which is often polluted by such organic wastes as COD and BOD_5, nitrites, nitrates, and suspended solid matters. The concentration of these pollutants is always 2-5 times higher than the acceptable limits set for the surface water resource (as stipulated in Category B of Vietnamese Environmental Standards) and in some areas, 10-20 times higher than the standard. The index of *E. coli* exceeds the acceptable limit by a hundred times and the waterways in some cities are black and stinking.

2.2 Africa

Africa (Figure 2.7) is the world's second-largest and second-most populous continent after Asia. At about 30,300,000 km^2 including adjacent islands, it covers 5.9 % of the Earth's total surface area and 20.3 % of the total land area. With more than 840,000,000 people (as of 2005) in 61 territories, it accounts for more than 12 % of the world's human population and it has a number of overlapping cultures.

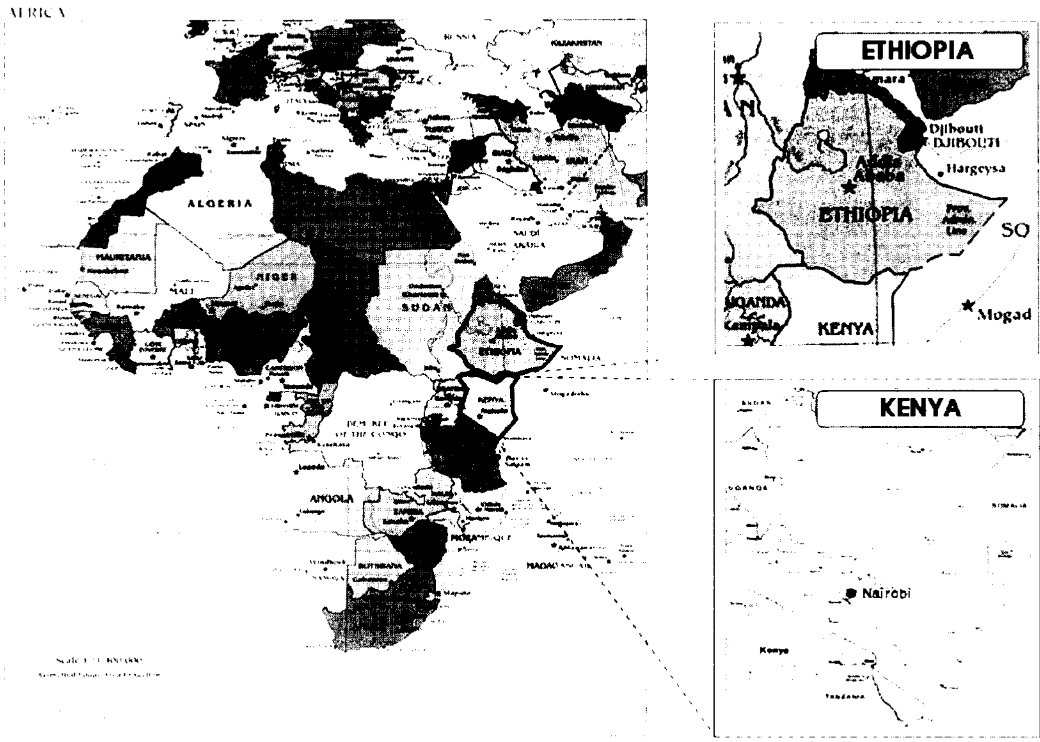


Figure 2.7 Map of Africa

Water Supply for Africa

According to the report of Global Water Supply and Sanitation Assessment 2000, Africa has the lowest total water supply coverage in the world, with only 62 % of the population having access to the improved water supply. This figure is based on estimates from countries that represent approximately 96 % of Africa's total population. The situation is much worse in rural areas, where coverage is only 47 %, compared with 85 % coverage in urban areas [9].

In global terms, the continent contains 28 % and 13 % of the world's population without access to the improved water supply and sanitation respectively. It is predicted that Africa will face increased population growth over the coming decades, with the greatest increase in urban areas. As a result, approximately 210 million people in urban areas will need to be provided with access to water supply services, and 211 million people to the sanitation services, if the international coverage targets for 2015 are to be met. A similar number of people in rural areas will also need to gain access. Given the assessment's findings concerning change in coverage over the 1990s, it appears that future needs for rural services may continue to be the most difficult to meet.

African population is expected to increase by 65 % over the next 25 years, presenting a huge challenge to services in the region. To achieve the year 2015 goal on water supply, in urban water, the additional 210 million people over the next 15 years will have to be provided with services, while in rural areas, the additional 194 million people estimated will need to have access to meet the target. Therefore, a total of approximately 400 million additional people will need to be provided with access to improved water supply in order to meet the 2015 target. Given the findings of the assessment 2000, this will require tripling of the rate at which additional people have been gaining access between 1990 and 2000 so new approaches will be needed to face this challenge.

Northern Africa has seen some progress in urban and rural areas, with the coverage increase of 2 % (from 88 to 90 % and from 82 to 84 % respectively). On the other hand, sub-Saharan Africa has seen some progress in rural areas, with 69 million more people gained access to water supply in rural settings between 1990 and 2002 (+ 9 %). At the same time, although there has been no change in the percentage of people served in urban areas, 82 million more people have gained access to water supply in towns. This is due to the demographic growth as well as the rural to urban migrations that had led to the population increase of 100 million in towns/cities.

Sanitation for Africa

Sanitation coverage in Africa is poor, with only Asia having lower coverage levels. Currently, only 60 % of the total population in Africa has the coverage varying from 84 % in urban areas to 45 % in rural areas. Most of the domestic wastewater generated in developing countries is discharged into the environment without treatment, contaminating the downstream water supplies used for drinking water, irrigation, fisheries and recreational activities. Wastewater treatment and reuse is an issue primarily in urban areas with sewerage systems. In comparison, in rural and urban areas with such on-site sanitation facilities as toilets and septic tanks, wastewater goes into the ground, where it is filtered and purified, provided that the toilet or other disposal site is sufficiently far from the drinking water sources. Wastewater treatment is a great challenge for developing countries because of its high cost and the technical skills required for its operation and maintenance. Experience shows that wastewater treatment and reuse is more likely to be funded in national budgets if integrated with national integrated water resources management plans or the environmental policies.

Northern Africa has seen some progress in urban and rural areas, with the coverage increase of 5 and 10 % respectively. Sub-Saharan Africa has seen a 4 % progress in terms of the percentage of population served with the improved sanitation facilities between 1990 and 2002, with the additional 85 million people with access to sanitation and mostly in urban areas (+ 57 million). The demographic increase (+ 181 million), however, contributed to the shortage of the percentage of people served.

2.2.1 Eastern Africa: Kenya

1) General Information

Water Resources

Kenya is classified as a "chronically water scarce" country with the limited freshwater of just about 612 m^3 per capita in 2004 and this figure is projected to fall further down to 245 m^3 per capita by the year 2025 [10], well below the minimum recommended for both current and projected populations. Much of the surface water in Kenya originates from five specific water sources: Mt. Kenya, Mt. Elgon, Aberdares, Mau Complex, and Cherengani Hills. Mismanagement of the upper reaches of these watersheds over the last 30 years has only aggravated the water crisis. The hydrometric network and data recording and reporting system for monitoring and assessing the river flow of water has been deteriorated so can no longer support the adequate assessment of the water resources. In addition, the number of river gauging stations in Kenya has been shrinking from over 900 in the early 70s to less than 100 currently[11].

According to the Ministry of Water and Irrigation (MWI), the estimates for the annual renewable freshwater currently stands at about 21.7 billion m^3 per annum, comprise of 19.6 m^3 of surface water and 2.1 m^3 of groundwater *(Note: Estimates for surface water have not been updated in recent years and may be substantially lower; estimates for groundwater need proper assessment, as they may be relatively higher)*. However, such phenomena as population increase, extensive degradation of catchments, pollution, over-exploitation of resources, and conflicts over land use have led to the serious degradation in both quantity and quality of this resource [12].

Water Availability per capita

The country's renewable freshwater availability was reduced from 1,853 m^3 per capita in 1969 for the population of 10.9 million people to 612 m^3 in 2004 for 33.9 million (Table 2.6). The demand to meet such multi-sectoral needs as agriculture, industrial development, electric power generation, and livestock development has been constrained by the increasing population and changes in production patterns, priorities, and choices. Along with the freshwater scarcity, the water storage per capita has also been declining (Table 2.6), and the storage capacities have been reducing due to sediment deposition and embankments breaching over the years.

Table 2.6 Increasing scarcity of freshwater in Kenya (1969-2004)

Year	1969	1979	1989	1999	2004
Population in millions (CBS)	10.9	15.3	21.5	28.7	33
Per capita availability (m^3)	1,853	1,320	942	704	612
Storage per capita (m^3)	11.4	8.1	5.8	4.3	3.9

Source: [10]

Throughout the 1990's, the percentage of Kenyans living below the poverty line of 1 USD a day was averaged at least 50 % [13]. Over the same period, investment in water resources management was decreased significantly, thereby reducing the potential to increase the percentage of population with access to potable water. This occurred despite the fact that Participatory Poverty Assessment (PPA) studies in 1994 and 1996, and the drafting of the Poverty Reduction Strategy Papers (PRSPs) in 2001, consistently showed that the poorly ranked water as the first or second priority in alleviating poverty. The failure to stress this as a high priority in those national planning documents had led to the serious under-funding for water resources management by the government over the years. Moreover, the continuous water pollution from urban and industrial wastes, the degradation of water quality due to the increased use of pesticides and fertilizers as well as the water hyacinth infestation in Lake Victoria and Lake Naivasha had been environmental concerns, resulted in aggravating the already deteriorating state.

Water Services

The provision and management of water services in Kenya has been facing enormous challenges over the years; the amount of freshwater supply has been declining, the water supply facilities are not properly maintained, and the level of management is generally poor. These factors have led to the rapid deterioration of available facilities and poor service to the consumers. About 75 % of the country's population is in rural areas, and over 60 % of the urban population lives in slum settlements, with a very poor infrastructure that largely hinders the effective service provision [14]. Moreover, the water sector has had very little investment over the years to meet demand from rapidly growing population and economy. Most of the facilities, which were constructed 20 to 40 years ago, lack proper maintenance and new investment, resulting in their failure to meet the water demand for the design population, let alone the existing population.

Sanitation & Wastewater Utilities

This has often resulted in leaving water for the poor out of funding priorities negotiated with development partners. It is well recognized today that there is the need to mainstream the social and economic equity in the Poverty Reduction Strategies and the Economic Recovery Strategies for the higher priority funding. The PRSPs are the most important documents on which the World Bank and other development partners base their negotiations on to support to the less industrialized countries like Kenya. Access to safe water, on the other, is currently estimated at 89 % in urban areas and 46 % in rural areas, with about 56 % and 12 % of the population served by house connections respectively (Table 2.7). However, access to safe water supply and utilities varies significantly from one region to another, and with considerable disparities within the same region.

Kenya has recently been experiencing the increased growth and expansion of urban centers. However, this situation has not been equally matched with the development of adequate sewerage and sanitation facilities to meet the demand. Only 30 towns out of those 178 currently gazetted towns and municipalities in the country are presently served with some forms of sewerage facilities. In terms of national population, about 81 % has access to safe sanitary means (7 % served with piped sewer while 74 % served with on-site sanitation like septic tanks or pit toilets) but 19 % without any considerable sanitation [16]. It is estimated only about 4 million people out of the entire population are served with sewers (Table 2.8).

Table 2.7 Water supply coverage in Kenya (1990-2002)

Area		1990	1995	2000	2002
Urban	Total	91 %	90 %	89 %	89 %
	HC	58 %	57 %	57 %	56 %
Rural	Total	30 %	37 %	43 %	46 %
	HC	11 %	11 %	12 %	12 %

Source: [15]
Note) Total; Total Improved Access, HC; Household Connection

Table 2.8 Sewer coverage in Kenya (estimates)

City/Town	Nairobi	Mombasa	Kisumu	Nakuru	Eldoret
Total Population	3,000,000	820,000	500,000	300,000	215,000
Population with sewers	1,800,000	500,000	200,000	180,000	125,000

Source: [17]

Table 2.9 Sanitation coverage in Kenya (1990-2002)

Area		1990	1995	2000	2002
Urban	Total	49 %	52 %	55 %	56 %
	SC	16 %	17 %	18 %	18 %
Rural	Total	40 %	41 %	42 %	43 %
	SC	0	0	0	0

Source: [18]
Note) Total; Total Improved Access, SC; Sewerage Connection

Even for those sewerage services available, the majority of existing sewerage facilities are in poor state mainly resulted from the lack of good maintenance and management. In particular, poorly controlled of effluent discharge from industry and sewage outfalls and excessive nutrient and agrochemical pollution from rural sources have impacted negatively on the water quality. The sewerage and sanitation sub-sector in Kenya (Table 2.8 and 2.9) thus requires a substantial development to ensure improved sewerage services and better environmental and public health standards.

2.2.2 Northern Africa: Ethiopia

1) General Information

Water Resources

Ethiopia possesses abundant water resources. The quantity of surface water from the 9 river basins, Abbay, Awash, Baro-Akobo, Genale-Dawa, Mereb, Omo-Gibe, Rift valley, Tekeze, and Wabe Shebele, is estimated to be 122 billion m^3 and its ground water potential is estimated to be 2.6 billion m^3, although the true potential is not known (Table 2.10). The freshwater resource per capita is estimated to be 1,924 m^3. However, only 2 % is annually utilized but 86 % used irrigated for agriculture [19].

Table 2.10 Surface water resources in Ethiopia

River basin	Catchment area (km^2)	Annual runoff (billion m^3)	Specific discharge ($L/s/km^2$)
Abbay	199,812	52.6	7.8
Awash	112,700	4.6	1.4
Baro-Akobo	74,100	23.6	9.7
Genale-Dawa	171,050	5.80	1.2
Mereb	5,700	0.26	3.2
Omo-Gibe	78,200	17.90	6.7
Rift Valley	52,740	5.60	3.4
Tekeze	89,000	7.63	3.2
Wabe Shebele	200,214	3.15	0.5
Afar-Danakil	74,000	0.86	-
Ogaden	77,100	0	-
Aysha	2,200	0	-
Total	1,136,816	122.00	

Source: [19]

Water Supply

Access to clean water supply and improved sanitation services is critical for sustainable development. However, despite the abundant water resources, water supply coverage in Ethiopia is very low due to lack of human, financial, and technical resources. About 81 % of the urban population has access to safe drinking water, while only 11 % of the rural population receives the water supply services in 2002 (Table 2.11). The water supply coverage in urban areas is equivalent to the average of sub-Saharan Africa, estimated at 82 % in 2002. However, the coverage in the rural areas is far less than the average, estimated at 45 %. Moreover, the rate of household connection is very poor with only 23 % coverage for the urban population and 0 % for the rural population.

Table 2.11 Water supply coverage in Ethiopia (1990-2002)

Area		1990	1995	2000	2002
Urban	Total	80 %	81 %	81 %	81 %
	HC	4 %	10 %	19 %	23 %
Rural	Total	16 %	14 %	12 %	11 %
	HC	0	0	0	0

Source: [20]

With regard to water consumption per capita per day, the Water Sector Development Programme (WSDP) suggests 30 to 50 L for urban areas and 15-25 L for rural areas respectively as the general design standards. In comparison, these figures in Ethiopia are only 15 L in urban areas and 10 L in rural areas [21]. These figures are even far less than the minimum of 20 L, recommended by World Health Organization (WHO).

Most rural areas use such groundwater sources, for water supply, as springs, hand-dug wells, shallow-drilled wells, and deep-drilled wells. In some areas, ponds, lakes, streams, rivers, and rainwater are also used. These water resources, however, are easily polluted and often run dry during drought season, resulting in low water consumption rate. In addition to low coverage, about 33 % of the existing rural water facilities in rural areas are non-functional because of the lack of funds for operation and maintenance, inadequate community mobilization commitment, and the lack of spare parts [21], implying the real coverage may be lower.

Sanitation

Access to proper sanitation in Ethiopia is in a worse condition. About 19 % of the urban population but only 4 % of the rural population respectively have access to improved sanitation in 2002. Between 1990-2002, the sanitation coverage in urban areas has only been increased 5 %, from 14 to 19 %, but for rural areas this figure is mere 2 % increase, from 2 to 4 % (Table 2.12). The rate of sewerage connection is even worse with only 5 % for the urban population but 0 % for the rural population. The sanitation coverage is far less than the average of sub-Saharan Africa and is estimated at 55 % and 26 % for urban and rural areas respectively in 2002.

Table 2.12 Sanitation coverage in Ethiopia (1990-2002)

Area		1990	1995	2000	2002
Urban	Total	14 %	16 %	18 %	19 %
	SC	7 %	6 %	5 %	5 %
Rural	Total	2 %	3 %	4 %	4 %
	SC	0	0	0	0

Source: [22]
Note) Total; Total Improved Access, SC; Sewerage Connection

In the past, the sanitation was a high priority for both government and communities in Ethiopia, resulting in very poor sanitation coverage. Except for Addis Ababa and a few urban centres, the sanitation facilities in Ethiopia are basically non-existent [23]. In addition, the situation in rural areas is more severe, with about 90 % of the rural population using open field for defecation and urination (Table 2.13).

Table 2.13 Sanitation facilities in rural areas of Ethiopia (1996-2000)

Year	Flush toilet	Pit toilets	Containers	Open fields	Others
1996	0.6	4.4	0.1	92	2.9
1998	0.9	6.5	0.2	92	0.4
2000	0.8	8.1	0	90.7	0.4

Source: [24]

In most areas of Ethiopia except for some core town areas, the piped sewerage systems are not feasible because they require large volumes of water to keep the waste flowing, with some reports suggesting the need of at least 50 L of water per capita per day. This amount, however, is too much for most African cities including Ethiopian cities. Therefore, those on-site facilities not using large amounts of water should be developed and promoted. It is also essential to integrate the sanitation and hygiene promotion with water supply projects to increase the sanitation coverage.

The poor water supply and sanitation coverage causes such water borne diseases as typhoid, paratyphoid, infectious hepatitis, and diarrhoea. As a result, over 70 % of those contagious diseases in the country are water borne/based diseases [25]. The incidences of diarrhoea, the main cause of infants/child morbidity and mortality, can be reduced by 50 % with the use of toilets, by 15 % using clean water, and by 35 % using the proper sanitation respectively [21].

3 Urban and Rural Sanitation (Wastewater) Management and Practice in Asia and Africa

3.1 Asia

3.1.1 Eastern Asia: China

1) General Information

China (Figure 3.1 and Table 3.1) has a great amount of water resources, 4th in the world with 2.8 trillion m^3. However, compared to this large capacity, the occupancy of drinking water per capita lies on the 128th in the world, is only one fourth of the world's average level [26]. Millions of dollars were subsequently lost because of the lack of waters, and those phenomena exist even in big cities, recognized by the central government.

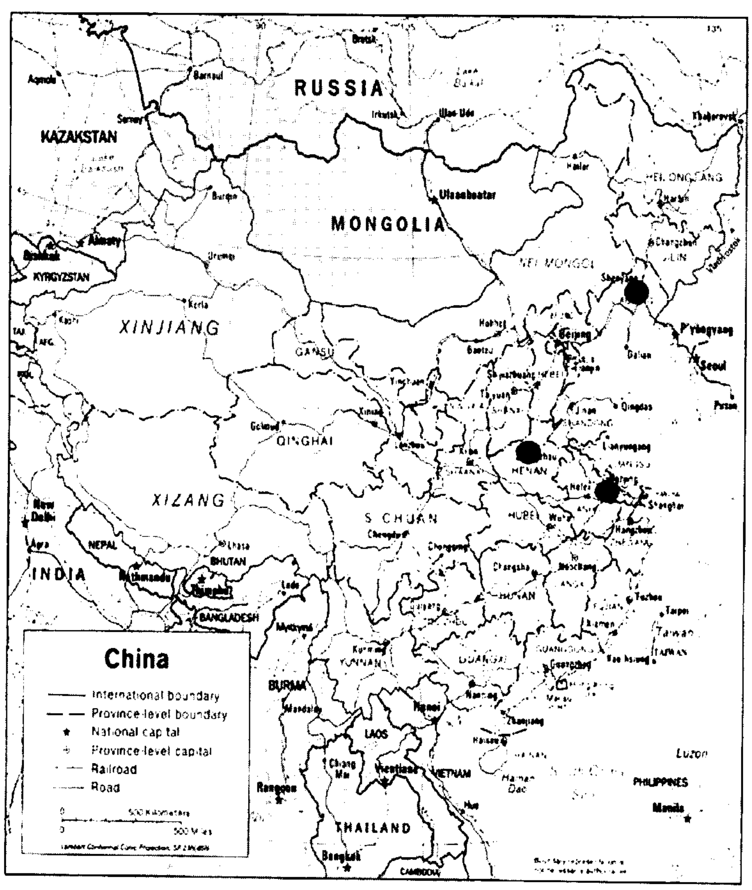


Figure 3.1 Map of China

Table 3.1 General information for China

Location	Eastern Asia
Area	Total: 9,596,960 km^2, Land 9,326,410 km^2, Water 270,550 km^2
Terrain	Mostly mountains, high plateaus, deserts in west; plains, deltas, and hills in east
Land use	Arable land: 14.86 %, permanent crops: 1.27 %, other: 83.87 % (2005)
Natural hazards	Frequent typhoons (about five per year along southern and eastern coasts); damaging floods; tsunamis; earthquakes; droughts; land subsidence
Environment issue	Air pollution (greenhouse gases, sulfur dioxide particulates) from reliance on coal produces acid rain; water shortages, particularly in the north; water pollution from untreated wastes; deforestation; estimated loss of one-fifth of agricultural land since 1949 to soil erosion and economic development; desertification; trade in endangered species
Geography	World's fourth largest country (after Russia, Canada, and US); Mount Everest on the border with Nepal is the world's tallest peak
Population	1,313,973,713 (July 2006 est.)
Population growth rate	0.59 % (2006 est.)
Infant mortality rate	23.12 deaths/1,000 live births (2006 est.)
Life expectancy at birth	72.58 years (2006 est.)
HIV/AIDS – adult prevalence rate	0.1 % (2003 est.)
HIV/AIDS – people living with	840,000 (2003 est.)
HIV/AIDS – deaths	44,000 (2003 est.)
GDP	Purchasing power parity - $ 8.859 trillion (2005 est.)
GDP - real growth rate	9.9 % (official data) (2005 est.)
GDP - per capita	Purchasing power parity - $ 6,800 (2005 est.)
GDP – composition by sector	Agriculture: 12.5 %, industry and construction: 47.3 %, services: 40.3 % (2005 est.)
Population below poverty line	10 % (2001 est.)
Budget	Revenues: $ 392.1 billion, Expenditures: $ 424.3 billion, including capital expenditures of NA (2005 est.)
Public debt	24.4 % of GDP (2005 est.)
Current account balance	$ 160.8 billion (2005 est.)
Debt – external	$ 252.8 billion (2005 est.)

Source: [27]

2) Environmental Status and Issues

Since 1980s, with the economic development together with the deterioration of water environment, the wastewater management has been implemented in China. The management scope has been expanded from the industrial point source wastewater treatment to the urban domestic and rural non point source (NPS) wastewater treatment. The significant results have been achieved for the industrial point source control and the end-of-point control is currently being replaced by the cleaner production strategy. There have also been significant results for the urban domestic wastewater management, and attentions have also been paid to the NPS pollution control as well.

It has been reported that the tap water supply rate in cities would be 90.2 % until 2005 [28]. However, this prediction does not cover the rural area that has a population of nearly 800 million and covers most land of China. In 2004, the total water supply amount was 554.8 billion m^3, and 23 % of the total water resources involved 81.2 % of the supply coming from the surface source while 18.5 % from groundwater. With the surface sources, the water storage was covered only 33 %, and the others came from those places with sufficient rainfall or storage. Lots of large-scale water conservancy has been constructing, showing this demand of water redistribution. At the spatial scale, the southern part of China provided 55.7 % of the overall water supply, which was 309.1 billion m^3, and had a larger proportion of 90 % surface water source because of the weather and rainfall, compared to the north. In comparison, most provinces in the north had more than 50 % groundwater source. In terms of water usages, the agricultural supply was shown a proportion of 64.6 %, implying China is a typical agricultural country. The industrial production accounted for 22.2 % of the total water supply, while 11.7 % for the household usage. The rest of the overall supply was used for the ecological repair, including retrieving water to some wetland and lakes.

Since 2003, the total water usage had been increased to 22.7 billion m^3: 15.3, 5.2, and 2 billion m^3 for agricultural, industrial, and household use, respectively. The average water consumption per capita was 427 m^3 in 2004, even though some differences were shown among the regions. Those differences among different areas, i.e., 436 m^3 for the east, 371 m^3 for the middle, and 487 m^3 for the west are due to such complex reasons as economic status, weather and rainfall. The daily water consumption in township and cities and in rural areas was 212 and 68 L per capita, respectively. This gap further shows the low life quality and poor sanitation status in the rural areas of China.

The water consumption of unit GDP (10,000 RMB), which indicates the efficiency of water usage, was 399 m^3. Likely, 196 m^3 of water was consumed for the unit value-added of industry (10,000 RMB), showing the water usage efficiency in industrial production. On the other hand, the water consumption for irrigation covered a large proportion among the total water consumption, with the average usage per hectare of 30 m^3. For these three indicators, the differences between regions were shown more obvious. Due to the large economic and efficiency disparities between these three areas, the east was the most efficient, showing 221 m^3 per unit GDP, 135 m^3 for unit value-added of industry, and 27.7 m^3 per hectare for irrigation. In comparison, these three indicators were 392, 240, and 25.2 m^3 for the middle, and 645, 241, and 38.7 m^3 for the west. Thus, the overall situation showed the economic growth and the usage efficiency decreasing from the east to the west, in accordance with the socio-economic investigation by some scholars [29].

The uneven temporal distribution is another character for China's water resources. In most areas, the precipitation for 4 months from June to September during the flood season accounts for over 70 % of the annual precipitation. For different years, the precipitation in wet years is 2-8 times of that in dry years. Moreover, it is quite common to have several wet or dry years consecutively. These features have made China a country with frequent flood or drought disasters, regional water shortage, and fragile ecosystem. In 2004, the total wastewater discharged were 48.24 billion m^3 with the increasing rate of 4.9 %. The total industrial wastewater discharged was 22.11 billion m^3, taking up 45.8 % of the overall wastewater, whereas the domestic wastewater emission was 26.13 billion m^3. The increasing rate for the industrial and domestic wastewater was 4.1 % and 5.5 % respectively. On the other hand, the total COD emission was 13.39 million m^3 and remained almost the same as in 2003. The domestic wastewater contributed more in COD emissions with the amount of 8.3 million m^3 with a slight increase of 0.9 %. The industrial COD discharge was less in quantity but had more complicated component, difficult to be treated.

The total NH_3-N emission was 1.33 million m^3 in 2004, with the domestic one dominant, taking up two thirds, and both domestic and industrial discharge contributed to the total increasing rate of 2.5 %. The ratio of the industrial wastewater discharged meeting the discharging standard was 90.7 % and the ratio of industrial water reuse was 74.2 %. These two indices show the treatment and the reuse efficiency had been kept increasing for several years in China [30].

In cities, 708 wastewater treatment plants had been constructed at the end of 2004, with the treatment capability of more than 73.87 million m^3 and with 218,900 km of pipeline connected. Comparing to the year 2000, the treatment facilities and the pipeline length were greatly increased, 66 % and 54 % respectively, and the overall wastewater treatment efficiency in cities and townships was 45.67 %, increased by 12 %. However, the domestic wastewater treatment efficiency was only 32.3 %, resulting in lots of COD in domestic wastewater directly discharged into the waters.

The water pollution accounted for half of the pollution accidents in 2004 and became the main barrier to the socio-economic development. As shown above, the water pollution became more serious while the demand for water resources was increased fast. In addition, the total number of facilities in cities was still unsatisfactory for the treatment requirement. More than 300 cities in China did not have the centralized wastewater treatment plant, and the collection systems were slowly constructed, depressing the treatment efficiency because of the large foundation gap. Other problems for the sanitation status included the lacks of supply factors, including water sources, supply pipelines, water reuse projects, and poor management [31].

The PRC's sanitation management policy is broadly consistent with the international trend. Similarly, the PRC's legal framework is also consistent with the international practice, even though the legal system is not yet mature compared to those developed countries, and the laws and regulations tend to be framed in less detail. The important PRC's sanitation management policy initiatives include:

- A national environmental regulatory body has been created by State Environmental Protection Administration (SEPA) (Laws and regulations at a national level generally support the above policies and further regulations.)
- Pollution declaration and pollution levy
- Planning and coordination of water sector management on a catchment basis
- Financing of wastewater services through user fees
- Rural NPS pollution control (pesticide and pasturage)
- Increased commercialization and use of private sector financing
- Increased corporatization of wastewater utilities (regardless of ownership)

Figure 3.2 summarizes the development of wastewater management in China.

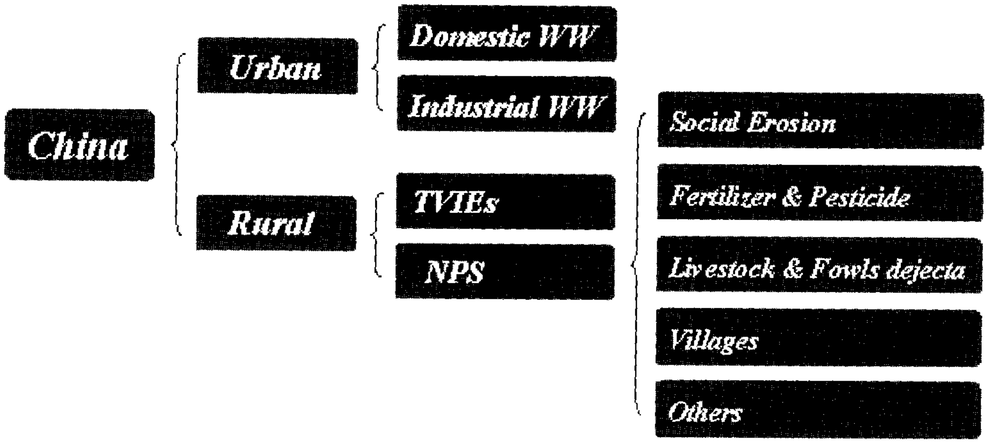


Figure 3.2 Status of wastewater management in China

Status of Wastewater Management in Urban Area

With the rapid urbanization, the urban domestic water consumption and the amount of wastewater are increasing gradually. The discharged amount of urban industrial wastewater is still at a relatively high level due to the rapid industrialization, although the degree of industrial wastewater management has become stronger. The management of urban domestic and industrial wastewaters is discussed separately since their management systems are different.

Urban Domestic Wastewater Treatment

The research report provided by the SEPA showed that since 1999 the investment for the urban wastewater treatment plant facilities has steadily been increased in China [32]. For those 325 cities with the wastewater tariff collection system, the investment for the urban wastewater treatment plants reached 38.6 billion RMB. At the end of 2003, 516 wastewater treatment plants had been built with the total disposal capacities of 32.48 million m^3/d. However, the disposal capacities still cannot match the need of the dramatically increasing number and size of cities. There are 660 established cities in China, with a population of 350 million. By July of 2004, there are still 61.5 % of cities without wastewater treatment plants. The volume of urban domestic wastewater discharged is increasing at the average rate of 5 % annually and surpassed the discharged volume of industrial wastewater for the first time in 1999, accounting for 52.9 % of the total volume.

Table 3.2 Status of urban domestic WWT in China (2002)

Region	Urban Domestic WW discharge (10,000 m^3)	Urban Domestic COD discharge (m^3)	Ratio of domestic WWT (%)
China [6]	2,323,420	7,829,006	22.3
Beijing	75,529	138,477	52.9
Tianjin	27,750	61,792	66.5
Hebei	66,719	274,062	19.1
Shanxi	59,596	160,057	16.8
Inner Mongolia	24,923	124,435	33.5
Liaoning	97,217	375,224	31.8
Jilin	50,542	239,836	27.1
Heilongjiang	68,601	377,334	11.7
Shanghai	127,207	281,820	18.8
Jiangsu	169,301	482,381	29.1
Zhejiang	91,051	295,177	35.7
Anhui	78,171	285,012	15.8
Fujian	58,422	197,826	26.9
Jiangxi	59,484	323,113	3.9
Shandong	124,041	442,781	37.5
Henna	124,106	368,030	20.2
Hubei	133,866	451,104	8.4
Hunan	108,389	431,935	7.7
Guangdong	344,217	744,793	21.2
Guangxi	87,531	284,494	10.2
Hainan	16,715	52,744	33.9
Chongqing	46,394	149,191	6.3
Sichuan	109,429	484,995	15.0
Guizhou	36,137	178,234	4.5
Yunnan	32,575	180,722	43.6
Tibet	480	746	
Shanxi	36,514	17,833	11.5
Gansu	17,880	11,641	31.2
Qinghai	7,548	3,385	4.4
Ningxia	11,753	3,668	24.9
Xinjiang	31,330	15,865	41.7

Source: [33]

At present, the urban wastewater treatment plants in China are rapidly being constructed and the ratio of domestic wastewater treatment varies significantly, as shown in Table 3.2. Due to the significant differences in economic development and policy implementations among different regions, construction and operation of urban wastewater treatment plants have been different as well (Table 3.3). At the end of 2002, the rate of wastewater treatment plant ranged between 10 % and 40 % in most regions. Tianjin was shown the highest treatment rate of 66.5 %, even though 22.6 % of the regions with the treatment rate of less than 10 %.

Table 3.3 Status of urban WWTPs status in China (2002)

Region	Number of WWTPs	Treatment capacity (10,000 m^3/d)	Length of sewerage pipeline (km)
China	423	2344	173,042
Beijing	12	170	6,170
Tianjin	3	76	8,828
Hebei	14	107	8,364
Shanxi	10	45	2,689
Inner Mongolia	19	40	3,561
Liaoning	11	136	8,880
Jilin	6	91	4,466
Heilongjiang	5	11	5,282
Shanghai	27	95	4,001
Jiangsu	53	223	16,744
Zhejiang	28	228	12,183
Anhui	9	50	5,007
Fujian	17	63	3,992
Jiangxi	1	8	2,392
Shandong	56	332	15,257
Henna	19	130	7,188
Hubei	11	52	8,181
Hunan	7	57	4,090
Guangdong	32	282	18,245
Guangxi	7	31	3,329
Hainan	5	39	2,833
Chongqing	6	14	2,671
Sichuan	11	73	7,203
Guizhou	3	14	1,904
Yunnan	14	47	2,277
Shanxi	3	16	1,940
Gansu	8	25	2,310
Qinghai	1	2	458
Ningxia	3	13	579
Xinjiang	17	74	2,261

Source: [33]

Table 3.4 Status of industrial WW emission & treatment in China (2002)

City	Number of enterprises	Emission of industrial WW (m^3)	Standard-meeting rate (%)	Number of WWTPs	Operation cost of WWTP (10,000 RMB)
China	41,008	1,274,115	91.7	37,121	1,291,261.4
Beijing	966	18,044	98.3	312	44,640.3
Tianjin	1,604	21,959	100.1	765	27,279.8
Shijiazhuang	358	19,044	90.0	511	11,085.7
Taiyuan	371	5,943	88.5	264	16,648.2
Huhehaote	75	1,818	83.6	49	1,101.2
Shenyang	441	6,799	99.5	398	4,458.7
Changchun	195	4,805	93.0	82	3,083.4
Jilin	172	14,033	92.9	127	46,295.4
Harbin	439	6,127	90.7	205	8,785.7
Shanghai	1,860	64,857	94.9	1,915	102,283.1
Nanjing	801	53,386	91.1	618	40,326.7
Hangzhou	1,013	69,983	97.4	934	37,096.4
Hefei	212	8,297	98.4	193	4,390.2
Nanchang	131	7,098	60.4	122	2,404.2
Jinan	410	5,388	93.5	221	10,016.5
Zhengzhou	831	10,463	94.8	635	9,890.5
Wuhan	321	34,976	92.0	284	14,912.0
Changsha	522	4,311	82.5	319	2,215.3
Guangzhou	1,199	24,148	84.1	1,199	47,586.2
Nanning	193	9,307	93.4	186	4,015.3
Haikou	39	504	100.0	20	538.1
Chongqing	1,442	79,872	89.4	1,187	18,063.0
Chengdu	1,032	33,452	100.0	813	9,050.9
Kunming	204	4,583	89.9	318	8,421.0
Xi'an	474	10,706	77.1	494	19,367.6
Lanzhou	200	5,474	84.5	121	8,113.7
Xining	56	2,215	83.8	65	918.9
Yinchuan	70	3,015	87.1	81	1,133.1
Wulumuqi	93	1,793	206.1	51	1,786.4
Dalian	544	30,205	95.1	372	11,814.0
Tsingtao	661	9,292	99.9	437	13,676.6

Source: [33]

Industrial Wastewater Treatment

The industrial wastewater treatment has been the priority of the government from the very beginning. Currently, standard-meeting discharge system and pollution levy system are the most important pollution control tools in China as shown in Table 3.4. Recently, the development of circular economy and eco-industrial Park is a novel way to improve the governance of industrial wastewater. Thus, the development of circular economy helps to reduce the wastewater production during the whole process while the development of eco-industrial Park promotes to treatment wastewater collectively to cut down the total cost of individual enterprises [34].

Status of WWTP Operation

Currently, the wastewater treatment capability still cannot match the expansion of city in numbers and scales, showing more than half of cities still without wastewater treatment plants. On July 14, 2004, six ministries including SEPA and National Ministr y of Construction announced that more than half of wastewater treatment plants could not operate normally due to the lack of financial resources so the effluent could not meet the discharge standard. Among 532, wastewater treatment plants investigated, half of them showed, on average, 152 days of standard-violation. Based on the data analysis of 660 cities at the end of 2003, the total wastewater discharge was 34.92 billion m^3, about 5.2 % more than that of 2000. There were 427 wastewater treatment plants in 2000 and the number was increased, by 43 %, to 612 in 2003. The treatment capacity was increased from 21.58 million m^3/d in 2000 to 42.53 million m^3/d in 2003.

Status of Wastewater Management in Rural Area

Even though the urbanization trend is astonishing, the rural population and area plays still a big part of China. Therefore, the management of rural wastewater is critical for the water pollution control in China. There are two major sources of rural wastewater, i.e., pollution from township and village industrial enterprises (TVIEs) and rural non-point pollution sources.

Since mid-1990s, through utilizing the strategy adopted for the urban industrial wastewater management, China began to control the TVIE pollution and some effects were achieved. However, the rural NPS are more difficult to deal with, due to such characteristics as asymmetric spatial and temporal distributions and uncertain pollution pathway and volumes. Currently, we are still lack of effective technologies and measures to deal with NPS, and very few policies exist. There had been a chronic and gradual process to establish the system to prevent and control non-point pollutions, adapted to the national situation [35].

TVIE Water Pollution Control

During the period of 1989-1998, water pollution load of TVIEs was shown the trend of rapid increase at the beginning followed by decrease in the end. As shown in Table 3.5, the wastewater discharge from TVIEs was increased from 2.683 billion m^3 in 1989 to 5.888 billion m^3 in 1995, by 120 %, and the proportion of TVIEs wastewater discharge was increased from 9.26 % to 20.95 %. After 1995, the wastewater discharge from TVIEs was shown decreasing, reduced to 3.840 and 2.940 billion m^3 in 1997 and 1998, respectively, while its proportion also decreased to 16.94 % and 14.67 %, respectively.

Table 3.5 Industrial wastewater and COD discharge in China (1989-1998)

Items	Unit (m^3)	1989	1995	1997	1998
Total wastewater discharge in China	100 mil	278.83	280.88	226.7	200.4
Wastewater Discharge from enterprises at county level or above	100 mil	252	222	188.3	171
Total TVIE wastewater discharge	100 mil	26.83	58.88	38.4	29.4
Percentage of TVIE wastewater	%	9.62	20.95	16.94	14.67
Total COD discharge in China	10,000	934	1378	1073	801
COD Discharge from enterprises at county level or above	10,000	757	768	666	509
Total TVIE COD discharge	10,000	177	610	407	292
Percentage of TVIE wastewater	%	18.95	44.27	37.93	36.45

Rural NPS Pollution Control

The NPS pollution control in rural areas in China is short of the efficient. As the point source pollution control becomes stricter and stronger, the importance of the NPS pollution control is obvious as well. The rural NPS includes:

Soil erosion

Soil erosion is the most important NPS that has the largest scale and is the most serious threat to eco-environment [36].

Fertilizer and Pesticide

It is a ubiquitous problem that fertilizers are used too much for the agricultural production but with lower efficiencies. The average amount of fertilizer in China (in pure dosage) reaches 375 kg/ha, which greatly surpasses the safe upper limit, 225 kg/ha, set by developed countries. Currently, the pesticide production capacity of China is 767,000 m^3 (converted to 100 % pure production), and China has become the second biggest production country after the US. The consumption reaches 500-600 thousand m^3, about 80 % of which is released directly to the environment [37].

Livestock and fowls dejecta

In 2003, the emission volume of livestock and fowls dejecta of China is over 2 billion m^3, which is 2.7 times that of industrial wastes. According to the survey, livestock and fowls dejecta are released to lakes and rivers without any disposal measures, polluting the surface water seriously [38].

Villages

Affected by traditional life style and socio-economic conditions, and due to lack of environmental infrastructures in rural areas, there are no specific entities in charge of the management and disposal of rural solid wastes. Thus, on-site wastewater discharge and unorganized disposal of solid wastes are very popular, and the main pollutants are P, N, and organic compounds.

Other pollution sources

Other rural NPSs include aquaculture, crop straw and wastewater irrigation, etc.

Comparison of Rural and Urban Sanitation

Due to differences in traditional life styles and socio-economic situation as well as the national development strategy, there is a dramatic imbalance between urban and rural areas, in terms of living quality and management capacities. With regard to the wastewater management, different strategies are adopted as well. Table 3.6 shows that the water consumption per capita in rural areas accounts only for 40 % of that in urban areas. After 2000, the rural population was decreased for the first time, because of the rapid urbanization process. However, due to the increase of domestic water consumption per capita in rural areas, the total water consumption in rural areas was still kept at the same level, and most of it was discharged into the water bodies.

On the other hand, the urban domestic wastewater is rapidly increasing. Because of the development of wastewater treatment plants in urban areas, the overall wastewater treatment rate has reached 25.8 % in 2003.

Table 3.6 Domestic water consumption in China (1997-2002)

Year	Urban Areas			Rural Areas		
	Water Consumption Per Capita (L/d)	Population Proportion (%)	Total Water Consumption (10,000 m^3)	Water Consumption Per Capita (L/d)	Population Proportion (%)	Total Water Consumption (10,000 m^3)
1997	220	29.9	2,970,216.7	84	70.1	2,656,290.4
1998	222	30.4	3,074,440.3	87	69.6	2,758,493.3
1999	227	30.9	3,222,396.7	89	69.1	2,826,747.2
2000	219	36.09	3,644,556.4	89	63.91	2,622,806.4
2001	218	37.7	3,824,452.5	92	62.3	2,671,725.5
2002	219	39.1	4,013,696.2	94	60.9	2,597,438.6

Source: [33]

3) Research Area

Nanjing City, Jiangsu Province

Located at the eastern part of China, Nanjing is the capital of Jiangsu Province, is an important central in the middle and downstream of the Yangtze River, and is situated at 32°03'N, 118°47'E. It belongs to the northern subtropical monsoon climate zone where the four seasons are clear, the annual mean temperature is 16℃, the annual precipitation is 1,106 mm, and the frost-free period is 237 days. At present, Nanjing has jurisdiction over 10 districts and 5 counties, covering an area of 6,516 km^2 and having a population of about 5,200,000.

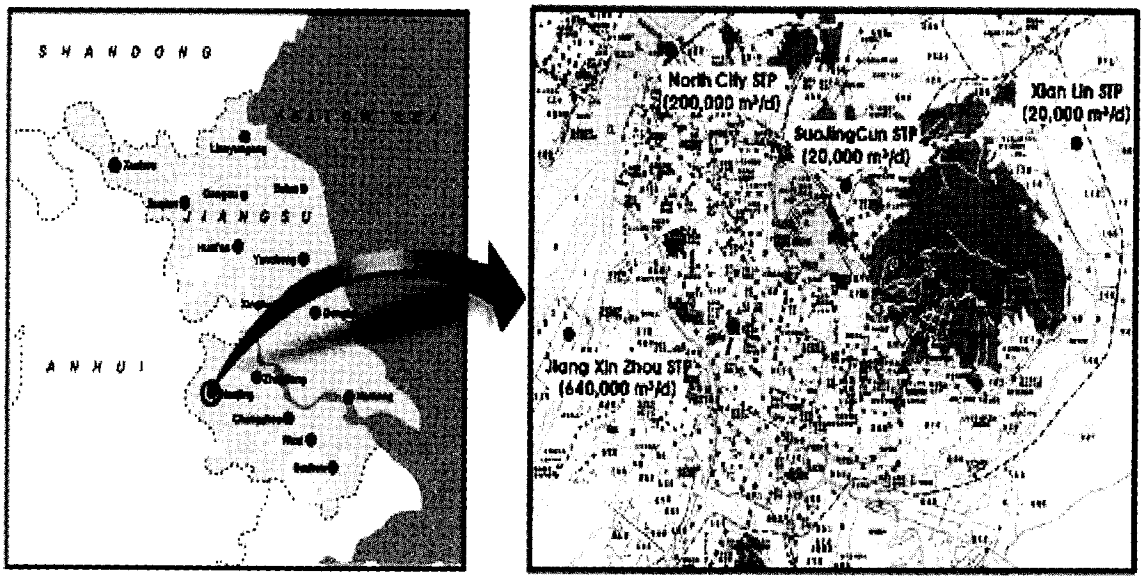


Figure 3.3 Map of Nanjing City

Water Supply System in Nanjing

Nanjing has a pipeline of longer than 2,800 km, supplying 1.78 million m^3 of drinking water per day. Five waterworks are facilitated for all the citizens at both sides of Yangtze River, as well as 12 pump station. The water sources for these 5 waterworks come from Yangtze River. Another 177 waterworks distribute water to the sub-cities of Nanjing and 589,000 m^3 of drinking water is supplied per day. In addition, some big factories in Nanjing also have their waterworks provided for both production and workers' usage. According to the government survey, all the water sources meet the national drinking standards [39].

The water fees in Nanjing are charged by the usage (Table 3.7). The household water for most citizens is charged by the usage amount. Twenty m^3 per household are the basic usage amount and the price is set low in order to give some welfare to the class with low income, who in general uses fewer commodities due to the affordable capacity. There are also some differences between different usages of water in Nanjing as one of developed cities in China. This kind of charge system is considered effective for both saving the water resources and caring about the poor and is currently being promoted throughout the country.

Table 3.7 Water usage and prices in Nanjing, China

Classification		Water Supply Fee (1)	City Construction Fee	WWT	Specification for the Province	Water Resources Fee	Price for the Household
Water Supply for Household Usage	water usage ≤ 20 m^3	1.09	0.06	1	0.02	0.13	2.3
	20 m^3 < water usage ≤30 m^3	1.635	0.06	1	0.02	0.13	2.845
	water usage > 30 m^3	2.18	0.06	1	0.02	0.13	3.392
Water Supply for Public Organization		1.17	0.08	1	0.02	0.13	2.4
Water Supply for Business & Factories		1.32	0.08	1.05	0.02	0.13	2.6
Water Supply for Special Industry		1.97	0.1	1.28	02	0.13	3.5

Source: [40]

Note) (1) including 0.04 RMB for the construction of water supply facilities

(2) real estate construction, hotels and restaurants, public baths and car washing

Wastewater Collection, Transfer, and Disposal System in Nanjing

In 2004, 897 million m^3 of wastewater was discharged, including 470 million m^3 of industrial wastewater, decreased by 3.8 % compared to 2003. The percentage of industry wastewater meeting the discharge standard was 90.25 %, same as 2003. For the industry wastewater, the main pollutants were COD and NH_3-N which accounted for 29,500 and 1,310 m^3, and decreased by 7 % and 30 %, while the emission amount of another six main harmful pollutants (-OH, CN^-, Cr, As, Pb, Cd) were 628,400 m^3, increased slightly, compared to 2003.

According to the survey from the environment protection bureau (EPB) of Nanjing, the emission intensity of industrial wastewater, COD, and NH3-N was 57.1 m^3/10,000 RMB, 3.59 kg/10,000 RMB and 0.16 kg/10,000 RMB, respectively, implying the cleaning degree of production technology and the efficiency of material usage. These three indices decreased by 35 %, 31 %, and 44 %, respectively, showing that the production efficiency was growing higher and the cleaner production made a significant progress. On the other hand, 427.62 million m^3 of domestic wastewater in Nanjing in 2004, but only 55.5 % (237.34 million m^3) was treated and the rest was directly discharged to the rivers.

At the end of 2004, five wastewater treatment plants had been in operation, which were Jiangxinzhou, North City, Suojincun, East City, and Xianlin WWTPs. Three of them had been operated with the secondary bio-technology facilities. They were Jiangxinzhou, North City, and Suojincun WWTPs with a load of 400,000, 300,000, 5,000 m^3/d, respectively. Since the capacity of Suojincun WWTP was too small, the treatment cost was too high. Therefore, following the planning after 2005, this plant would combine with the North City WWTP to reduce the cost. Two extensive projects, 200,000 m^3 daily load for East City WWTP and 240,000 m^3 additional load for the second Jiangxinzhou WWTP, were about to finish, and then the treatment ratio would be higher than 85 % of the total wastewater.

In 2004, 38 projects were carried out and 280.7 million RMB were invested on industrial wastewater treatment. At the end of that year, 32 projects were finished and 20,577 m^3/day of capacity was added, and the reuse ratio of industrial wastewater was 70.4 %, increased by 2.6 % compared to 2003. In Nanjing, 27 big companies discharged 70 % of the wastewater. The remote online survey was applied to these factories as well as all the wastewater treatment plants, and all the discharged water from these met the discharge standard. The construction of four primary sewerage pipeline systems were planned in the city, the gathering systems paralleling with Jingsi Road, Hongwu North Road, Main Road on the west and Main Road on the east. Then, some secondary pipelines were to be connected to the primary pipelines of the sewerage gathering system as well as some pump stations. Once completed, such problems as separation of rainfall from wastewater would be solved and would greatly enhance the collection capacity.

Estimation of Household Water Use and Sewerage Generation in Nanjing

Following the "planning of Yangtze River Delta", the population would be 6.8 million in the whole metropolitan area [41]. Through the linear prediction, then, 1,036 million m^3 of wastewater would be generated in 2010. However, no more large-scale wastewater treatment plant is planned to be built in the next five years, and only 21 to 26 million m^3 capacity would be extended in the next few years, resulting in a big gap. Although the average water usage in the future would be decreased and declined by 10 % due to the various efforts following the "Eleventh Five Years Plan", there is still a big disparity between demand and municipal supply, 92-95 million m^3 per year. This large gap must be considered in coming years with respect to the city development strategy.

Sewer Network in Nanjing

To match up to the capacities of existing and extensive wastewater treatment plants, new sewer works of 130 km of dedicated wastewater sewers and the associated secondary branches will be constructed, and this will intercept the sewage and transfer it to the respective wastewater treatment plants and five dual-purpose pumping stations [42]. In main districts of Nanjing, the separate sewer works were built only in Xianlin and Hexi districts and the combined sewer systems exist in most old districts. Because of the requirements of historic sites protection, the complete reconstruction of combined sewer systems are not allowed, and subsequently the local alterations have been transferred to the wastewater treatment plant, whereas during the rainy period, 15 minutes after the start of raining, the wastewater in pipelines would be discharged into the river instead of being transferred to the treatment plant. Nonetheless, it still needs further reconstruction.

Table 3.8 WWTP construction projects in Nanjing (after 2005)

Project	Scale (10,000 m^3)	Location
Jiangning WWTP	4	Jiangning District
South City WWTP	10-20	Tiexin Bridge District
Xianlin(Tiebei)WWTP	10-15	Yanziji; Maigao Bridge
2nd Jiangxinzhou WWTP	24	Hexi District
2nd East City WWTP	10	Maqun District, Tiexin Bridge

Shenyang City, Liaoning Province

Shenyang, China's fourth largest city with a population of 7.2 million in 2005, reigns as the capital of Liaoning province. It lies on 41°N, 122°E, with the temperature between - 30. 5℃ and 25℃, including four months of frozen period. Located about 100 miles inland from the Bohai Sea in China's Northeast corner, it is best known as an industrial behemoth. Zinc, copper, and lead smelting plants are combined with heavy machinery, textile, medicine, chemical, transformer, and tractor manufacturing plants to mold the powerful economic muscle. Shenyang plays an important role in northern China, and is the first city, mentioned in Northeast China as an industrial centre as well as a transportation junction.

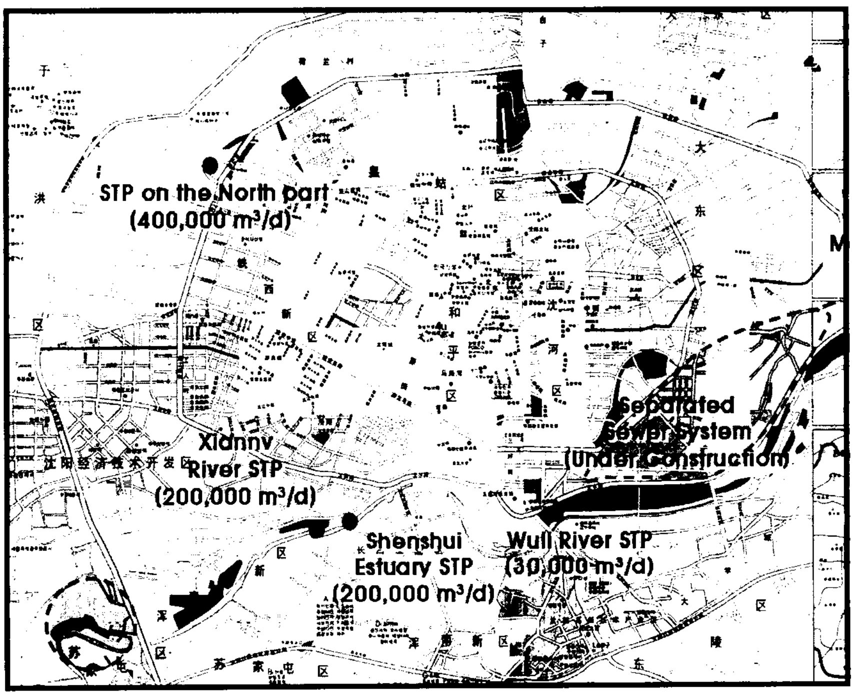


Figure 3.4 Map of Shenyang City

Water Supply System in Shenyang

As a big city, Shenyang has a large demand for drinking water. As shown in Table 3.9, from January to October 2004, the total demand of drinking water was 383.72 million m^3, compared to 451.51 million m^3 in 2003. The length of underground pipeline is 2,600 km to transmit that amount of water. All the drinking water surveyed by the environment supervision center of Shenyang in 2003 and 2004 met the standard.

Shenyang has 9 waterworks and 34 water sources of which 33 are groundwater sources because the surface water around the city had been polluted and cannot satisfy the requirement as drinking water, and the proportion of groundwater usage is 72 %. The only surface water source is Dahuofang reservoir at Fushun City. The price of pipeline water in Shenyang is 1.90 RMB per m^3, including 0.5 RMB for the wastewater treatment fee and 0.4 RMB for the secondary pumping fee, and this price has not been changed for 7 years. On the other hand, the limiting water resources and the increase in more pollution have affected the fiscal budget of the government, a new way of charging the water fee according to the amount used would be applied after carefully researched.

Table 3.9 Water supply in Shenyang, China

	Unit	2001	2002	2003	2004 (Jan.-Oct.)
Supply from water sources	10,000 m^3	48,963	46,126	45,150	38,372
Water amount under surveyed		48,963	46,126	45,150	38,372
Amount (meet the standard)		48,963	45,858	45,150	38,372
Ratio (meet the standard)	%	100	99.42	100	100

Wastewater Collection, Transfer, and Disposal System in Shenyang

Total wastewater discharged in 2004 was 1.86 million m^3/d, containing the main pollutants of COD, SS (suspended solids), and NH_3-N at 202, 86.6, and 32.3 m^3, respectively. Table 3.10 shows the wastewater discharged along with the spatial distribution. As shown, most wastewater and pollutants were discharged from the downtown area, covering 84.3 % of the total wastewater and, 76.9 % of the gross COD and NH_3-N emission (also refer to Table 3.11). The sewerage system was built in 1903 and experienced from the direct pumping to rivers to the gathering in the artificial trench, and to the underground trench avoiding smells to the tunnels collecting the wastewater and discharging after treated. The drainage pipeline system was constructed according to the hypsography of the city, higher on the east and north and lower on the west and south, resulting in the wastewater flowing from the upstream, east and north, to the downstream, west and south. The converging water surface of the urban area was

186.97 km^2, and the municipal sewerage system was comprised of three main drainage systems of the south, the north, and the west, with 1,600 km underground sewerage pipeline and 34 pump stations. Furthermore, two individual sewerage systems, Hunnan and Huishan Trench, facilitated the overall function of municipal capacity for citizens.

Table 3.10 Wastewater discharged in Shenyang

Area	Wastewater discharged (10,000 m^3/day)	COD (m^3/day)	NH_3-N (m^3/day)	Discharging Destination
Downtown	156.86	203.94	32.16	Hun River
Suburb and sub-cities	27.88	45.76	7.47	Liao River, Beishao River, Hun River
Non-point pollution (discharged to the river)	0.4	0.72	0.1	Liao River, Hun River, Beisha River
Total Amount	185.14	250.42	39.73	——

Estimation of Household Water Use and Wastewater Generation in Shenyang

Near 10 million people are predicted to live in Shenyang [43], and the pressure of wastewater generation would greatly increase accordingly. However, water shortage and the promotion of saving water would decrease the water consumption. Compared to 1.86 million m^3 of wastewater generated per day in 2004, it would be increased to the 2.6 million m^3/d. Eleven wastewater treatment plants are planned to be built in the future, and the total capacity would be exactly 2.6 million m^3 by 2010, implying the prediction of municipal construction can meet the society development in Shenyang. However, the investment and the operational efficiently of those new facilities are two main factors to determine the future development of wastewater treatment projects.

Sewer Network in Shenyang

As in Nanjing, the construction of sewers and pumping stations will be to match with the extensive wastewater treatment plants. In addition, the reuse of treated water is also planned. In the next 5 years, 10 washing cars plants will be built to reuse the treated water and the storm water collection plans will be carried out [44], and the matching pipelines will be constructed.

Table 3.11 Wastewater and pollutant discharge in Shenyang (2004)

Area	Amount of Wastewater Discharged (10,000 m^3/day)	Pollutant Discharged (m^3/day)	
		COD	NH_3-N
Xinmin County	2.12	2.988	0.510
Liaozhong County	1.967	5.863	1.242
Faku County	1.061	3.344	0.185
Sujiatun District	6.210	7.638	1.494
Xinchengzi Distict	4.278	5.262	1.029
Kangping County	2.34	7.380	0.408
Yuhong District	7.03	8.647	1.691
Dongling District	3.77	4.637	0.907
Total Amount	27.88	45.76	7.47

Table 3.12 Wastewater distribution in Shenyang, China

Drainage System	Total Amount of Wastewater (10,000 m^3/d)	Discharge Destination	Sewerage Amount (10,000 m^3/d)	Treatment Status
Northern Part	35.7	WWTP in North Part	26.9	Treated
		Weigong Trench Underground	8.8	Untreated
Southern Part	68	Wuli River WWTP	3	Treated
		Shenshui Estuary WWTP	20	Treated
		Lingkou Drainage Hole	45	Untreated
Western Part	48.3	Xiannv River WWTP	16.5	Treated
		Weizhao Trench	19.4	Untreated
		Zhangshi Trench (Surface and underground)	12.4	Untreated
Eastern Part	3.06	Huishan Trench	1.06	Untreated
		Mantang River WWTP	2	Treated
Hunan District	1.8	Hunnan Pump Station	1.8	Untreated
Total Amount	156.86	684,000 m^3 were treated before discharged		

Until 2004, Shenyang had 5 wastewater treatment plants in use. The Mantang River wastewater treatment plant had been under operation steadily for more than one year. Between January and September, the average treatment capacity was 20,000 m^3 /d, and this was its full operational load. All the water letting out reached the discharge standard level Ⅱ. In case of the southern part of Wuli River wastewater treatment plant (capacity, 100,000 m^3/d), between January and September, the incoming wastewater did not reach the requirement and the treatment amount was only 60,000 m^3/d, and the discharged water reached the standard level Ⅱ. The Shenshui Estuary wastewater treatment plant (capacity, 200,000 m^3/d) discharged its effluent to Hun River as the environmental supplementary water that reached the standard level Ⅱ. The Xiannv River wastewater treatment plant (capacity, 240,000 m^3/d) was supposed to fully treat after the construction completed. Thus, between January and August 2/3, that expectation was not reached because one important pump station was not finishing its construction until September. After that, the plant worked under the full operational load. In addition, since it was a new facility, the effluent did not reach the standard level Ⅱ until the second half. The wastewater treatment plant in the northern part (capacity, 400,000 m^3/d) is with the A/O biochemical active sludge technology and the main equipments from France. From January to September, a steady amount of 330,000 m^3/d of wastewater was treated to the discharge standard level Ⅱ (Table 3.13).

Table 3.13 Operational situations of the five WWTPs in Shenyang (Jan 2005)

Plant	Capacity (100,000 m^3/d)	Average Treated Wastewater (100,000 m^3/d)
WWTP in the Northern Part	33.0	32.8
Shenshui Estuary WWTP	20.0	20.0
Xiannv River WWTP	20.0	19.7
Wuli River WWTP	3.0	3.0
Mantang River WWTP	2.0	1.8

Henan Province

Henan, an agricultural province, is located in the middle-lower valley of Yellow River, with its name derived from the province lying south of the river (Figure 3.5). As one of the earliest developed regions in the country, it was a political and cultural center in ancient China. According to the 2000 census, its total population is 95.55 million, with 21.47 million or 23.2 % as urban residents and 71.09 million or 76.8 % living in rural areas. In 2005, it was shown the GDP of 1,054 billion RMB and the GDP per capita was 11,236 RMB. Relying on abundant resources of agriculture and its by-products and minerals, it has many industries including textile, food, coal, oil, power, chemistry, construction material, and electronics.

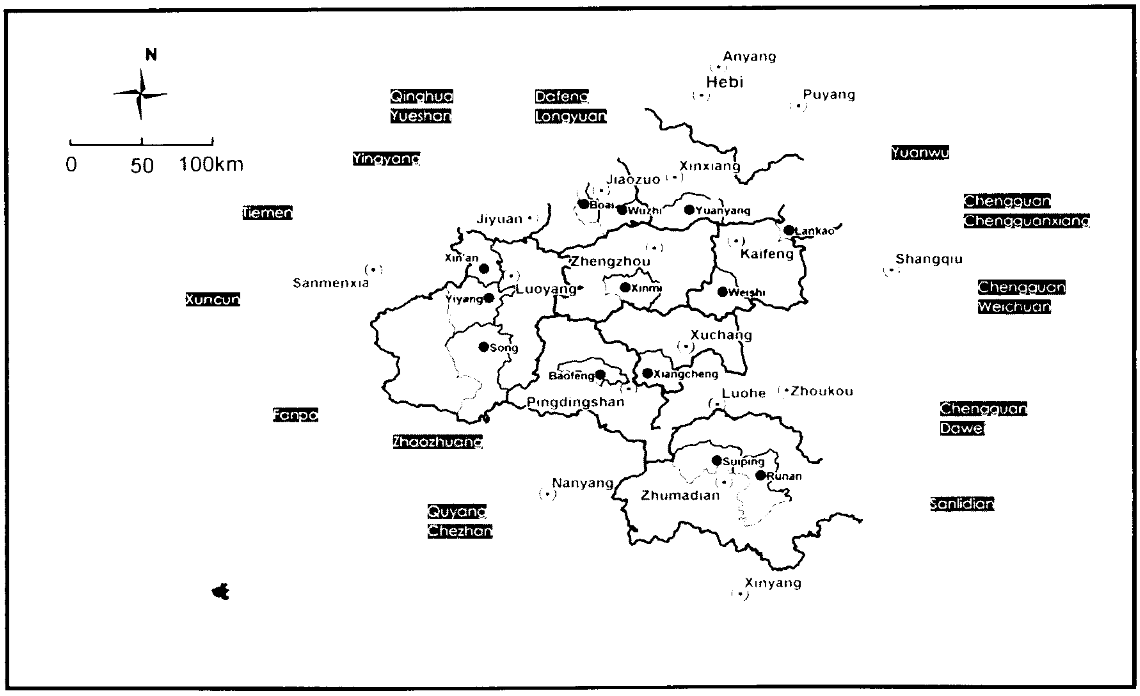


Figure 3.5 Map of Henan Province

In Henan Province, there are more than 1,500 small rivers along with 470 river catchments, with the area of more than 100 km^2, and these rivers are part of the four water systems, Yellow River, Huaihe River, Haihe River, and Hanshui River. The amount of available surface water is about 1 billion m^3, and 13 billion m^3 per year, respectively. According to the 1995 TVIE survey, the emission of wastewater and COD in Henan were 4.43 and 7.08 times higher than the national level, compared to those of Jiangsu reaching about half of the national levels.

Water Supply System in Henan

In a survey by the World Bank that covered half of Henan Province, only 10 % of the residents received the piped potable water, which is much lower than the average in Asian countries. It is also much lower than the Taixin Metropolitan in Jiangsu Province with 64 %. The source of most potable water is groundwater from privately owned deep wells. It is shown that most counties provide between 100 and 300 liter per capita per day (L/cap.d), similar to the national average of 258 (Table 3.14), even though there are large regional discrepancies. For example, Lankao County in Henan Province has a very small number of people, at 30,000, provided with the piped safe drinking water, and the daily flow of 12,000 m^3 or 400 L/cap.d was provided by the plant built in 2000. On the other hand, such counties as Xinmie and Runan received less than 100 L/cap.d from the water supply system constructed in 1960s and 1980s, respectively. In addition, because of the system age, some potable water supplied is contaminated with the very high leakage. As mentioned previously, about 90 % of the population uses the private shallow wells, but the local rapid industrial development and poor drainage systems will impact on the integrity of these private wells. In the long run, the private shallow wells must be gradually decommissioned, preferably in the next 5 to 10 years.

Table 3.14 Water supply structure of Henan Province, China (2003)

County Name	Pipeline Water Supply Ratio in Chenguan	Pipeline Water Supply Ratio in rural area	Supply from Self-owned Wells	The ratio of non-pipe line water supply	Water Supply quantities in Chenguan
	%	%	m^3/d	%	L/d
Xin'an	>95.0	0	N/A	N/A	222
Yiyang	55	0	11,500	95	242
Song	90	0	N/A	N/A	na
Yuanyang	0	0	20,000	100	0
Bo'ai	90	0	27,000	95	160
Baofeng	75	0	20,000	74	210
Wuzi	60	0	21,530	97	174
Xiangcheng	16	0	30,000	99	329
Weishi	30	0	27,000	98	139
Lankao	40	0	15,400	N/A	333
Xinmi	98	0	28,800	93	26
Suiping	44	0	N/A	N/A	186
Runan	75	0	20,000	N/A	80

Table 3.15 Status of water supply in Henan Province (2003)

County name	Drinking water sourced	Depth of well	# of Waterworks	Year built	Standard meeting rate	Water supply quantity	Length of water supply pipeline	Sanitized
Unit		M			%	m^3/d	km	
Xin'an	U	160	2	2,000	95	12,000	63	yes
Yiyang	U	150	2	na	100	8,000	37	yes
Song	U	na	1	1,993	100	12,000	24	yes
Yuanyang	0	0	0	0	0	0	0	0
Bo'ai	U&S	150	1	1,971	100	13,000	37	yes
Baofeng	U	50	1	1,976	100	11,000	22	no
Wuzi	U	150	1	na	92	10,000	26	yes
Xiangcheng	U	100	1	1,991	na	6,000	40	yes
Weishi	U	200	1	1,989	na	5,000	10	yes
Lankao	U	500	2	1,992	80	10,000	23	yes
Xinmi	U&S	400	6	na	100	3,000	135	yes
Suiping	U	200	1	1,966	na	9,000	24	yes
Runan	U	200	1	na	na	6,000	25	no

*Note) * U-underground water; S-surface water*

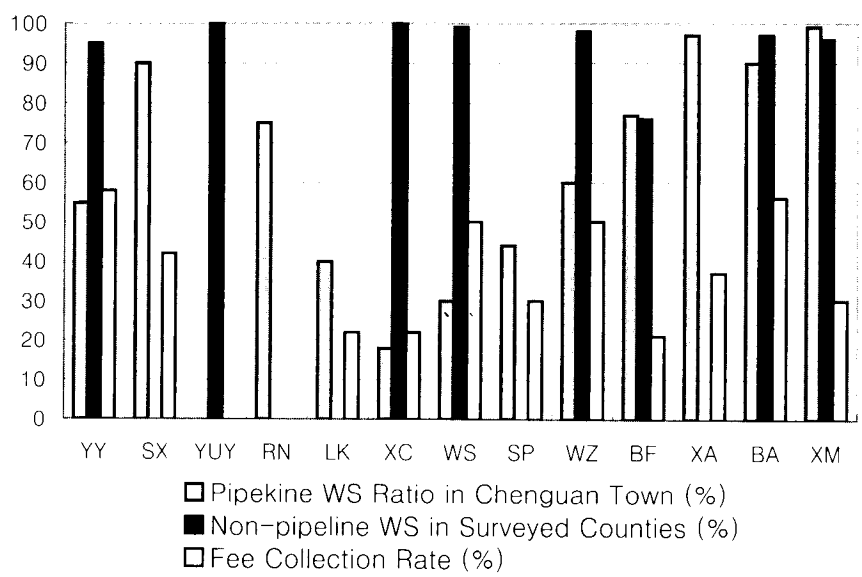


Figure 3.6 Water supply service in Henan Province

Table 3.15 summarizes the existing water supply plants in Henan Province. The monitoring cost is around 1 % of the total operation cost and the management and technical staffs are about 30 % of the total staff, and both numbers indicate a low priority for the water supply system. The staff per unit water supply capacity is too high compared to those developed regions and countries. Furthermore, the low ratio of monitoring cost also means the low safety of the water supply system and the low ratio of management and technical staff means the low management level for those water supply facilities as well. Figure 3.6 further shows the water supply service for those surveyed areas in Henan Province.

Wastewater Collection, Transfer, and Disposal System in Henan

There are no wastewater treatment plants in town and townships for the surveyed area of Henan Province, although the volumes of wastewater discharged are enormous. Especially, the industrial discharges contain many undesirable pollutants in large quantities. According to the TVIE survey in 1995, the emission factors of wastewater and COD in Henan are 4.43 and 7.08 times that of the national level and about half compared to Jiangsu. Industries were required to install the pollution control equipment to meet standards published in 1997 and 2000. However, it was found that many enterprises operate the pollution equipment during inspections, while the industries claimed that they could comply with the emission standards, even though their ability is questionable. Sixty two percent of the rivers in the surveyed area are of Class IV or worse. Non-point sources loadings of BOD, nutrients, and microorganisms, although not specifically measured, appear to be a major problem in the agricultural counties.

Recently, local governments are paying more attention to the environmental quality. However, the pollution phenomenon remains at county level, as many polluting industries are transferred from municipality and coastal regions. The environmental quality of a specific county really depends on the development strategy adopted by the local leaders. Water and air pollutions are the major pollutions in the surveyed counties and the industrial water pollutants account for most of the water pollution. According to the statistics, the industrial wastewater in most counties takes up over 70 % of the total wastewater. In terms of COD, those industrialized counties show its ratios higher than 70 %, and for such industrialized countries as Bo'ai and Xinmie, the ratios are over 90 % (Table 3.16). The data about non-point sources are usually not collected and only the consumption data of pesticides and fertilizers are available in some counties.

Table 3.16 Wastewater emissions and water quality in Henan Province

County name	Industry wastewater discharge	Life wastewater discharge	Percentage of Industry wastewater to total	Industry COD discharge	Household COD discharge	River Name	Water quality ***
Unit	m^3/y	m^3/y	%	m^3/y	m^3/y		
Xin'an	51,580,000	5,910,000	90	275*	2,097	Jianhe River	V
Yiyang	30,480,000	Na	na	641	na	Luohe River	II
Song	11,370,000	3,720,000	75	276	1,303	Yinhe River	II
						Ruhe River	II
Yuanyang	na	na	na	na	na	Tianran Trench	na
						Wenyan Trench	na
Bo'ai	26,000,000	3,000,000	90	10,000	6,000	Dashahe River	V-
Baofeng	5,680,000	8,030,000	41	2,103	2,409	Jingchanghe River	II
						Shihe River	III
Wuzhi	27,990,000	4,010,000	87	14,153	1,905	Qinhe River	IV
						Huanghe River	II
Xiangcheng	6,950,000	5,260,000	57	48**	na	Beiru River	II
						Yinhe River	IV
Weishi	2,903,500	2,680,000	52	1,940	1,613	Jialuhe River	V
						Shuangxihe River	V
Laokao	3,000,000	na	na	650	na	Huanghe River	III-IV
Xinmi	50,750,000	4,300,000	92	9,570	2,100	Shangmuhe River	V-
Suiping	8,800,000	1,830,000	83	2,733	913	Ruhe River	III-IV
Runan	209,000	4,030,000	5	Na	2,015	Ruhe River	IV
Taixing	74,525,100	8,850,000	89	6,044	na	Changjiang River	II
						Rutai Canal	III

*Note) *: Major industries are electricity and coal mining.*

***: This number is suspicious.*

****: China Surface Water Quality Standard GB-3838 (2002)*

Currently, such industries as paper and pulp, leathering, chemical industry, food industry, and electricity are the major polluting sources. The standard-meeting movements in 1997 and 2000 forced most enterprises to install the pollution control equipment, a major factor in pollution reduction. According to the interview and data collected, most enterprises can comply with the emission standards, even though their claim is suspicious. There is rather the possibility for both enterprises and the EPB providing wrong information. It can be concluded, from these observations, that those industrialized counties in Henan are more polluted than those developed counties in coastal areas even though they are still at the early phase of economic development. Therefore, there are strong needs to enhance the pollution control via some potential effective means and the construction of wastewater treatment plant is one of the most effective solutions. Although other counties in Henan are currently not that much polluted, if they follow the same development approach adopted by those industrialized counties in Henan, they may soon become heavily polluted as well.

WWTPs in Henan Areas

Currently, there is no single wastewater treatment plant, and no actual construction of wastewater treatment plants as of November 2004, in those surveyed areas. According to the interview, however, there are urgent needs for wastewater treatment facilities in urban areas. Except for the industrial wastewater, domestic and agricultural wastewater have not been treated in those surveyed counties of Henan and no separate drainage systems exists yet for wastewater and rainwater. This subsequently increases the difficulty of wastewater collection and treatment to some extent. In fact, wastewater pipelines have not been built in those surveyed counties, and townships other than Chenguan Town do not have capacity to treat the wastewater, resulting in a random discharge. The planning of wastewater treatment plant is usually conducted by the county government, and in southern part of Jiangsu, thanks to the strong financial capability of township government, most funds are provided by themselves with about 30 % of the total investment coming from the county or upper levels.

The watershed management in this region gives an additional pressure for building wastewater treatment facilities. Therefore, Henan Provincial Construction Department required that by 2007 all the "Chenguan Towns" must build wastewater treatment plant, consistent with the national policy for the pollution control in Huaihe River basin. Unfortunately, this objective cannot be achieved with the current progress. In terms of financial ability, in most areas, the local government cannot fully provide the resources needed, so there are urgent demands for debts and domestic/international loans.

3.1.2 Southern Asia: Vietnam

1) General Information

Vietnam (Figure 3.7 and Table 3.17) is located in the center of the Southeast Asian and lies in the eastern part of the Indochina peninsular, bordering China to the north, Laos and Cambodia to the west, and the South China Sea and Pacific Ocean to the east and south, covering an area of 329,560 km^2 and with a population of 84.4 million, and its land is primarily agricultural with a central tropical rainforest. Vietnam acquired independence from France in 1954 with the government of Socialist Republic, and its capital is Hanoi with 3.7 million people.

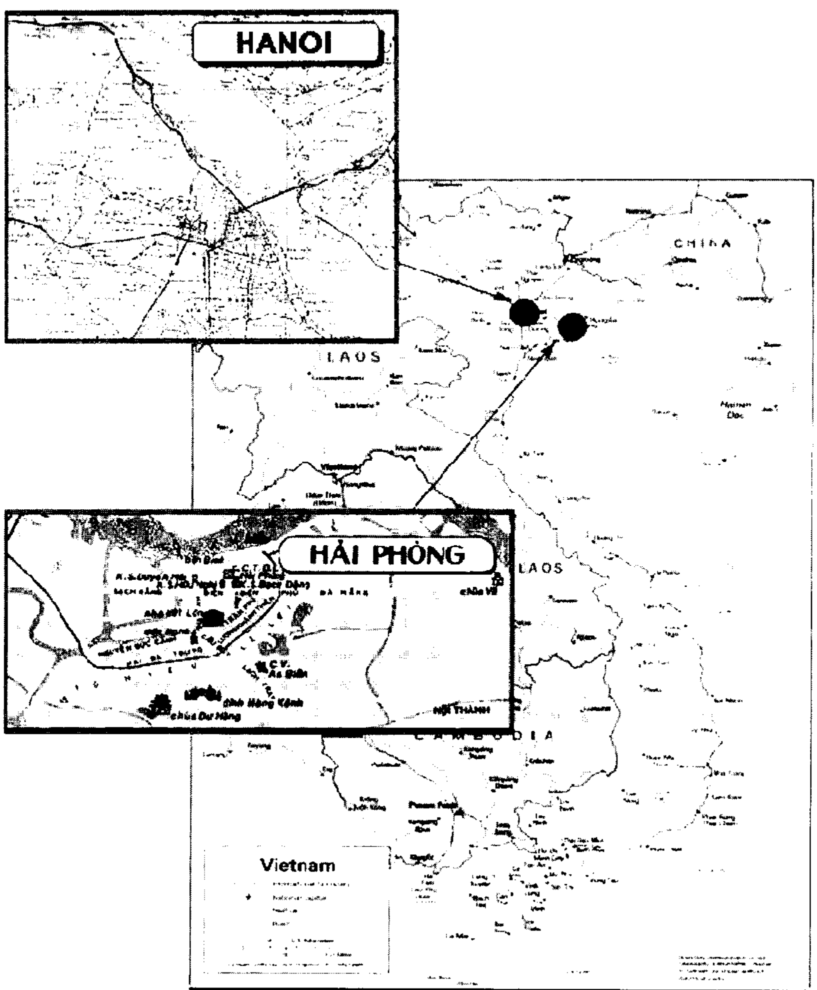


Figure 3.7 Map of Vietnam

Table 3.17 General information for Vietnam

Location	Southeastern Asia
Area	Total: 329,560 km^2, Land 325,360 km^2, Water 4,200 km^2
Terrain	Low, flat delta in south and north; central highlands; hilly, mountainous in far north and northwest
Land use	Arable land: 20.14 %, permanent crops: 6.93 %, other: 72.93 % (2005)
Natural hazards	Occasional typhoons (May to January) with extensive flooding, especially in the Mekong River delta
Environment issue	Logging and slash-and-burn agricultural practices contribute to deforestation and soil degradation; water pollution and over-fishing threaten marine life populations; groundwater contamination limits potable water supply; growing urban industrialization and population migration are rapidly degrading environment in Hanoi and Ho Chi Minh City
Geography	Extending 1,650 km north to south, the country is only 50 km across at its narrowest point
Population	84,402,966 (July 2006 est.)
Population growth rate	1.02 % (2006 est.)
Infant mortality rate	25.14 deaths/1,000 live births
Life expectancy at birth	70.85 years
HIV/AIDS – adult prevalence rate	0.4 % (2003 est.)
HIV/AIDS – people living with	220,000 (2003 est.)
HIV/AIDS - deaths	9,000 (2003 est.)
GDP	Purchasing power parity - $ 232.2 billion (2005 est.)
GDP - real growth rate	8.4 % (2005 est.)
GDP - per capita	Purchasing power parity - $ 2,800 (2005 est.)
GDP – composition by sector	Agriculture: 20.9 %, industry: 41 %, services: 38.1 % (2005 est.)
Population below poverty line	19.5 % (2004 est.)
Budget	Revenues: $ 11.64 billion, Expenditures: $ 12.95 billion, including capital expenditures of $ 1.8 billion (2005 est.)
Public debt	48.2 % of GDP (2005 est.)
Current account balance	$ -309 billion (2005 est.)
Debt - external	$ 20.16 billion (2005 est.)

Source: [45]

2) Environmental Status and Issues

The faces of the environment are always changing in urban areas because of buildings and infrastructure being constructed constantly. This is one part of the urbanization process to develop economic and social factors made by humans. Compared to the past, the pace of urbanization in Vietnam is low but apparently increased in recent decades, especially from the renovation, a certain historical development. However, there is a fact that the human influence based on the subjective enforcement to nature and environment without a master strategy leads to negative results, and the quality of the environment, especially water environment, is deteriorating. Figure 3.8 summarizes the development of wastewater management in Vietnam.

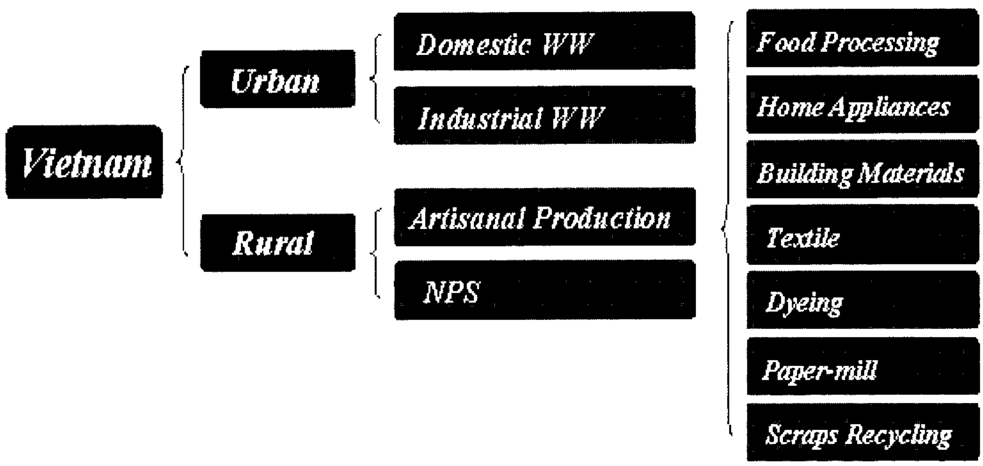


Figure 3.8 Status of wastewater management in Vietnam

Status of Wastewater Treatment in Urban Area

The recent development of urbanization and industrialization is accompanied by the increasing sanitation and industrial wastewater with more diversified and privatized component. Moreover, many industrial enterprises located in residential areas that just happened as a part of urbanization and poor planning management influenced on the environment. The status of sanitation in urban areas is in low levels (Table 3.18). According to data from the Ministry of Construction, 10-20 % population in large urban areas and 30-50 % in smaller ones still use toilets, 2 cells toilets or public. The percentage of households with septic tank is 50-80 % for the urban type I and II, while only 20 % for other types.

Table 3.18 Wastewater service for urban household in Vietnam

Type of Urban	Households getting wastewater service (%)
Type I	48
Type II	44
Type III	25
Average in Northern	27
Average in Southern	52
Average	44

Urban Domestic Wastewater Treatment

In 1997, a wastewater treatment plant with a capacity of 2,500 m^3/hr was built with the technology transferred from the Centre for Urban and Industrial Environment Technology, in a Bai Chay (Halong city). Wastewater from houses, hotels, and tourism and entertainment places, after separated from wastewater pipes and streams, was pumped into the wastewater treatment plant. The treated wastewater has the content of 20 mg/L BOD_5, below 30 mg/L sludge, and below 5,000 MNP/100 mL coliform, meeting the Vietnamese standard TCVN 5943 – 1995, for discharging into coastal areas. However, for many reasons, this wastewater treatment plant still did not reach the project's targets.

Urban wastewater: From 1960, the treatment unit in Quang Trung living quarter (Vinh city) has been applying the oxygen trench unit considered as a completed treatment unit with the most reasonable technology ever in the country. However, due to the poor management, it had been soon downgraded and subsequently there is almost nothing left now. The latest one in Vuon Dao (Bai Chay – Halong) does not operate effectively, either. Many other units built could not be operated, resulted from many mistakes.

Hospital wastewater: From 1970s, there had been several treatment units designed by foreigners, with the biological technology and so called "sticky technology" applied. However, as they turned out not suitable to the management level, they were torn down. These hospital treatment units designed and built, following the bio-natural technology like bio-filters and aeration tanks are in bad condition or ineffective. Therefore, choosing a suitable method for treating wastewater is still a problem for the water supply and drainage consultants.

Besides, more studies should be done about the industrial wastewater treatment. There are currently about 100 industrial zones in the whole country, with 54 located in the southern provinces (30 zones have been in operation,) but the wastewater treatment plants have been built only 7 zones (Bien hoa 2, Loteco, Amta, Vietnam - Singapore, Vinh loc, Tan thuan, Linh trung, Bien hoa 1, and Nhon trach). Large-scale industrial zones are with the treatment units having the average capacity of 7,500–15,000 m^3/day, while for the smaller ones, 2,000–7,000 m^3/day. These treatment units are often designed and built by foreign companies with imported equipment so the cost is high. Although the quality of treated water meets the environmental standards (except for the Vietnam – Singapore industrial zone), the operation of these units is still not cost-effective.

Along with sanitation/wastewater, rubbish from river-nearby houses as well as from the city (about 30-50 % uncollected) goes into the pipes and irrigations, resulting in clogging and overflowing, leading to the more severe pollution. Therefore, the sanitation drainage in urban areas is generally without treatment before. Urbanization and industrialization usually lead to the environmental pollution. The amount of untreated wastewater discharged into rivers and lakes is increasing, while their self-purifying ability is limited. Sanitation from houses is discharged to the irrigations or to lakes and rivers through the drainage system. This is the main reason for the pollution of lakes and rivers in the city and suburbs.

Status of Wastewater Management in Rural Area

In recent years, due to the progress in intensive farming and the increase in cropping frequency and area under cultivation, the production of grains has grown rapidly. In addition to agricultural development, artisanal production and development of small industries in rural areas has resulted in the formation of specialized villages located in all provinces and in the suburbs of cities. However, this has also resulted in some environmental problems. During the industrialization process, artisanal production and small industries were rehabilitated and developed in many traditional artisanal villages or communes. According to some estimates, there are more than 1,500 specialized artisanal villages, and their popular trades are food processing, home appliances production, building materials production, textile, dyeing, paper-mill, and scraps recycling (recycling of nylon, plastic, aluminium, iron, lead, copper etc.). The production equipments and technologies in these villages are often old and obsolete, and the production facilities are installed in households or scattered within villages. This causes adverse impacts on the health of local people and the air and water pollution in some artisan has reached alarming levels.

The existing conditions of environmental sanitation in rural areas of Vietnam are very poor, especially in the poor rural areas. Except for some communes surrounding big cities accessing the piped clean water supply, most of the rural areas in Vietnam have to use water from dug wells, waterways, or rainwater without the sanitary treatment. Consequently, in some rural areas, this situation has led to the spread of several diseases such as malaria, hemorrhage and Japanese encephalitis, and the ones caused by parasitic worms.

3) Research Area

Hanoi City

Figure 3.9 below shows the map of Hanoi city, chosen as a research area for this report.

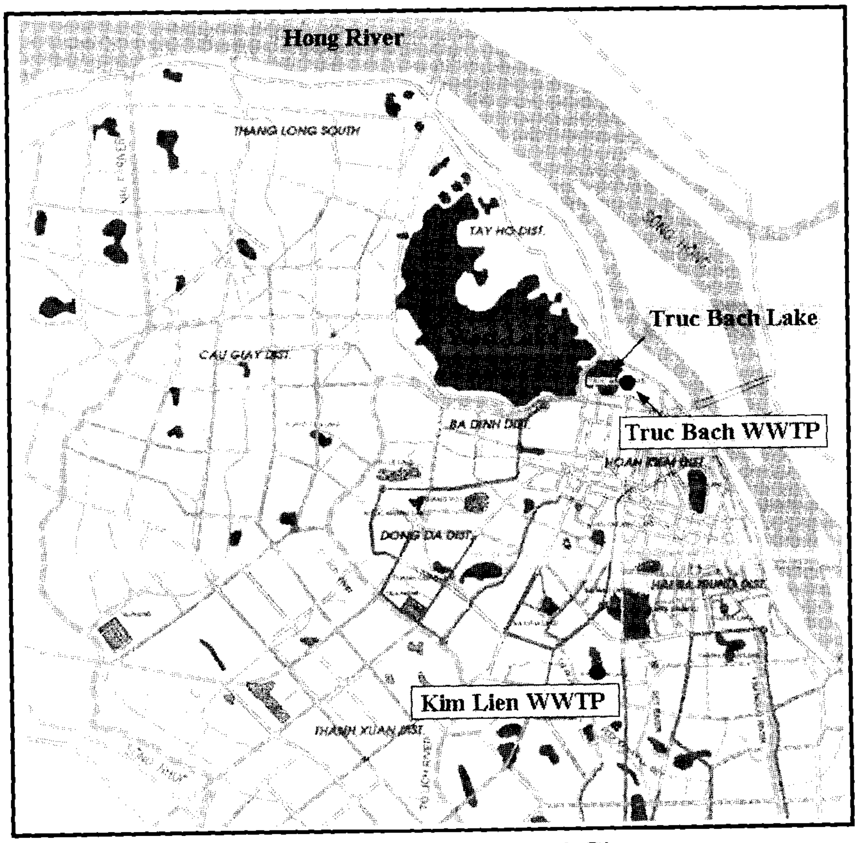


Figure 3.9 Map of Hanoi City

Underground Drainage Pipelines in Hanoi

The underground drainage pipelines built before 1939 was a combined system with varying dimensions, total length of about 70 km, and service area of approximately 1,008 ha, and the system served 380,000-400,000 citizens. This system, however, had been degrading rapidly and seriously. In 1989, on the other hand, the total length was 120 km, with the service rate of 16m/ha for about 900,000 inhabitants in urban area. According to the report of Hanoi Water Sanitation Company in 1995, the total length of the system was 180 km with the service area of 77.5 km^2, and about 70 km of pipelines was constructed during the French Domination period before 1939 and concentrated at the old city center. Other parts were constructed in expanding inner areas with the density of 18 m/ha, but they were arranged irregularly and there were even no drainage system in some areas. Furthermore, the amount of pipelines with the diameter less than 400mm-600mm was about 65 %, and they have been degrading badly so the drainage ability was worse.

Open Channel Network and Lakes in Hanoi

The Hanoi's wastewater is drained to the 4 main rivers and some ponds and lakes (Table 3.19).

Table 3.19 Wastewater flow in Hanoi, Vietnam

Basin	Flow (m^3/d)
To Lich River	150.000
Lu River	55.000
Set River	65.000
Kim Nguu River	125.000
Nhue River	55.000
West Lake	7.000
Total	458.000

The drainage open channels system of Hanoi City has 4 main channels with the total length of 38 km, connected to To Lich River, Lu River, Set River, and Kim Nguu River, and the length of the drainage river is 36.8 km. The bottom levels of these rivers vary from +1.0m to +2.0m, while their water levels are usually regular, +4.0 - +4.5m, but it might be +5.5m when raining. There are 110 lakes in Hanoi, with the area of 1,020 ha and connected by the drainage channels. Among these, 18 lakes are in the inner area, with the total area of 640 ha and serving for regulation and drainage. Aside from the drainage function, they also have such other functions as entertainment, recreations, landscaping, fish breeding, etc. Therefore, the water level of these lakes is always high level, thus limiting the drainage ability.

In 1998, the Hanoi water sanitation project – phase I was implemented by the Japanese Official Development Assistance (ODA) loan with the total investment cost of $ 200 million. The drainage system of Hanoi had been improved since this project was executed with the present total length of 280 km. Main rivers had been rehabilitated by dredging, lining, and walking roads. As a result, the influent flow was more and the urban landscape was improved. Especially, in Hanoi, Yen So pumping station – phase I was constructed with the capacity of 45 m^3/s, the storm-water was pumped from To Lich River to Red River.

Collection and Treatment System in Hanoi

The domestic wastewater is disposed of mainly from the residential areas of the old Hanoi area (1,008 ha) and distributed into 5 underground sewer systems. The volume of domestic wastewater in Hanoi is estimated to be from 100,000–188,000 m^3/day, making up 41 % of all the dirty wastewater. This volume is drained mainly through the rivers of To Lich (30 %), Kim Nguu (25 %), Set & Lu (13 %) and runs into the city ponds and lakes. The domestic wastewater has high content of organics and floating substances, most of which not treated before being discharged into public sewers or channels, ponds, and lakes. Previously, a model of wastewater treatment system of Kim Lien was constructed in the city, with a separate drainage system for residential areas as planned. The wastewater was collected from septic tanks and households to the wastewater pumping station and pumped into the treatment station. However, the Kim Lien treatment station was stopped operating for decades due to the inappropriate treatment technology, and this separate sewer network functions as a public sewer.

According to the report on present status of Hanoi environment in 2000, at present, only about 24 major service establishments (hotels, office headquarters, commercial centers, etc.) have their domestic wastewater treatment stations constructed. Septic tanks are used for toilets flushing water. Still, due to the improper quality of construction and management, the content of dirty substances in wastewater usually several to many times exceeding the allowable standard. The wastewater flow from the service and industrial zones usually makes up more than 55 % of the total wastewater volume of Hanoi (200,000-263,000 m^3/d). This flow has different characteristics of each industry and generally exceeds the allowable standard of TCVN 5945-1995 so needs to be treated. However, only a small percentage of this kind of wastewater has been treated, 4.4 % (11.523 m^3), and the main reasons are as follows:

- There are still many industrial establishments using the outdated production technology.
- The industrial groups and enterprises are scattered throughout.
- The investment on the wastewater treatment is still superficial.
- The management measures and the handling of the violations are still ineffective.

In addition to those existing 9 industrial zones, 5 new ones have also been established in Hanoi. Out of the total of 369 industrial establishments (including 156 large ones) and 14,000 small handicraft establishments, only 30 have their own wastewater treatment systems (Table 3.20) according to the report on present status of Hanoi environment in 2001. The wastewater of such industries as dyeing, leather, food processing, and chemicals has high content of pollutants directly discharged into the drainage system without being treated, resulting in a serious contamination of drainage rivers in Hanoi. The main industrial zones of the Hanoi Drainage Project studied are the ones of Thuong Dinh, Hai Ba Trung District, Cau Buou-Van Dien, and Phap Van-Van Dien. At present, there are only 29 central and local hospitals in the urban area of Hanoi. Among them, just 4 possess wastewater treatment facilities. They are the hospitals of Bach Mai, Thuy Dien (Children's hospital), Tuberculosis, and Viet Duc, and each treatment stations has a capacity of 300-800 m^3/d.

Table 3.20 Industrial wastewater effluents in Hanoi

Industrial Zone	Number of employees	Pollutants		Volume of wastewater
		SS (kg/d)	BOD (kg/d)	
Thuong Dinh	2,079	4,866	1,855	28,185
Hai Ba Trung District Area	16,491	8,706	6,561	2,106
Van Dien Area	2,248	4,050	519	1,432
Chem Area	3,108	774	96	1,647
Sai Dong Area	5,695	1,962	484	2,531

Source: [46]

According to the urban classification criteria (Decree No. 72/2001/NĐ-CP dated Oct 5, 2001), for the past few years, there have been some ODA funded projects in three types of urban areas: special urban, type I urban and type II urban.

Special urban area:

Hanoi has a project of "Drainage management in Hanoi – 1st period (1995 – 2001)".

In comparison, Ho Chi Minh City has three projects: Drainage management in Nhieu Loc – Thi Nghe, Environmental improvement in Ho Chi Minh City – Tau Hu – Ben Nghe – Doi Te basins, Urban improvement and sanitation in Tan Hoa – Lo Gom canal.

Type I urban area: Drainage management projects in Hai Phong, Ha Long, Da Nang, Hue, etc.

Type II and III urban area: Drainage management projects in DaLat, Thai Nguyen, Viet Tri, etc.

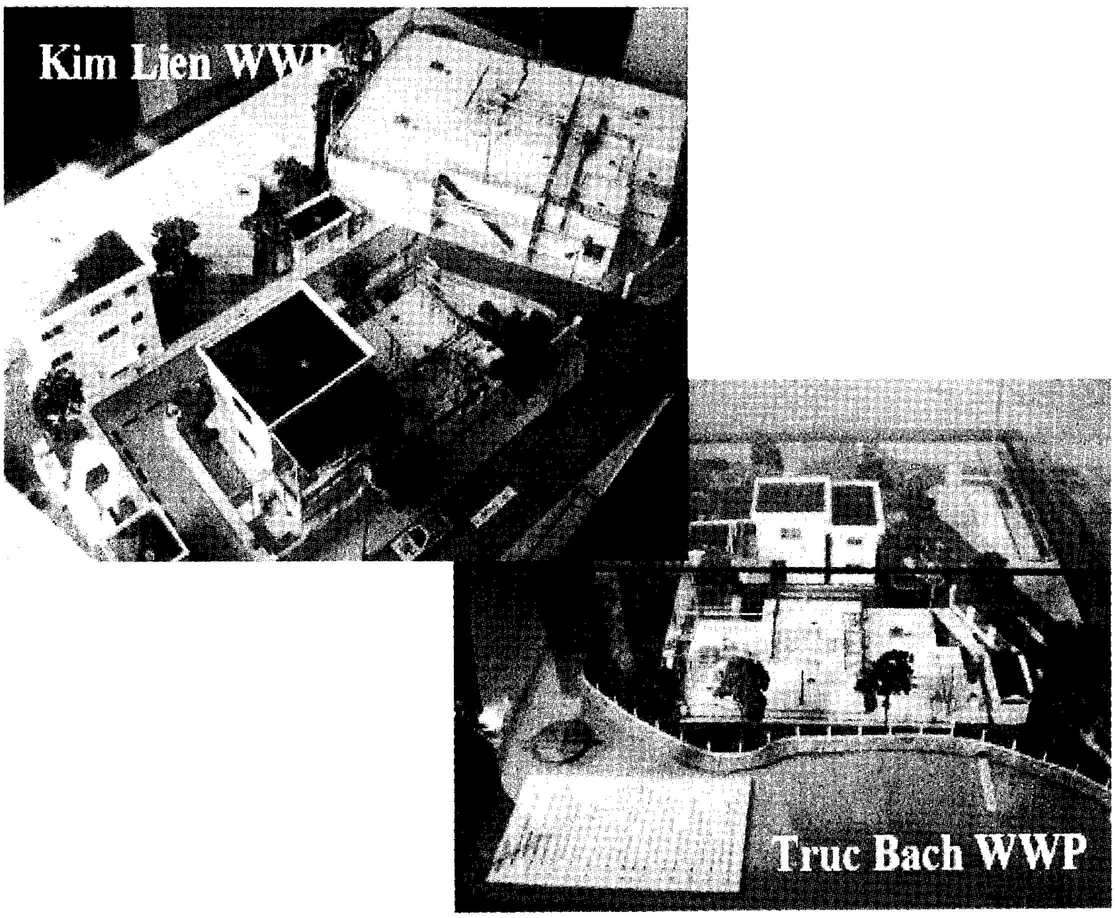


Figure 3.10 Kim Lien & Truc Bach WWTP in Hanoi City

In addition to the drainage management project implementing and supposed to be finished by 2003, the other projects (more than 14 projects) are being carried out in different periods in Hanoi. Apart from those projects financed by the foreign investors, there have been some other drainage and wastewater treatment projects in type III and IV urban areas organized by the Vietnamese consultancy companies. The 1st period of Hanoi Drainage Project has been carried out from 1996 to 2003, and for wastewater treatment, there had been only Kim Lien and Truc Bach (Figure 3.10). However, the ground clearing was still no completed to allow the pilot wastewater treatment units to be built. On the other hand, deploying the technology designs for these units has been faced with many troubles and obstacles, resulted in a delay of this article.

Therefore, the drainage project in Hanoi will be implemented in several periods: the 1st period will focus on re-building the key storm-water drainage in order to minimize floods, while improving the storm-water drainage network for the old areas – flood solutions for emergency situations; the 2nd will complete the storm-water drainage for the whole To Lich River Valley and conduct the investment on wastewater systems for some small valleys. This is a right approach for improving the status of Hanoi wastewater system and social requirement. Establishing the main pipe and orienting the storm-water system by other projects, followed by the master development plan, will create opportunities to improve the system in each small valley or area and will be a good initiative in storm-water drainage within the city.

Ho Chi Minh City

Underground Drainage Pipelines in Ho Chi Minh

According to statistical data in 1989, the total length of the system is 450 km, covering 2.8 million inhabitants, 32 m/ha (0.16 m per capita). There are 17 districts out of the total 22 urban and rural districts, having a partial or full combined drainage system with the coverage area of 62 km^2 (12 %). The highest coverage of 100 % is in No.1, No.3, and No.5 District and the lowest coverage of 0.3 % is in Binh Chanh District. According to the report of Urban Water Sanitation Company, there are 561 km pipelines with the diameter over 400mm and 415 km other pipelines with the diameter smaller than 400mm, under its management. The system includes 100 km (20 %) constructed over 100 years ago, 250 km (50 %) constructed between 30 to 100 years ago, but only 150 km (30 %) constructed since 20 years ago.

Channels and Drainage System in Ho Chi Minh

There are about 27 big conduits and 16 small canals in the whole city. These canals have been used by the illegal encroachment of households. Furthermore, the bottom of canals was consolidated with the domestic solid wastes from households. Therefore, flooding has occurred frequently during rainy seasons at the urbanized area of 35 km^2 and the agricultural land with the area of 230 km^2. For the inner basins, the amount of domestic and industrial wastewaters directly discharged into rivers and canals inside the city is very large without treated. According to the estimated figures, the present wastewater amount is about 729,000 m^3 of which the BOD is higher than 193,000 kg and it could increase rapidly in the future. For example, it is estimated that it could be 541,000 m^3/d in Doi–Te, Tau Hu, and Ben Nghe and 64,000 m^3/d in Nhieu Loc - Thi Nghe basins. This makes the water quality of those rivers worse and unacceptable. Currently, there is no wastewater treatment plant except for some enterprises and hospitals. According to the report of the city drainage system, only 50 % of the population has septic tanks, but these tanks treat only the toilet wastewater and other kinds of wastewater are discharged into sewer pipes or combined drainage systems, resulting in the rivers almost same as wastewater.

Hai Phong City

At present, there is almost no urban wastewater collection and treatment system except the sewerage system and pumping stations for Dong Quoc Binh residential area, but this system is ineffective. The interceptor sewers surrounding Tam Bac Lake at the city center, on the other hand, was regarded as a typical proposal to improve and protect the environment for inner lakes by the local Government. All kinds of wastewater in the city are currently discharged into the combined drainage system. Sanitation and industrial wastewater are almost untreated before discharged to the rivers, 20 km irrigation and regulation lakes (58 ha). Some places like: Viet Tiep hospital, canned fish factory, and Dong Quoc Binh living quarter have wastewater treatment plant but damaged.

The typical private wastewater drainage system like the one in Dong Quoc Binh living quarter was built as planned, but now it has become a combined drainage system. It is extremely complicated and almost impossible to rebuild and improve this system to get back to its original purpose. The private drainage system was rebuilt here in 2001, based on the available system, and the new sewerages settled from the wastewater outlets. However, through the test of the pumped wastewater amount, it was found that there was a large sum of storm-water (in rainy days) and ground water (in non-rainy days) in this private drainage network. The use of CCTV camera is being considered, searching the sewer inside to define its exact status and then develop new ways for rehabilitation – to continue using the private drainage or to replace with the half-private one.

Both domestic and industrial wastewater have polluted the water in Cam River, Tam Bac Lake, and Lach Tray Lake. In addition, due to the development on urbanization and manufacturing, the waste discharged into the sea gate areas is increasing considerably; during 1996–2000, about 100,000 m^3 of wastewater discharged into the sea each day; whereas between 2001–2010, it is estimated to reach 185,000 m^3/d. In general, wastewater in urban areas is really dirty as it is untreated or treated but without meeting requirements (BOD, 60–390 mg/L; COD 80–500 mg/L; DO, below 1 mg/L). Therefore, together with the sludge (6,000–8,000 m^3/yr), wastewater directly pollutes those receiving water bodies of at lakes, ponds, canals, irrigations, and rivers around the inner city.

Drainage Network in Hai Phong

The network includes about 67 km of main pipelines with the diameter of DN300-DN1200, 30 km of box culvert with the dimension of 400 x 500, 500 x 600, 700 x 1300. Furthermore, there are also about 104 km of pipelines and box culverts with small dimensions with the service area of 31.8 km^2 and the coverage of 416,000 inhabitants, implying the density of pipelines is 0.19 m per capita. The box culverts in old center were constructed before 1954, with the structure of brick or stone masonry and concrete cover slabs, and are still used according to the primary survey. The system was affected by the tidal of Cam River and Tam Bac River. During the high tidal, the water has not been discharged to the rivers but concentrated in the drainage channels and sometimes the water back flowing into the system (the average level of the rivers is +3,8 m, while the existing ground level at low places in the city is only +4,0 m), so the flooding problem is unavoidable.

Open Channels

There are two main channels in the City, Northeast channel and Southwest channel with the total length of about 6 km.

Tidal Gates

Currently, there are about 50 outlets to lakes (total area of regular lakes in the city is about 50 ha) and rivers within the Hai Phong drainage system. The tidal gates have been operated based on the tidal regime, depended on the water levels of those rivers. The most important tidal gates in the Hai Phong drainage system are May Den and Vinh Niem tidal gate. However, these tidal gates were under the operation and management by the Irrigational Department, so it caused many difficulties to the Water Sanitation Company to define the subjective proposals to drain the water and to minimize the flooding.

Hue City

According to the report of Hue Urban Environment and Public Works Company, the existing drainage system of Hue City is 92.49 km long, including 36.86 pipelines with the dimension bigger than 400 mm, 30.34 km of masonry channel, and the remaining 27 % of the natural channels. There has been an ODA project implemented for the city.

Nam Dinh City

The total length of existing drainage system is 40 km, and about 40 % are open channels. In 1998, the Kenh Gia storm-water pumping station was constructed with the capacity of 45,000 m^3/h. In summary, most of the cities are flooded in rainy seasons. The flooding occurred over a long time at delta urban areas, with those mountainous urban areas usually flooded. Subsequently, the construction works are damaged, traffic is jammed, and the economy lost badly. The rainfall of the country is high, with the average of 1,960 mm (two times higher, compared to the average in Asia). Most cities are located and concentrated in the low-lying delta flat terrain so the flooding problem is more complicated and difficult to overcome.

3.2 Africa

3.2.1 Eastern Africa: Kenya

1) General Information

Kenya is located in Eastern Africa bordering the Indian Ocean (Figure 3.11), between Somalia and Tanzania, covering an area of 582,650 km^2 and with a population of 34 million. The capital of the country is Nairobi with a population of 2.14 million. More than 75 % of the country is classified as arid and semi arid. Kenya plays a pivotal role in the economy of East Africa. In 1993, the government began some reform for the economic growth such as the removal of import licensing, price controls, and foreign exchange controls. However, following strong economic growth in 1995-96, Kenya's economy stagnated, with the GDP growth failing to keep up with the population growth rate. Much of the government's poverty reduction efforts are focused on improving public services and market access for the country's vital agricultural sector, which accounts for an estimated 75 % of its employment and 60 % of its income. Kenya's endemic poverty and extremely high unemployment (currently estimated at over 40 %) have caused to keep the country among the world's 20 poorest nations.

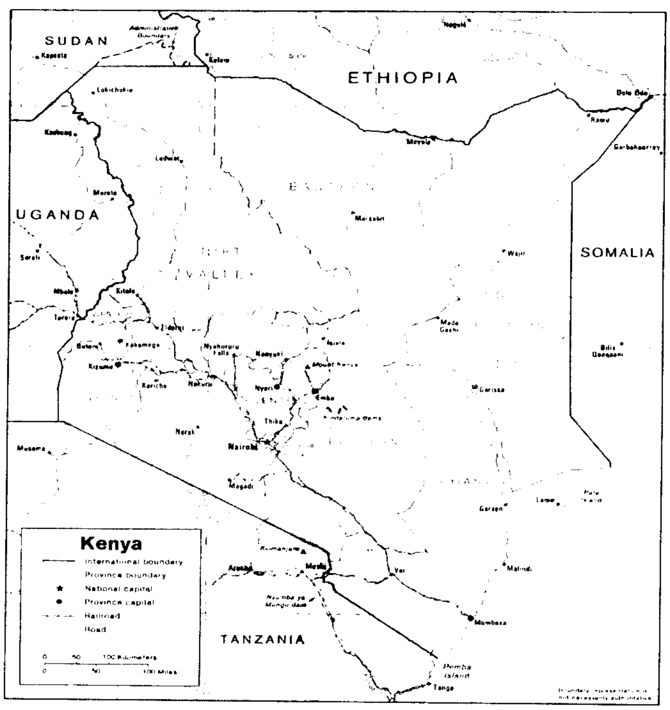


Figure 3.11 Map of Kenya

(Source : http://www.farmershelpingfarmers.ca/kenya.php)

Table 3.21 General information for Kenya

Location	Eastern Africa
Area	Total: 582,650 km^2, Land 569,250 km^2, Water 13,400 km^2
Terrain	Low plains rise to central highlands bisected by Great Rift Valley; fertile plateau in west
Land use	Arable land: 8.01 %, permanent crops: 0.97 %, other: 91.02 % (2005)
Natural hazards	Recurring drought; flooding during rainy seasons
Environment issue	Water pollution from urban and industrial wastes; Degradation of water quality from increased use of pesticides and fertilizers; Water hyacinth infestation in Lake Victoria; Deforestation; Soil erosion; Desertification; poaching
Geography	Kenyan Highlands comprise one of the most successful agricultural production regions in Africa; Glaciers are found on Mount Kenya, Africa's second highest peak; unique physiography supports abundant and varied wildlife of scientific and economic value
Population	34,707,817 (July 2006 est.)
Population growth rate	2.57 % (2006 est.)
Infant mortality rate	59.26 deaths/1,000 live births
Life expectancy at birth	48.93 years
HIV/AIDS - adult prevalence rate	6.7 % (2003 est.)
HIV/AIDS - people living with	1.2 million (2003 est.)
HIV/AIDS - deaths	150,000 (2003 est.)
GDP	Purchasing power parity - $ 37.15 billion (2005 est.)
GDP - real growth rate	5.2 % (2005 est.)
GDP - per capita	Purchasing power parity - $ 1,100 (2005 est.)
GDP - composition by sector	Agriculture: 16.3 %, industry: 18.8 %, services: 65.1 % (2004 est.)
Population below poverty line	50 % (2000 est.)
Budget	Revenues: $ 3.715 billion, Expenditures: $ 3.88 billion, including capital expenditures of NA (2005 est.)
Public debt	50.2 % of GDP (2005 est.)
Current account balance	$ -1.543 million (2005 est.)
Debt - external	$ 7.391 billion (2005 est.)

Source: [47]

2) Environmental Status and Issues

Status of Wastewater Management in Urban Area

The main causes of surface water pollution include effluent from agricultural activities and related industries, soil erosion, industrial and household effluent, and leachate from waste landfill sites. Water quality is not monitored regularly because of financial constraint and absence of monitoring systems. Research carried out by some institutions mainly universities, have revealed that water pollution is rampant in almost all urban centers and cities.

Key Facts on Water Pollution

Agricultural Effluent

- The main pollutants from agricultural activities are fertilizers and pesticides and silt from the soil erosion.
- Inorganic fertilizers amounting to 0.4 million m^3/yr and pesticides amounting to about 10,000 m^3/yr are used.

Industrial Effluent

- The agricultural-related industrial effluent is stemmed from coffee, sugar and sisal processing, resulting in high BOD due to organic substances.
- The river water contains extremely high levels of colon bacillus from the feces of humans and domestic and wild animals. When the river water is used, therefore, it should be at least filtered and sterilized.
- The survey of the Dagoretti slaughterhouse affecting the rivers of Nairobi and Kabuthia showed that the number of E. coli at 5,420/100 mL, which was very high [48].
- The survey of Nairobi Dam recorded a high colon bacillus count of >18MPN [49].

Sewerage

- According to the breakdown of the pollution load on Lake Nakuru, 43 % of BOD, 42 % of COD, 90 % of Total Nitrogen, and 9 % of Total Phosphorous came from sewerage.

Less than half of the population has access to the proper sanitation facilities. Between 1990 and 2002, the urban coverage has been increased from 51 % to 57 %. However, the rural coverage has increased by only 3 % to 43 % and the percentage of sewerage connection in rural areas remains at 0 % (Table 2.9). No more than 30 % of the present 142 urban areas have sewerage systems due to financial and planning deficiencies. Where the public sewerage is not provided, sewage is disposed of in various ways: e.g., direct discarding of wastes, sewage disposal by underground permeation, regularly collected septic tank systems, and dug toilets. Currently, there are 42 sewerage systems in 142 cities (about 30 %). There are sewerage systems in no more than 20 towns in areas other than Nairobi and Mombassa. The method for the disposal of sewage in areas without sewerage can be divided as follows:

- Discarding wastes on the ground: Common, although unsanitary and odourous.
- Underground permeation: Common in urban shanty areas, but with sanitary problems in the open spaces/streets.
- Tanking: Regularly replaced (dry season, once a week and rainy season, twice a week) and the collected sewage from septic tanks is put into the sewers.
- Dug toilets: Common in shanty areas in Nairobi, Mombassa, and other cities, but there is concern that the underground water may be polluted by the sewage permeating underground.

National Water Quality Preservation Strategy

National Effluent Standards

The Water Pollution Control Section (WPCS) of MWI is responsible for setting the effluent standards required for the discharge of effluents to a watercourse. The national effluent standards for the direct discharge of an effluent into a watercourse are shown in Table 3.23. The national standard for discharge to a receiving stream specifies two main effluent parameters that must be considered in the design of sewage treatment works, as follows [17]:

- BOD not to exceed 20 mg/L.
- Fecal coliform not to exceed 5,000 MPN per 100 mL.

More specific standards are developed as the need arises for discharges from various agriculture, industrial, and commercial sources of wastewater to public sewers and watercourses.

Table 3.22 National effluent standards in Kenya

Effluent Standard	
"A"- Acceptance into Public Sewers	
BOD (5 days at 20°)	Not to exceed 450 mg/L
pH	To be in the range 6 to 9
Temperature	Not to exceed 35^0 C
Suspended Solids	Not to exceed 300 mg/L
Four-hours oxygen absorption for permanganate	N/80 at 27v, 100 mg/L
Greases	The wastes should not contain more than 100 mg/L of greases that dissolve in Ethyl-ether
Oil, Petrol, Kerosene or other combustible materials	These must be intercepted.
Toxicity	The wastes should not include any toxic materials.

Source: [17]

Note)

(1) *In addition the waste should not contain materials that might damage pipes or treatment works.*

(2) *The flow must not exceed the capacity of the sewerage system and a meter is to be provided with a logbook to record flows, which can be Inspected by the City Engineer or Medical Officer of Health.*

(3) *Quarterly tests will be carried out, at the expense of the industry concerned, in accordance with the "Standard Methods for the Examination of Water, Sewerage and Industrial Wastes", issued by the American Public Health Association (APHA).*

In general, where the public sewerage systems exist, industries usually discharge their effluents into the sewers. Industrial wastes that cause the water pollution include: petroleum oil by-products from oil refineries and petrol stations, heavy metals from paint-related chemical industries and pulp industries, molasses from liquor making industries and sugar factories, sludge from fish and food processing factories, wastes from tanneries, wastes from slaughter-houses, dust from cement factories, etc.

Financing the Water Sector

The 1998 Aftercare Study of the National Water Master Plan estimated the funding requirements for building infrastructure for the water sector until 2010 at approximately

$ 2.8 billion. This figure excludes the investment in hydropower and water quality networks, capacity development, and flood control structures. A more recent study, "Towards a Water-Secure Kenya" (April 2004) estimated that about $ 500 million are required per annum over the next 30 years (a total $ 5 billion by 2015) to develop the per capita water storage capacity same as that of South Africa which suffers similar variable climate. With hardly any new water and sewerage services investment projects planned or even implemented between 2000 and 2004, and only a few implemented in 2005, the Government of Kenya (GOK) expects only limited implementation of envisaged projects in 2006. To meet the proposed targets, including the MDGs, the government will have to implement a huge portion of the strategies and investment programs between 2007 and 2015.

Table 3.23 Water use requirements in Kenya

Intervention	Total Required Resources (KShs billion)
Water storage & Environmental Conservation	31.18
Capacity building	0.64
Legal/institutional framework	0.35
Water for irrigation	24.80
Flood mitigation	85.36
Total	142.34

Source: [50]

Each of the proposed targets, interventions, and activities has 2005 as the baseline, including unit costs for each activity, which assumes an inbuilt 5 % annual increment from 2005 to 2015 in case of Kenya. It is considered that starting 2005, a 10-year rehabilitation program has to be implemented to replace about 80 % of the existing water and sewerage infrastructure. The 2004 study estimates that a total investment cost of about $ 3 billion will be required by 2015 to meet the relevant targets for the water supply and sanitation provision [51]. In addition to the provision of these services, the country requires other specific interventions in the field of water, to ensure the attainment of the water-related MDGs as summarized in Table 3.23.

Sources of Finance for Service Providers

The main channels of funds for the water supply and sanitation in Kenya include:

- The GOK through allocations in the annual budget - mainly utilized by the MWI and the National Water Conservation & Pipeline Corporation (NWCPC).
- Local Authority Budgets, for designated Local Authorities charged with the responsibility of water service provision.
- Non-budgetary funding by Donors / NGOs - mainly for use by Community Based Organization (CBO) dealing with water services activities.
- Self-financing (internal generation) by Water Services Providers (WSPs), NWCPC, CBOs, and local utilities.
- Direct expenditures by communities and households.

The GOK budget constitutes the largest source of funding to the sector, contributing about 29 % of the total sector finance. Donor/NGOs contributions, Local Authority Budgets and internal generation by WSPs each constitute about 20 % of the total. The new reform framework seeks to streamline the financing mechanism of the sector, with an emphasis on the sustainable internal generation by service providers. The main funding mechanisms envisaged under the new framework include:

- The Water Services Trust Fund (WSTF) – mainly for areas not adequately covered by water services.
- More streamlined GOK budget allocation – channeled mainly through the Water Services Board (WSB) in consideration of set targets and equitable distribution and efficiency.
- Enhanced self-financing (internal generation) mechanisms particularly by the WSPs.
- Indirect funding through private sector investments in water services.

Effective mobilization and use of financial resources in the Kenya Water Sector has been recommended. It has been suggested that this can be achieved significantly through:

- An effective institutional and regulatory framework – to ensure good governance of sector institutions, improved monitoring and transparency, sustainability of existing and new investments, and adequate support mechanism for sector institutions.
- An appropriate design of financing rules and mechanisms – which protects user charges, enhances creditworthiness of WSBs/WSPs, and enhances resource leveraging.

3) Research Area

Nairobi City

Nairobi (Figure 3.12), the capital of Kenya, is located near the central highlands of the country, at an altitude of approximately 1,660m above the sea level. Nairobi is Kenya's principal economic, administrative, and cultural center, and is one of the largest and fastest growing cities in Africa. It is already the leading industrial and commercial metropolis in East and Central Africa.

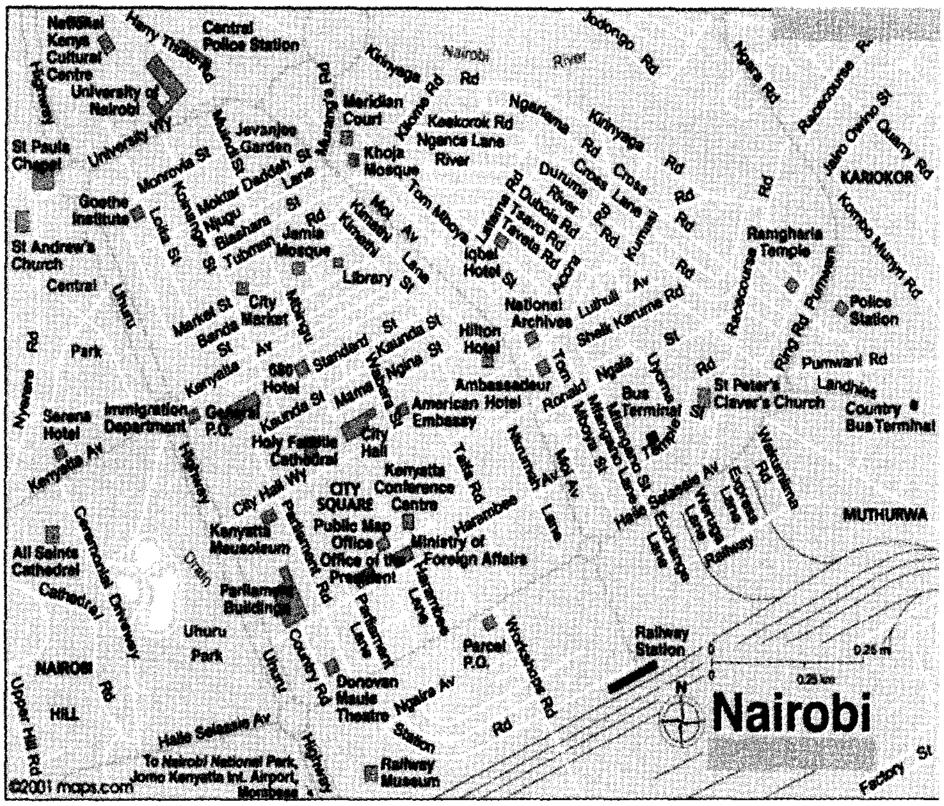


Figure 3.12 Map of Nairobi

The population of the Nairobi has grown from 2.3 million in 1998 to an estimated 3 million currently, with 55 % living in slums or "informal settlements". Nairobi has more than 130 such slums, housing more than half the city's population on less than 2 % of its land [52]. The conditions in these informal settlements are what those international aid agencies refer to as "extreme poverty" – people living on less than a dollar a day, and Kibera is the largest such slum in Nairobi.

Table 3.24 Water sources in Nairobi, Kenya

Category	Piped	Well	Stream/River	Other	Total
Person	93,497	446	247	6,453	102,224
%	91.5	0.4	0.2	6.3	100

Source: [51]

Table 3.24 shows the water sources in Nairobi. The Census revealed that the majority of the population in Nairobi uses main sewer, septic tank, and pit toilets for the disposal of sewage (Table 3.25). As shown, more than half of the population uses the main sewer. However, there is a huge difference between non-slum households and slum households, showing 81.2 % and 9.5 % respectively. The overwhelming majority of slum households use a pit toilet. As a total, the septic tank is the second useful means to manage the sewage, after the pit toilet. For the informal settlements, on the other hand, there is no centrally managed sewer system run by the officially recognized institution (this includes the main sewer as well as the septic tank).

Table 3.25 Sources for sewage disposal in Nairobi, Kenya

Sewage disposal	Slum households (Count in persons)		Non-slum households (Count in person)		Total (Count in person)	
	Count	%	Count	%	Count	%
Main Sewer	3,811	9.5	50,477	81.2	54,288	53.1
Septic Tank	292	0.7	5,189	8.3	5,481	5.4
Cess Pool	240	0.6	1,269	2.0	1,509	1,5
Pit Toilet	33,583	83.9	4,825	7.8	38,408	37.6
Bucket Toilet	315	0.8	287	0.5	602	0.6
Bush	854	2.1	24	0.0	878	0.9
Others	935	2.3	123	0.2	1,058	1.0
Total	40,030	100	62,194	100	102,224	100

Source: [53]

Status of Water Supply in Nairobi

Although the utility supplies 392,000 m^3 each day and the consumption is only 350,000 m^3, there are constant shortages and service interruptions. For those presently served by the utility, 40 % do not receive a 24-hour supply and 30 % receive water once in two days while 10 % receive water only once a week [54]. Compared to the rest of the country, Nairobi has the highest access to the safe water supply, standing at about 94 % of the population, shown in Table 3.26.

Table 3.26 Status of safe water supply in Nairobi, Kenya

Current Access	Potential		Current Mode of Access				
%	Ground m^3/hr	Surface m^3/s	Piped	Borehole	Protected Well	Protected Spring	Rain Water
94	*	0.1	91	1.6	0.2	0.2	1

Source: [13]
* No data available for groundwater potential

According to the World Bank's Country Assessment Report for Kenya, the number of piped connections in Nairobi by the Nairobi City Council (NCC) stood at 160,000 households in 2004. Nearly all the others, largely poor households, obtained water from the alternative sources listed above. Despite the low average water use, estimated at only 40 L per capita per day, the households in Nairobi are paying remarkably high unit prices for water. The average cost is estimated to be \$ 3.50 per m^3 [55]. Furthermore, the residents of informal settlements who depend on vendors often have to pay up to 10 times more for their water than those middle or high-income residents who have a direct access to supplies from the NCC [56].

The effects of recurrent drought in Kenya have also increasingly implied that the water demand level cannot be met. As a result, the service providers have often resorted to rationing the water supply to households and business premises in the city in order to sustain the diminishing supplies for longer periods. Nairobi's informal settlements have always been the most affected since the 1980s. Despite housing a significant proportion of the city's population, water supply and sanitation services are rarely expanded to cover them. Most efforts to serve the urban poor and slum dwellers with water have been limited to the provision of a few standpipes, delivery by water tankers, or other makeshift arrangements. Even the city's satellite towns such as Athi River, Ngong, Ongata Rongai, and Ruai also face the problems of the slum areas. They not only lack the piped water but even the sewerage system. Although they are expanding rapidly to ease the congestion in cities residential estates, the water and sanitation problems are making them less and less attractive. Apart from Athi River, with the piped water, the rest have to rely on the salty borehole water that is not only extremely expensive but also delivered under the unhygienic conditions by handcraft vendors. Nor do any of the satellite towns have sewerage systems. They rely on septic tanks, most of which are mere depressions in the ground covered with concrete slabs.

Status of Sanitation and Health

Sanitation often lags behind water supply as the focus of attention in many Kenyan urban centers including Nairobi, and does not capture public interest in the same way as disease or hunger. Approximately 48 % of the city's population is served by sewer network. The length of main sewer lines within the city is approximately 210 km, with varying diameters of less than 600 mm (140 km), 600 mm to 1,500 mm (60 km), and larger than 1,500 mm (10 km) [17].

Table 3.27 Sanitation status in Nairobi, Kenya

Current Access	Current Mode of Access				
%	Main Sewer	Septic Tank	VIP Toilet	Improved Pit Toilet	Pour Flush Toilet
99	48.2	6.7	12.6	29.5	2

Source: [13]

Even though the NCC provides truck-emptying services within the city, due to the lack of trucks and unreliable services, more private operators have also been licensed since 1998, to carry out the mechanical emptying. The trucks discharge the sludge into the city's sewerage network since the treatment plants are far from the city center. The situation is more serious in densely populated low-income areas where households use pit toilets. Despite those upgrading programs supported by various donor agencies and NGOs have improved the quality of toilets for the past 10 to 15 years, the equipment for sanitation (for emptying toilets and septic tanks) are still inadequate, and these areas are also not easily accessible for trucks or mechanical emptying. Due to inadequate capacity and institutional weaknesses in the management of wastewater and the provision of good sanitation services, some wastewater ends up in residential areas. Such wastewater eventually develops into the wastewater ponds, which then become major sources of such waterborne diseases as malaria in these areas.

According to David Kuria, Nairobi's slums are among the most unsanitary in the world, and women are more affected by these conditions than men. The Kenyan policymakers are becoming more aware of women's role in providing, managing, and safeguarding water and sanitation services. However, they lack the knowledge of how access varies by gender and across wealth groups [57]. Intestinal worm infections are very common in children, particularly in these informal settlements. It is estimated that diarrhea kills more people than tuberculosis or malaria in the slums of Nairobi. The better sewerage and sanitation management could prevent many such cases and could be a more sustainable way than the drug treatment, to control these infections. With the water sources for Nairobi continuing to diminish, the innovative mechanisms are needed to treat the wastewater for re-use as well as to improve the sanitation services in the city. Improving the access to sanitation should also involve raising the political profile of sanitation and hygiene, particularly within the informal settlements.

Water and Sanitation Services Under the New Sector Reforms

Based on the 2002 recommendations of the Public-Private Infrastructure Advisory Facility (PPIAF), and the Water Act 2002, the GOK adopted an institutional arrangement that would involve the transfer of Nairobi's water supply and sanitation provision to a private operator, including rehabilitation and extension of the city's water supply and sewerage works. Under the new sector reforms, seven WSBs have already been established, with one for Nairobi – the Athi Water Services Board (AWSB). Under the AWSB, the Nairobi City Water and Sewerage Company (NCWSC) was established in 2003, to operate commercially as a Water Service Provider for the city. The water supply and sanitation provision in Nairobi was taken over by the NCWSC in August 2004, and the water services cover the whole city and its environments.

Intended Impacts of Service Improvements

A major expansion project for Nairobi's Sewerage System has been launched (Table 3.28). NCWSC is already carrying out a number of sewer rehabilitation and extension works in some densely populated low-income residential estates – Dandora, Kariobangi, Eastleigh, Kawangware, Kasarani and Huruma. With the new infrastructure, the common incidence of dumping the liquid waste in open drains is expected to reduce considerably, thus improving both health and environmental conditions in those project sites.

Table 3.28 Targeted sanitation status in Nairobi, Kenya (2015)

Target Access	Target Mode of Access				
%	Main Sewer	Septic Tank	VIP Toilet	Improved Pit Toilet	Pour Flush Toilet
99.5	48.7	6.8	12.7	29.8	2

Source: [13]

Wastewater Treatment in Nairobi

Sewerage treatment in Nairobi at the Dandora Sewage Treatment Works (DST), located about 81 km east of the Central Business District (CBD). NCWSC employs the waste stabilization ponds/sewage stabilization ponds (SSP) system at the Dandora STW. The SSP is a low-cost sewerage treatment system that uses bacterial activity to remove organic matter, nutrients and microbes in sewage. The SSP used at the Dandora STW are usually operated in series, in the order of anaerobic, facultative, and maturation ponds. In general, the waste from the city and the surrounding urban dense settlements is drained into the larger water environment –Nairobi River and Nairobi Dam – through waste streams: Sewage waste, Grey water, Storm water, and Solid waste. The characteristics of sewage for Nairobi are shown in Table 3.29.

Table 3.29 Characteristics of sewage in Nairobi, Kenya

Chemical/physical characteristic	Unit : mg/L
BOD_5	448
SS	550
TDS	503
Chloride	50
Ammonia (N)	67

Source: [58]

The treated effluent from the Dandora sewerage treatment plants is discharged into the Nairobi River, which runs across the city. Hence, it is necessary for the effluent to be of high quality to avoid polluting the river, a drinking water for the down stream low-income communities. Efforts to improve the quality and capacity of the sewerage treatment facilities have yielded positive results, enhancing the water quality of the Nairobi River. The effluent standards being achieved from the two treatment plants are

BOD ≤ 20 mg/L (filtered sample), COD ≤ 50 mg/L (filtered sample), and SS ≤ 30 mg/L [17]. The NCC recently increased the capacity of the pond system at Dandora Estate, so the effective treatment capacity currently covers about 65 % of Nairobi's population - an increase of about 85 % over a period of 10 years [55].

Kibera Slums in Nairobi

Kibera is the biggest slum in Nairobi and the second largest in sub-Saharan Africa after Soweto in South Africa. Kibera's population has risen from 500,000 in 1999 to the estimated population of about 700,000 people in 2006, representing about 25 % of the population in Nairobi. Kibera is situated in the southwestern urban zone arrounding Nairobi, approximately 7 km from the city center, and covers about 250 ha of land. With the current estimate of nearly 2,800 inhabitants per ha, it is considered the most densely populated informal settlement in sub-Saharan Africa [52]. Despite its large population that also makes up the majority of the city's poorest people, Kibera has little access to the water supply, estimated to receive less than 10 % of the city's total consumption. There is only approximately 25 km of the piped water supply network in the entire settlement and much of this network receives little or no water. The amount of water supplied by the utility to the Kibera settlement is about 20,000 m^3/d, and 40 % of the supplied water is estimated lost through leakage and the remaining 60 % sold in kiosks [59].

There are two main reasons believed contributing to the limited water supply to Kibera, compared to other settlements in Nairobi. One is the limited capacity of the pumping station supplying to this part of the city and the other is the tendency to divert available water to the neighboring high-income areas where both political influence and revenue collection are greater. Consequently, Kibera's water demand is facing the growing informal water market by private small-scale providers. More than 650 local water vendors currently sell water to the residents in kiosks scattered throughout the settlement. About 98 % of these are parts of the private entrepreneurs, while only the remaining few are run by CBOs and NGOs [59]. Up to 85 % of the households draw water from the kiosks (private and community owned). Kibera residents pay for water ten times higher than what is paid by residents in middle and high-income areas in Nairobi [60]. Water prices range from approximately $ 1.30 per m^3 when the supply is regular to as high as $ 6.60 per m^3 during water shortages. Thus, the unit water cost in Kibera can rise above the average water price at the private connections in European countries [59].

Sanitation and Health Status in Kibera

The overall state of sanitation and health in Kibera has been very poor over the years, due to the lack of basic sanitation facilities and practices - lack of quality water, open sewers, disposal of waste and feces in open areas and drains, prevalence of stinking toilets, no rubbish collection, lack of public health facilities, and poor hygiene practices. The quality of water supplied through many kiosks in Kibera is highly damaged; the water vendors supply unsafe drinking water from unknown sources including the nearby Nairobi River, a highly polluted water source. Open sewage trenches in the area carry refuse and human waste to the Nairobi River, which lies at the base of Kibera valley and then runs into Nairobi Dam. Both river and dam are used for swimming, bathing, and clothes washing by the residents.

Moreover, the drinking water is contaminated by the infiltration of liquid waste and the overflowing toilets into burst pipes. Kiosk operators pump the drinking water through low quality plastic pipes, which are laid alongside the open sewers full of wastewater, resulting in the contamination of water during its transportation from the supply network to the kiosk. Besides, the plastic pipes are exposed, often broken, and are repaired without care for sanitation, creating a suitable habitat for water-borne diseases like cholera and typhoid. Contamination also occurs at the kiosks due to the poorly maintained storage tanks and the unhygienic handling of water.

As a result, most health problems are directly or indirectly associated with the quality of water and environmental sanitation. Such water-related diseases as diarrhea, malaria, and typhoid are common in the area, and the mortality rate is high. There are no public sector health services available in the settlement, while the private health service providers are expensive and beyond the reach of most residents. A research on poverty eradication in Kibera in 2005 showed that the toilet facilities cost Ksh5 (6 US cents) per visit per family member. The 2005 report by Community Support Group (CSG-Kibera) says there is an average of 1 pit toilet for every 50 to 500 people, and the households with pit toilets in the area are 26.6 % of the total population. Space is so valuable that landlords are reluctant to give up the potential rent income by using the scarce land to provide toilets. This lack of adequate toilets in Kibera forces residents to use alternative means for the excreta disposal, such as the 'flying toilets' in more details in Box 4.11.

Manual Pit Emptying in Kibera

An estimated 28 % of households in Kibera use the manual emptying method for pit toilets [59]. This is mainly due to such unfavorable conditions as the overcrowded housing units that hinder access to the mechanical de-sludging equipment, and the heavy sludge which is difficult to be pumped into trucks. There exists no defined disposal site for the human waste manually emptied in Kibera. Transporting sludge is difficult since it is carried either in buckets or by handcart. The waste is thus commonly disposed of by pouring the sludge into streams, drains, or sewer manholes in the settlement when it is liquid or by dumping it just anywhere when it is dry. Subsequently, this random excreta disposal leads to further contamination of the Nairobi River water and poses adverse health risks to the residents.

Measures to improve water and sanitation services

In the context of the ongoing water sector reforms, the water supply for Kibera is now being undertaken by the new NCWSC. It is envisaged that this will improve the water supply in Kibera and even the quality of water provided. In addition, the practical measures are also being undertaken to ensure the improved business environment for small-scale providers and the better water services for slum dwellers. For example, by establishing the local water providers association, the entrepreneurs are now able to achieve self-regulation, improve their credibility, and develop relations with the utility [59].

A number of schemes and projects have been initiated by various water and sanitation NGOs to bring the clean water and sanitation to Kibera. The separate VIP toilets for males and females and the huge water tanks are gradually being installed in Kibera, to ensure proper sanitation and clean water. The small-scale providers (SSPs) also play an important role in the sanitation provision and management, through the management of public toilet blocks, the construction of toilets, and the removal of sludge. ue to the lack of exhauster facilities for toilets, technological innovations and experiments between manual and conventional emptying services are also being tried in Kibera. An experimental exhauster service (Vacu-Tug) is now being used by NGOs and CBOs in the area to serve a small portion of the community.

Meru Municipality

Meru Municipality is located in Kenya's eastern province, approximately 300 km north of the capital city, Nairobi. The population of the area is currently estimated at about 53,900 [61]. Meru has a rich agricultural inland with agriculture as the main economic source. Thus, most of the economic, commercial, and industrial activities in the area are agriculture and service based. Situated on the eastern slope of Mount Kenya, the Municipality covers an area of about 62 km^2 and approximately 31 km^2 has the water supply coverage. The land rises to a height of 1,800 m and then slopes eastward to River Tana. The area prevalently experiences the temperate climate with a mean annual rainfall of about 1,280 mm and temperatures ranging from about 4°C in July to about 30°C in February and October.

Status of Water Supply in Meru

Until 2002, the water supply in Meru was under the control of the Municipal Council. However, in 2003, the Meru Water and Sewerage Services (MEWASS) took over the supply of water from the Council. The Municipality is currently served by the piped water distribution system run by MEWASS. The main sources of water in the area include Kathita River, Gatabora Stream, and Gatabora Spring, through 2 boreholes and 23 community water projects [62]. About half of the total area is covered by the water supply system and the Municipality is estimated with the water production capacity of about 7,000 m^3/d. The area's distribution system is comprised of about 3,848 m connections as of December 2005. However, because of the low water connection rate resulting from the existence of many alternative community water sources, it is estimated that the MEWASS currently supplies only about 3,900 m^3/d, through the metered connections. An overall expansion of the water connection coverage is therefore recommended.

Table 3.30 Projected population and water demands for Meru, Kenya

Year	2005	2008	2010	2015
Population (CBS)	53,941	57,747	74,164	106,703
Water demands (m^3/d)	8,259	9,131	11,727	16,873

Source: [16]

Like the production capacity, the total treatment capacity is estimated at 7,000 m^3/d. The water treatment in Meru is carried out at the treatment plant comprised of 6 composite units and 2 rapid sand filters. However, only about 3,870 m^3 is produced from the treatment facility due to the low water connection. Table 3.30 shows the projected population and the demand for water in Meru.

Status of Sanitation and Sewerage System in Meru

According to the recent preliminary study on the sewerage system in the area, about 2,500 m^3 of water is currently consumed per day and about 700 m^3 of sewage is generated per day. On the other hand, the sewer network in the Municipality was estimated only about 616 sewer connections as of August 2005, representing only 20 % of the area covered by the water supply [16]. The existing sewer pipes, varying in sizes from 4" (-100 mm) to 6" (-150 mm) diameter concrete, are considered undersized for the municipal sewerage system compared to the international standards, and may be subject to the frequent blockages. If the water connections and supply is to be intensified by 2008 as targeted, such sewers will need rehabilitation and replacement with adequate pipes.

The socio-economic survey of the area revealed that the sewer network serves only about 15 % of Meru residents, with most of the beneficiaries of the sewer facilities coming from the central business district. The high incidence of water-related diseases in the area - particularly malaria, typhoid, and amoebas - has generally been attributed to poor sanitary conditions and unsafe drinking water. However, there has been a remarkable decrease in the number of water-related diseases since the MEWASS started supplying water to the Meru town (Kenya Times Media Trust 2005). The sanitation issues found to be of key concern include:

- Discharge of the raw sewage by residents into the nearby streams, which has led to the serious degradation of water quality for the downstream users.
- Overflowing septic tanks.

As a preventive measure, many residents have now opted for such forms of treatment before drinking the water, as boiling, chemical treatment, and filtering. Results from the analysis of grab samples of raw sewage and treated effluent from the treatment works in terms of BOD_5, COD, and SS are shown in Table 3.31. The improvements in water consumption and the repairs of sewer networks allow higher flows into the treatment works and this accounted for the difference in wastewater quality between the two samples.

Table 3.31 Wastewater quality in Meru, Kenya

Parameter	Raw Influent 23-2-05	Raw Influent 30-11-05	Final Effluent 23-2-05	Final Effluent Filtered 30-11-05	First Maturation Influent 30-11-05	Standards
pH	7.4	6.6	8.2	7.8	7.2	6.5 - 8.5
Conductivity	1,637	-	1,121	-	-	2,500
BOD_5	1,350	280	100	20	130	20
COD	1,600	310	640	30	180	30
Total Alkalinity	450	-	350	-	-	-
TSS	2,030	240	98	20	40	30
TDS	949	40	645	20	20	1,200
Permanganate Value	255	-	47	-	-	-
Salinity	9	-	0.3	-	-	-

Source: [16]

Wastewater Treatment in Meru

The existing treatment works in the area was designed in 1972, and consist of inlet works, measuring flumes, and ponds (a primary facultative pond and 3 maturation ponds). The primary treatment begins at the inlet works chamber, which consists of a screen channel provided with coarse and fine screens and a grit chamber. The particulates including grits are trapped and removed by the inlet chamber screen, thus allowing the influent to enter the pond free of them. The treatment facility is also comprised of a recently installed measuring flume, 2.53 m long and 152.4 mm wide, and 4 ponds. The first facultative pond is fitted with a baffle wall dividing the inlet and outlet works which prevent the short circuiting, allowing enough retention time before the final effluent passing to next ponds for the further treatment. The 3 maturation ponds, although still temporary and not yet fixed with the flow measuring devices, are intended for the flow from the facultative pond during de-sludging.

Since there is no natural river close to the treatment works for discharge, all the effluent are confined within the soakage area, comprised of an open channel with the lateral agricultural pipes to the soakage field. Rehabilitation of the sewerage treatment works and introduction of the anaerobic ponds are recommended to ensure the better wastewater management.

Eldoret Town

Eldoret is the fifth largest town in Kenya, with the present estimated population of 215,000. The town has a rich agricultural inland and has undergone sustained urban growth, commercial and educational development, and industrialization over the last 40 years. The GOK has assigned Eldoret as one of the towns to attain the city status in a very near future. The town is located in Rift Valley Province on Uasin Gishu Plateau, approximately 320 km from Nairobi and 65 km north of the equator and at an altitude of about 2,080 m above the sea level. The Sosiani River crosses the municipal area of Eldoret from southeast to northwest. The region has a temperate climate throughout the year, with the average maximum temperature of 23.4 ℃ and the average minimum night temperature of 9.8 ℃. The total annual rainfall varies between 545 mm and 1,615 mm, and the precipitation occurs mainly during April and May with a short dry period in June, followed by the increasing rainfall in July and August and declining in September and October. Then, a dry period of 4-5 months with scattered showers follows.

Water Supply System in Eldoret

The Eldoret town is served with the water from two dams in Ellgrin and Chebara, and these two sources are capable of serving Eldoret with 36,000 m^3/d. Each currently provides 18,000 m^3/d, although the Chebara dam has a provision for the further argumentation to 28,300 m^3/d in the future. Both systems have separate treatment works but share the storage facilities as well as the network system. Currently, the Eldoret town is adequately served with the potable water.

Sewerage System in Eldoret

The town has a well functioning sewerage system comprised of sewers and sewage treatment plants. One of the wastewater treatment plants is new and the construction works were completed in May 2004, while the other was rehabilitated in order to increase its capacity and efficiency. These works were undertaken under the Eldoret Sanitation Project, whose key objective was to provide the Eldoret town with the adequate sanitation and sewerage system. At the same time, the surface water resources of the Sosiani River, which runs through the town and is being used downstream for the water supply purposes, had to be protected. It was also important to construct another wastewater treatment plant and to improve the sewer network since the existing wastewater treatment plant was not capable of treating the wastewater in terms of both quantity and quality while the part of sewer networks was overloaded.

The Eldoret Sanitation Project was implemented from August 2002 to May 2004, and it encompasses the modern technology and its operations make it one of the most efficient wastewater treatment plants in Kenya. Since the completion of Eldoret Sanitation Project, approximately 50 % of the town's population is served by the sewer network. The rest of the population resides in areas where the population density is relatively low and the on-site sanitations (pit toilets and septic tanks) are available to meet the sanitation requirements. In the future, as these areas attain higher densities of population, the appropriate extensions to the sewer network will have to be made for them.

Estimation of Household Water use and Wastewater Generation in Eldoret

The present water demand in Eldoret town is approximately 24,000 m^3/d and the sewage generated is around 10,000 m^3/d. Hence, the total capacity of the sewage treatment works of 18,000 m^3/d is adequate to treat the expected sewage volumes up to the year 2015, when the new treatment works will have to be expanded.

Wastewater Collection and Transfer System in Eldoret

The sewage collection and transfer system in the Eldoret town is through a network of sewer lines constructed. Most of the sewers are constructed using UPVC and concrete for the larger diameters. The main sewers vary in diameter from 200 mm to 600 mm with the plot connections of 150 mm. The length of sewer lines within the Eldoret town is approximately 120 km. The total number of plots connected to the sewer system at present is 8,778, of which 8,338 are domestic and 440 are commercial.

Wastewater Treatment Plants in Eldoret

There are two sewage treatment works in Eldoret town:

- The new sewage treatment works with a capacity of 10,000 m^3/d, comprised primarily of a waste stabilization ponds system and a stage of trickling filters.
- The old sewage treatment works, which has been rehabilitated and expanded, with the capacity increased from 4,900 m^3/d to 8,000 m^3/d, by introducing the trickling filter stage.

The treated effluent from the two wastewater treatment plants is discharged into the Sosiani River, which runs across the Eldoret town. That is why it is very important for the effluent to be of high quality to avoid polluting the river, a drinking water source for the downstream communities. The effluent standards being achieved from the two treatment plants are: BOD, < 200 mg/L (filtered sample); COD, < 500 mg/L (filtered sample); and SS < 300 mg/L [17].

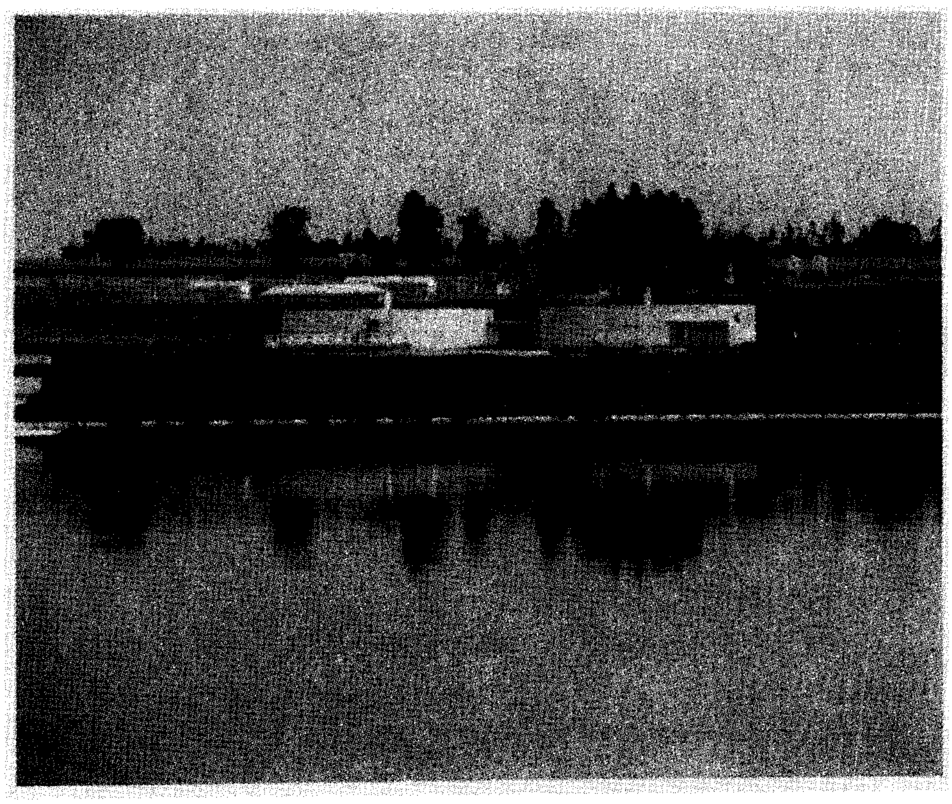


Figure 3.13 Trickling filters and primary ponds – Eldoret Sanitation Project

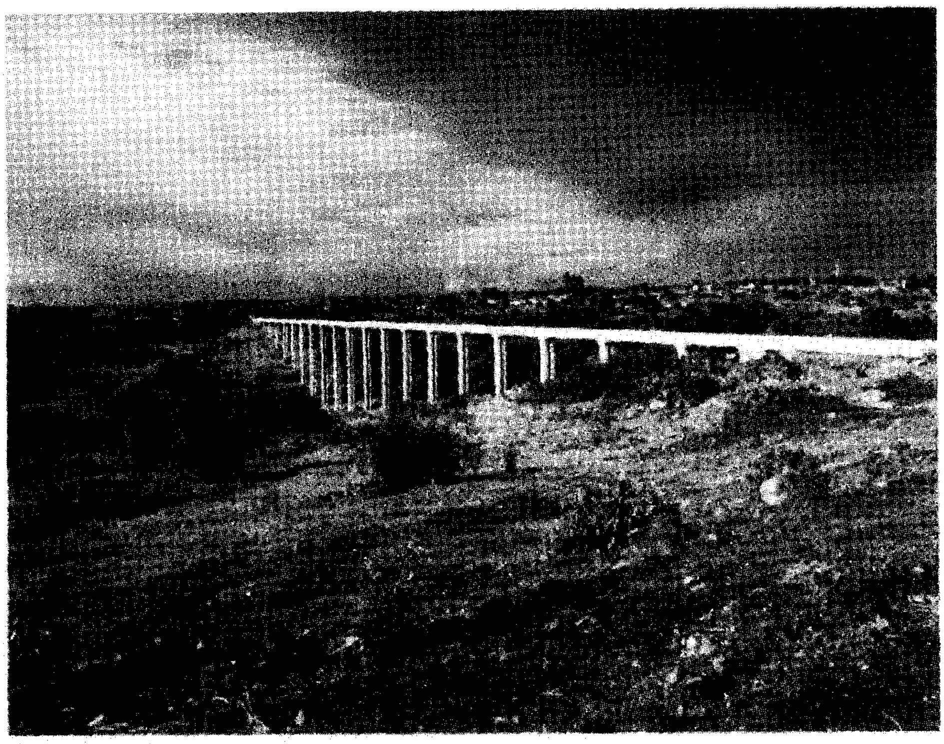


Figure 3.14 Aerial crossing, sewer line 52 – Eldoret Sanitation Project

Table 3.32 Sewerage treatment plant in 5 largest cities in Kenya

Information	Dandora	Mombasa	Kisumu	Nakuru	Eldoret
Daily wastewater flow (m^3/d)	250,000	40,000	22,000	20,000	18,000
Domestic wastewater (m^3/d)	180,000	16,000	14,000	11,000	10,000
Pollution Equivalents	BOD-550, COD-1000, F.C. – 1×10^6				
Industrial wastewater (m^3/d)	60,000	10,000	6,500	5,000	5,000
Separate system	Yes	Yes	Yes	Yes	Yes
Drainage area (km^2)	600	250	300	263	180
Types of treatment	WS Ponds	M/B	M/B	M/B	M/B
Quality criteria	BOD (mg/l) $\leq$ 20, COD $\leq$ 50, SS $\leq$ 30				
Effluent receiving body	River	Ocean	Lake	Lake	River
Types of sludge stabilization	Drying beds	Drying beds	Drying beds	Drying beds	Drying beds

3.2.2 Northern Africa: Ethiopia

1) General Information

Ethiopia (Fig. 3.15 and Table 3.33) is located in eastern Africa and west of Somalia, covering an area of 1,127,127 m^2 and with a population of 73 million. The official name is Federal Democratic Republic of Ethiopia (FDRE), and the capital city is Addis Ababa with 2.3 million people. Ethiopia is a multi-ethnic (83) state with various languages spoken (200 dialects). The main three languages are Amharic, Tigrigna, and Oromifa, and English is also widely spoken. About 90 % of the population makes living on land, mainly as farmers. Agriculture is the backbone of the national economy, and the principal exports from this sector are coffee, oil seeds, pulse, flowers, vegetables, sugar, and foodstuffs for animals. There is also a thriving livestock sector exporting cattle, hoofs, and animal hides and skins. There exist mainly three seasons in Ethiopia - dry season from October to January, short rainy season from February to May, and long rainy season from June to September. Drought and floods are the major natural disasters in Ethiopia. The country has been severely threatened by the drought in every 7-8 years, and once the drought occurs, it affects the region for 2 or more years and the country suffers from famine.

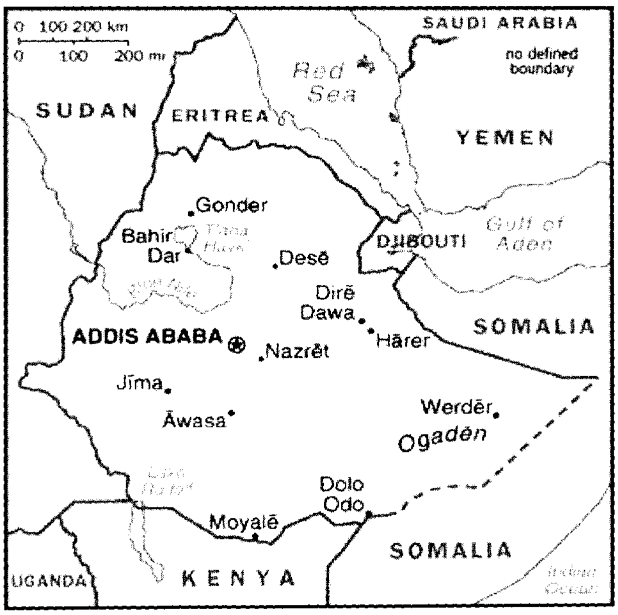


Figure 3.15 Map of Ethiopia

(Source:http://www.sas.upenn.edu/African_Studies/CIA_Maps/menu_CIA.html)

Table 3.33 General information for Ethiopia

Location	Northeastern Africa
Area	Total: 1,127,127 km^2, Land 1,119,683 km^2, Water 7,444 km^2
Terrain	High plateau with central mountain range divided by Great Rift Valley
Land use	Arable land: 10.01 %, permanent crops: 0.65 %, other: 89.34 % (2005)
Natural hazards	Geologically active Great Rift Valley susceptible to earthquakes, volcanic eruptions; frequent droughts
Environment issue	Deforestation; overgrazing; soil erosion; desertification; water shortages in some areas from water-intensive farming and poor management
Geography	Landlocked - entire coastline along the Red Sea was lost with the de jure independence of Eritrea on 24 May 1993; the Blue Nile, the chief headstream of the Nile by water volume, rises in T'ana Hayk (Lake Tana) in northwest Ethiopia; three major crops are believed to have originated in Ethiopia: coffee, grain sorghum, and castor bean
Population	74,777,981 (July 2006 est.)
Population growth rate	2.31 % (2006 est.)
Infant mortality rate	93.62 deaths/1,000 live births
Life expectancy at birth	49.03 years
HIV/AIDS – adult prevalence rate	4.4 % (2003 est.)
HIV/AIDS – people living with	1.5 million (2003 est.)
HIV/AIDS - deaths	120,000 (2003 est.)
GDP	Purchasing power parity - $ 62.88 billion (2005 est.)
GDP - real growth rate	8.9 % (2005 est.)
GDP - per capita	Purchasing power parity - $ 900 (2005 est.)
GDP - composition by sector	Agriculture: 47.5 %, industry: 9.9 %, services: 42.6 % (2005 est.)
Population below poverty line	50 % (2004 est.)
Budget	Revenues: $ 2.338 billion, Expenditures: $ 2.88 billion, including capital expenditures of $ 788 million (2005 est.)
Current account balance	$ -844 million (2005 est.)
Debt - external	$ 5.101 billion (2005 est.)

Source: [63]

2) Environmental Status and Issues

Status of Wastewater Management in Urban Area

Pit toilets are the common sanitation facility in the country. Access to the sanitation facility is less than 18 % in urban areas while barely 4 % in rural areas. Between 1990 and 2002, the urban coverage had increased by only 3 % from 16 to 19 %, while the figure in rural areas is more pitiful with just 2 % increase from 2 to 4 % (Table 2.12). The connection percentage in rural areas remains 0 %. Most households in the urban area use the pit toilets, except for Addis Ababa where only a few use toilets with the septic tank. The national master plan for drinking water supply and sewage is to be completed later this year.

The water pollution in Ethiopia is caused mainly by industrial activities, domestic wastewater, and agricultural activities. The major industrial activities include food, beverage, chemical, textile, and leather and shoe manufacturing. Even though the Public Health Proclamation prohibits the discharge of untreated liquid wastes generated from septic tanks, seepage pits, and industries into water bodies or water convergences, almost 90 % of industries in Addis Ababa discharge their untreated effluent into water bodies, streams, and open land [64].

In addition, most domestic wastewater is also discharged without the proper treatment, due to the lack of facilities and awareness. The untreated domestic wastewater, containing human excreta, contaminates both surface and ground waters, causing many waterborne diseases. As a result, the concentrations of heavy metals, coliforms, and nitrate in surface and ground waters have been increased significantly.

Rural Water Supply and Sanitation Programme

In the past, the investment within the water supply and sanitation sub-sector was focused on urban areas only. As a result, the access to the WSS services in rural areas is very low. To overcome this situation, the GOE jointly with the Asia Development Fund (ADF) launched the Rural Water Supply and Sanitation Programme in 2005 to achieve the goals (Table 3.34) and to meet the MDG targets in the rural areas [21]. Table 3.35 shows the concentrations of major water pollutants in the Addis Ababa catchments.

Table 3.34 Rural water supply and sanitation programme goals (2005)

Component	Goals
Water supply coverage	35 %in 2008, 4 5 % in 2010, 62 % by 2015
Sanitation coverage	21 % in 2008, 32 % in 2010, 54 % by 2015
Average distance to nearest water points	Reduce from 3km in 2004 to 1km by mid 2008
Average travel time to water points	Reduce from 3 hours in 2005 to 1 hour by mid 2008
Water consumption per capita	Increase from 10 l/c/day in 2004 to 20 l/c/day by mid 2008

Source: [21]

Table 3.35 Concentration of main water pollutants in Addis Ababa catchments

Pollutant		Streams	Springs	Boreholes
Heavy metals (part per billion)	pH	7.72	6.61	8.62
	Mn	2,187.44	29.88	5.14
	Cr	4.24	1.84	1.30
	Ni	9.03	0.32	0.51
	As	1.20	8.44	0.44
	Pb	0.00	4.64	16.58
	Zn	0.00	3.05	35.25
Coliform (Count/mL)		743	320	83
Nitrate (mg/L)		270	419	0.5

Source: [65]

3) Research Area

Addis Ababa City

According to the Central Statistic Authority [66], the population of Addis Ababa (Fig. 3.16) had grown from 443,728 in 1961 to 2,112,783 in 1994. Meanwhile, the projected population of Addis Ababa in the year 2000 was 2,495,000. According to the 1994 population and housing census, there were a total of 380,307 housing units in Addis Ababa, with 374,742 in urban areas and 5,565 in rural areas. The typical volcanic features of Addis Ababa had mainly been built up of acidic and intermediate lava flows, thus characterized by rugged landscapes and steeper slopes.

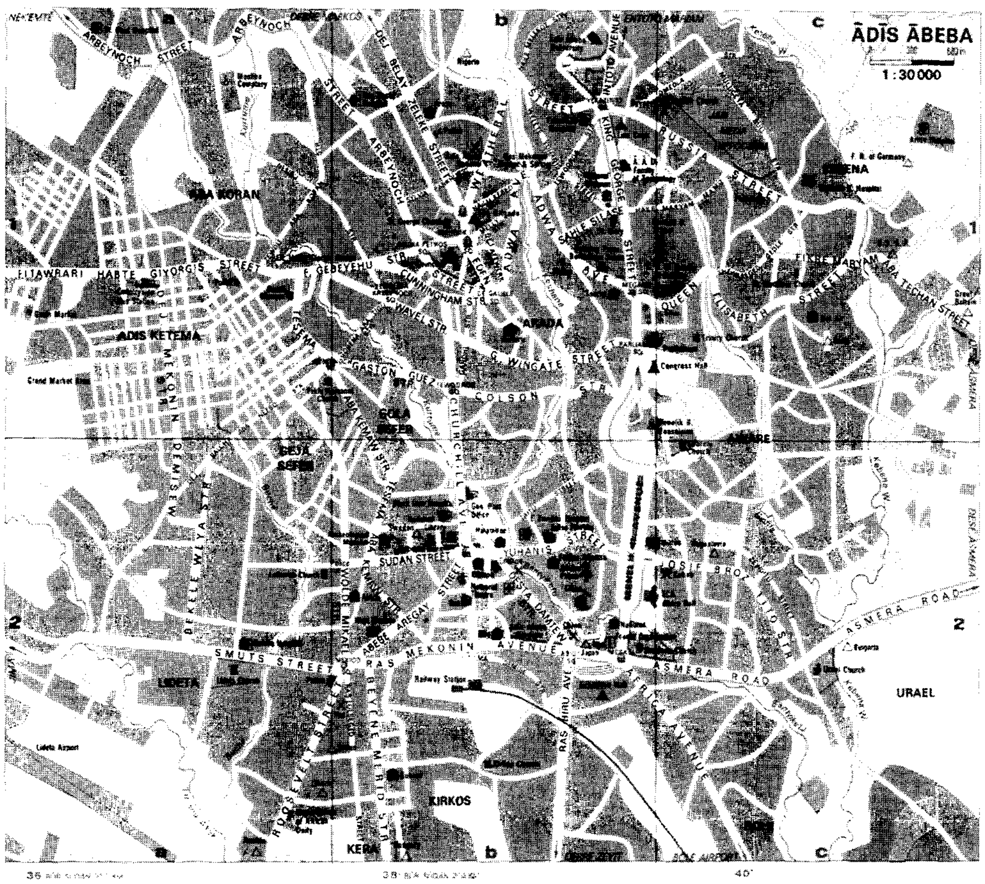


Figure 3.16 Map of Addis Ababa City

The foundation and expansion of Addis Ababa was associated with the rapid conversion of land from rural to urban uses more than anywhere else in the country. The less controlled urbanization that includes the construction of residential houses, commercial centers, transport infrastructure, various types of industry (65.3 % of all industries in the country), parks, and recreational areas covers most proportion of the urban parts in Addis Ababa. On the other hand, the agricultural activities including crop production, cattle breeding, and tree planting cover the major proportion of the rural parts in Addis Ababa. Moreover, to satisfy the demands of construction materials, such as dimension stones and aggregates, hundreds of quarries are actively operating around the city.

Currently, the available water resources for the city are from surface water reservoirs, shallow and deep bore wells, hand-dug wells, and springs. However, there is a shortage of the municipal water supply in different parts of the city, particularly during the dry season. Consequently, most of the industries, some residential houses, and governmental and non-governmental organizations have own water wells in their premises to alleviate the problem. In comparison, in the peripheral parts of the city, where there is a serious shortage of the municipal water supply, the problem is being overcome by using the spring water. However, most springs are not developed and vulnerable to the various types of pollutants, and the problem has become severe especially in the most southern part of the city.

Water Supply and Sanitation in Addis Ababa

The water supply coverage of the city is very high, covering 98.4 % of the population (Table 3.36). However, the rate of household connection is only 4.4 %, and the rest of the population use yard taps, public standpipes, and boreholes. About 40 % of thc produced water is lost and wasted through the leakage or other means.

Table 3.36 Water supply status in Addis Ababa (2000)

Components	House connection	Yard taps	Public standpipes	Boreholes with hand pumps	Total served
Population served (thousands)	108	1,173	1,107	17	2,404
%	4.4	48.0	45.3	0.7	98.4

Source: [67]
Note) Total population was 2,444,000 in 2000

The state of sanitation coverage in Addis Ababa is in a poor condition (Table 3.37). Addis Ababa has a separate sewerage system for sanitary and storm drains. However, it is very difficult to discriminate between these two. The sewerage system serves only the central part of the city with connections for about 15,000 people, which is less than 1 % of the city's population [21]. The majority of the population use such on-site sanitation systems as septic tanks, wet toilets, VIP toilets, and simple pit toilets, with the last as the predominant ones in the city. These toilets sometimes overflow by flooding, resulting in the groundwater causing severe health problems.

Table 3.37 Sanitation status in Addis Ababa (2000)

Population	Public sewers	Septic tanks	Wet toilets	VIP toilets	Simple pit toilets
Population served (thousands)	2	55	58	87	216

Source: [67]

With regard to the wastewater treatment, it is very difficult to find the recent reliable information. The WHO report (2000) indicated that only 0.5 % of wastewater from the public sewers was treated. According to the report by Worku and Adam (1999) [68], about 100,000 m^3 of wastewater and 3,600 m^3 of fresh excreta and urine were produced per day and about 4,500 m^3 of wastewater were treated per day at the Kalitti wastewater treatment facility (lagoon). It also states that "there are also digestion tanks in Kalitti to treat pit toilet sludge and septage, but they are not working well as designed." As a result, the majority of liquid wastes are discharged into the public water without any form of treatment, causing public health hazards and environmental degradation.

The mismanagement of solid wastes is also a big problem in Addis Ababa. According to the Addis Ababa city website [69], less than 68 % of solid wastes generated in Addis Ababa are collected. The rest is just dumped into open sites, drainage channels, rivers, and valleys as well as streets. The unplanned urbanization and the fast growing urban population further aggravate the urban waste management.

Sewerage System in Addis Ababa

The discharge of untreated sewage into surface water can lead to the gross pollution. Even though Addis Ababa has a separate sewerage system, the storm drains are generally designed and built separately from the sanitary sewerage. However in Addis Ababa, it is very difficult to differentiate the storm drains designed to collect the rainstorm runoff from that of sewer lines, because of the wastewater emanated from the different sources being continuously discharged into the drain systems without any prior treatment. The drainage in the city is connected to the nearby watercourses. The streams also directly receive the untreated sewage from toilets, petrol stations, garages, industries, etc. The problem becomes acute, especially where the drains are open (ditches) and filled with solid wastes. As a consequence, the passage of water in the storm drain is blocked, causing the wastewater outflow into the ground surface. The severity of this problem can be noticeable during the rainy season where there is a high runoff and liquid wastes from the drainage over flooding the city street.

At present, there is a limited sewerage line in the city, built-up to collect the liquid wastes from different sources. The potential population which can be served of and connected to the sewer system has been estimated, in the Wastewater Master Plan Study, as 456,000 (16 %) and 848,000 (22 %) in the year 2005 and 2015, respectively. The inaccessibility of the sewerage line forces people to discharge into water bodies, connecting the pit toilets to streams, and the unsecured splashing on the surface [70]. Likewise, the localization of the sewerage line in the limited area contributes for the illegal sewage discharge to the sewerage. To fulfill the design criteria, most industries are required the primary treatment plant that costs additional investments in the sector. Consequently, they rather prefer the illegal dumping that costs nothing, and no one would accuse them of their misbehavior.

Wastewater Treatment in Addis Ababa

Table 3.38 shows the distribution of households in Addis Ababa, based on the type of their toilet facilities. As shown, the dug pit toilets which could be manually emptied were by far the most common toilet facility (68.3 %) and were prevalent for both slum and non-slum households. Almost twice more non-slum households used the flush to sewage system or septic tank, compared to the slum households (7 % compared to 4 %). While only 7.3 % of households used the traditional pit toilet (not emptied), this was much more prevalent in non-slum households than slum households (11.2 % compared to 6.8 %). Less than 10% (8.9 %) of households used the bush as a toilet facility, but this was considerably more prevalent amongst slum households than non-slum households (9.9 % as opposed to 1.1 %). As shown in Table 3.39, the waste originated from more than one half (52.8 %) of households is collected by the government, whereas 12.7 % of households dumping their waste on the street or in a vacant plot. The open burning was also prevalent among households (11.9 %).

Table 3.38 Sources for sewage disposal in Addis Ababa (2003) (Unit: %)

Items	Slum	Non-slum	Total
Flush to sewage system or septic tank	4	7	4.4
Non-flush toilet to sewage system	10.1	8.3	9.9
Dug pit toilet (can be emptied)	67.7	72.5	68.3
Traditional pit toilet (not emptied)	6.8	11.2	7.3
Bucket	0.7	0	0.6
Bucket	9.9	1.1	8.9
Road	0.8	0	0.7

Table 3.39 Waste collection in Addis Ababa (2003) (Unit: %)

Items	Slum	Non-slum	Total
Not answer	1.0	4.3	1.4
Collected by government	52.8	52.8	52.8
Collected by community association	6.1	8.2	6.4
Collected by private co.	7.7	8.5	7.8
Dumped in the compound	0.7	1.3	0.8
Dumped in the street or vacant plot	13.7	5.2	12.7
Open burning	11.4	15.6	11.9
Buried	0.4	0.7	0.5
Composted	1.7	2.2	1.8
Recycled	0.2	0	0.1
Fed to animals	0.1	0	0.1
Thrown into the river	4.2	1.2	3.8

The most common (36.3 %) method for disposing water used for dish washing, laundry, and bathing was to pour into soakage, cesspit, or septic system (Table 3.40). A similar proportion of both slum and non-slum households carried out this practice, but a much larger proportion of households with the improved water source practiced this, compared to households with the unimproved source (38.9 % as opposed to 16.5 %).

The second most common way (31.6 %) for disposing the washing water was onto street surface or empty space, with the slum households doing this practice more than non-slum households. The washing water from 15.2 % of households was piped onto street surface or empty space.

Table 3.40 Washing water disposal in Addis Ababa (2003) (Unit: %)

Items	Slum	Non-slum	Total
Piped in soakaway cesspit or septic system	8.1	10.4	8.4
Piped onto street surface or empty space	15.1	16.4	15.2
Piped directly to garden	3.4	11.2	4.3
Poured into soakaway cesspit or septic system	36.3	36.6	36.3
Thrown onto street surface or empty space	33.1	19.7	31.6
Emptied in garden	1.5	2.2	1.6
Emptied in river	2.3	1.7	2.2
Emptied in toilet	0.3	1.7	0.4

The existing conventional biological treatment plant located in southern Addis Ababa covers about 40 hectares of land. The plant site falls within an industrial area and slopes to the Little Akaki River. The plant has been sized to serve a population of 50,000 with a sewage flow of 7,600 m^3/d. The sewage collected using vacuum trucks is discharged into the drying beds constructed on the eastern banks of Little Akaki River and Mt. Yerer ber. In general, the inefficient waste collection and disposal, the lack of concern among the responsible bodies to use the available resources, and the current illegal dumping practice threaten the sanitary situations in Addis Ababa more than any time. The problem will continue and become severe in the coming years unless the sound corrective and protective measures taken. The rapid population increment, the less controlled urbanization, and the present inadequate sanitation in Addis Ababa would aggravate the problem more than expected.

4 Analysis and Evaluation on the Status of Environmental Infrastructure

4.1 Policy Responses and Strategy Analysis

4.1.1 Eastern Asia: China

Environmental Laws

The development of wastewater management legal system is actually the history of wastewater management. Table 4.1 shows laws (acts or regulations) regarding the sanitation management in China since 1984. The issue of Water Pollution Protection and Control Act in 1984 was the beginning of wastewater management in China. It stipulates that all the industrial wastewater discharged into the water environment must be in accord with the discharge standards and it must be charged if the discharged wastewater is above the standard. It was the beginning of industrial point source wastewater management. After that, related water environmental standards, discharge standards, and levy systems had been established gradually. At this stage, the industrial wastewater control was the first priority.

Since 1997, cities in Huai River Watershed in China had been required to build wastewater treatment plants. There is also a pilot wastewater tariff in this region [71]. In 1999, the MOC required the centralized wastewater management system in urban areas. In 2002, MOC, Planning Commissions, and SEPA together issued the Notice for wastewater Tariff Collection and Construction of Urban wastewater treatment plant [5]. It marked the establishment of principles of "user pay for urban infrastructure" and "purchasing power parity (PPP)". Since 2001, the SEPA had started to regulate the rural NPSs. The issue of Cleaner Production Promoting Law in 2002 indicated that the end-of-point pollution control had transformed the full process management.

Table 4.1 Sanitation management laws of China (Since 1984)

Time	Acts or Regulations
1984.5	Water Pollution Protection and Control Act of PRC
1988.1	Water Act of PRC
1989.7	Drinking Water Resources Protection Management Statute
1989.12	Environment Protection Act of PRC
1994	Urban Water Emission Permission Statute
1998.4	Construction Project Environment Protection Management Statute
1998.9	Urban Water Supply Price Management Statute
1999.9	Announcement: Levy wastewater fees and establish urban wastewater emission, collected disposal mechanism
2000.3	Detailed rules of WPPCA-84
2000.3	Environment Pollution Protection and Control Act of PRC
2000.4	Detailed rules of EPPCA-2000
2000.5	Urban Wastewater Disposal and Pollution Protection and Control Technology Policies
2001.5	Pasturage Pollution prevention and management Statute
2001.11	Pesticide management bylaw
2002	Notice for WW Tariff Collection and Construction of Urban WWTP
2002	Cleaner production promotion law

Note) State Department issued in 1997.5, emended and issued in 2001.11

Environmental Standards and Regulations

In the past decades, the standards development was in a good progress in China. The government stipulated the nomenclature of environmental standards and delegated the authority at different levels for promulgating and supervising the implementation of such standards. China will continue the legislation works, and Table 4.2 and 4.3 show the environmental standards related to water quality and wastewater discharge, respectively, in China.

Table 4.2 Water quality standards in China

Standards Serial Number	Standards name	Issued date
GB 3838-2002	Surface water environmental quality standards	2002-04-28
GB 3097-1997	Seawater quality standards	1997-12-03
GB 14848-1993	Ground water quality standards	1993-12-30
GB 5084-1992	Farmland irrigation water quality standards	1992-01-04
GB 11607-1989	Fishery water quality standards	1989-08-12

Table 4.3 Wastewater discharge standards in China

Standards Serial Number	Standards name	Issued date
GB 19431－2004	Monosodium glutamate industry discharge standards	2004-01-18
GB 19430-2004	Citric acid industry discharge standards	2004-01-18
GB 18918-2002	WWTP of town's pollution discharge standards	2002-12-24
GB 14470.1-2002	Weapon industry water pollution discharge standards detonator	2002-11-18
GB 14470.2-2002	Weapon industry water pollution discharge standards fire medicament	2002-11-18
GB 14470.3-2002	Weapon industry water pollution discharge standards ammunition	2002-11-18
GB 18596-2001	Pasturage Pollution discharge standards	2001-12-28
GB 13458-2001	Compound ammonia industry water discharge standards	2001-11-12
GB 18486-2001	Wastewater sea treatment project pollution control standards	2001-11-12
GB 3544-2001	Paper making industry water discharge standards	2001-11-12
GB 8978-1996	Wastewater integrated discharge standards	1996-10-04
GB 15581-1995	Caustic soda ,PVC industry water discharge standards	1995-06-12
GB 15580-1995	Phosphoric fertilizer industry water discharge standards	1995-06-12
GB 14374-1993	Spaceflight propelling agent water pollution discharge standards	1993-05-22
GB 4287-1992	Textile, dyeing and finishing industry water discharge standards	1992-05-18
GB 13456-1992	Steel industry water discharge standards	1992-05-18
GB 13457-1992	Meat machining industry water discharge standards	1992-05-18

Wastewater Management Organization

The wastewater management is mainly governed by the current administrative structure of the central government and such groups of laws as urban planning law, water law, environmental protection law, and water pollution prevention and control act. Both vertical and horizontal systems are applied for the wastewater management. At the central level, the environmental protection departments are responsible for examining all new, expanding, and rebuilding projects. They are also in charge of the pollution by industrial point sources and rural NPSs. The construction departments are responsible for the construction of sewage systems and wastewater treatment plants. The water resource departments are responsible for water function zoning, water quality monitoring, and other duties. The governments at provincial, municipal, and county levels have their own environmental protection bureaus and other related departments. The local government also has strong influences on the environmental decisions making process. In addition, there are also some watershed management commissions in China, in charge of the trans-boundary water management issues. However, there are always conflicts among different stakeholders, such as different provinces and cities.

4.1.2 Southern Asia: Vietnam

Environmental Law and Decree

The National Assembly has approved the government's proposal to create the Ministry for Natural Resources and Environment (MONRE) by the decision 02/2002/QH11 on August 5, 2002. The Decree No 86/2002/ND-CP on November 5, 2002, provides in general functions, tasks, powers, and organizational structures of the ministry and ministerial agencies. The Decree No 91/2002/ND-CP on functions, tasks, powers, and organizational structures of the MONRE has been given on November 11, 2002. Until now the Ministry of Science, Technology and Environment (MOSTE) has been the top decision-making body with the overall responsibility within the environmental sector. Besides the ministry, there have been several other agencies involved in the management and protection of the environment. The local environmental agencies under the management of provincial People's Committee play important roles in management of environment and execution of environmental policies.

In Vietnam, the basic national environmental policy is based on the Law on Organization of the Government (September 30, 1992), the Law on Environmental Protection (ratified by the National Assembly on December 27, 1993), and the Decree No. 175-CP (issued on October 18, 1994). The National Assembly ratified the Law on Environmental Protection on December 27, 1993, and the decree has been issued on October 18, 1994. In the Law, there are very clear articles to prevent the environmental pollution in general, and also articles concerning the wastewater management, while the Government Decree provides the guidance for implementation of the law on environmental protection.

The Article 2 defines wastes, pollutants, and environmental pollution as follows:
"Wastes mean substances discharged from daily life, production processes or other activities. Wastes may be in solid, gaseous, liquid or other forms. Pollutants mean factors that render the environment noxious. Environmental pollution means alteration in the properties of the environment, violating environmental standards"

Laws and Regulations on Environmental Impact Assessment

On October 18, 1994, the Government of Vietnam (GOV) issued a decree providing the Guidance for the Implementation of the Law on Environmental Protection, which includes the assessment of environmental impacts. This decree, together with other documents needed for the environmental impact assessment (EIA), was published in 1995 by the MOSTE as a separate guideline document.

The Guidance for Implementation of EIAs for Technical-Economic Projects was proposed by the MOSTE in September 1993 (No. 1485/Mtg). According to this guideline and the guideline No.73/Ttg issued by the Prime Minister on December 27, 1993, the Hai Phong People's Committee issued a guideline for EIAs for Technical-Economic Projects No. 49 CT/UB.

Until now the MOSTE has been the responsible authority for the approval of EIAs Report, but according to the Decree 91/2002/ND-CP the MONRE has established many other departments such as the EIA and Appraisal Department. The EIA, however, can be appraised by the local DONRE based on their knowledge of local conditions and further be delivered to the City People's Committee for approval, if delegated by the MONRE.

Environmental Standards and Regulations

As the government stipulates the nomenclature of environmental standards and delegates the authority at different levels for promulgating and supervising the implementation of such standards, the MOSTE has published the Vietnamese Environmental Standards in 1995 and 1998 through 2002, and the standardization work is in progress and the MONRE will continue the work.

Table 4.4 Vietnamese environmental standards (MOSTE 1995, 1998-2002)

Number of standard	Name of standard
TCVN 5998-1995	Guidance on sampling on marine waters (ISO 5667-9:1992)
TCVN 5999-1995	Guidance on sampling of wastewater (ISO 5667-10:1992)
TCVN 5298-1995	Requirements on using wastewater and sludge for irrigation and fertilizing.
TCVN 5524-1995	General requirements for protecting surface water against pollution
TCVN 5525-1995	General requirements for protection of underground water
TCVN 5944-1995	Groundwater quality standard
TCVN 6982:2001	Water quality – Standards for industrial effluent discharged into rivers using for water sports and recreation
TCVN 6983:2001	Water quality – Standards for industrial effluent discharged into lakes using for water sports and recreation
TCVN 6984:2001	Water quality – Standards for industrial effluents discharged into rivers using for protection of aquatic life
TCVN 6985:2001	Water quality – Standards for industrial effluent discharged into lakes using for protection of aquatic life
TCVN 6986-2001	Standard of industrial wastewater discharge to coastal seawater which are used to serve for protection of sea products
TCVN 6987-2001	Standard of industrial wastewater discharge to coastal seawater which are used to serve for water sport and entertainment
TCVN 7222:2002	General requirements on environment for central wastewater treatment plants
TCVN 5298:1995	Requirements for using wastewater and sludge for irrigation and fertilizing.
TCVN 5948-1999	Allowed limitation values for road motor vehicle noise
TCVN 5949-1998	Allowed limitation values for noise in public and residential areas
TCVN 6962:2001	Vibration and shock – Vibration emitted by construction works and factories – Maximum permitted levels in the environment of public and residential areas

In cases where the applicable Vietnamese standard is inadequate and not regulated or applicable, the project agencies must obtain MONRE's approval for the use of equivalent standards of the countries that have provided the technology and equipment to Vietnam, or apply the equivalent standard from a third country. The environmental standards related to the water and wastewater quality in Vietnam are shown in Table 4.4. Besides these water related standards, there are also several other standards concerning air, noise, and soil qualities.

BOX 4.1: Enforcement and Control Strategies

The urban sanitation issues include sewerage and storm-water drainage.
The details are:

- Abolishing the flood in urban areas during the rainy season.
- Establishing the urban drainage system with a suitable treatment technology and meeting the environmental standards.
- Extending the capacity of the urban drainage system, from 50-60 % (2005) to 80-90 % (2020), for each urban level and type. For Hanoi, Ho Chi Minh city, the second typed urban, and the urban area with growing economy and industrial zones, processing zones, and tourist areas, this figure could be 90-100 %.
- The urban environment is to be protected and upgraded and to attract the foreign investment on industries of tourist, trade, service, etc., boosting the economy rapidly and sustainable.
- Establishing a financial mechanism that makes sure of the sustainable development for enterprises and urban drainage system.
- Developing technologies, reinforcing applying new technologies through the technology transfer, and modernizing the urban drainage system to reach the international standards or at the same level with other countries in the area.
- Applying advanced standards, principles, and laws, helping the Vietnamese sanitary integrated into the world and matching with the Party - Government open-door policy as well.

Performance

Until now, the GOV has been paying a commendable attention to addressing the environmental degradation. The biggest cities such as Hanoi, Ho Chi Minh city, Hai Phong, Danang, and Halong will all have the sewerage and sewage treatment facilities in place in the next few years and the investments are also being planned for several secondary cities. It will, therefore, be important to establish the best institutional practice models that can be replicated, and three models are appearing. In the largest cities, the separate drainage/sewerage collection and treatment companies are being formed (for example, Ho Chi Minh city, Hanoi, and Hai Phong). In medium cities, the drainage/sewerage services are being undertaken either a) by the URENCOs, along with solid wastes and other municipal activities, or b) as a part of the combined water and drainage/sewerage company. There is no consensus on the most appropriate model in Vietnam, but the combined water and wastewater model provides opportunities for economies with scale and scope, as well as a greater commercial orientation.

The small-scale providers in rural area, such as the local entrepreneurs – who act as the providers of construction project management, design, and marketing services as well as the suppliers of pre-made cement cylinders - are obviously performing well based on the significant increase in hygienic toilet usage. The successful intervention of IDE and DANIDA *(Note: Support to Small-Scale Private Sector Development and Marketing for Sanitation in Rural Areas in Vietnam. First annual progress report for 2003, February 2004)* demonstrated the potential profitability of the septic tanks business line proven by the fact that the majority of purchases were paid in full without any need for micro-credits. The technological choice of toilets reflected the preference of convenience and social status to the price.

4.1.3 Eastern Africa: Kenya

Environmental Policy and Strategy

In order to address the numerous constraints in the country's water sector, the Government of Kenya (GOK) put in place a national policy framework for the water and sewerage development in the country. The definitive policy framework is contained in the country's Sessional Paper No. 1 of 1999, also known as the National Policy on Water Resources Management and Development or simply the National Water Policy. This policy gave rise to the Water Act 2002, which provides the legal framework for the same. In further response to the current national crisis in water supply and sewerage services, the government has also developed two water strategy documents: the First National Water Resources Management Strategy (NWRMS) and the National Water Services Strategy (NWSS) which also includes the sewerage services.

Kenya's Poverty Reduction Strategy Paper (PRSP) and Economic Recovery Strategy for Wealth and Employment Creation (ERSWEC) 2003-2007 also provide recommendations for the implementation of structural reforms to make the water and sewerage services autonomous, efficient, and effective. Other policy documents of the government that address the issues of water and sewerage include the Industrial Transformation to the Year 2020 and the Sessional Paper No. 3 of 1999 on National Poverty Eradication, 1999-2015. Kenya's most important environmental law, entitled The Environment Management and Coordination Act 1999, is a product of a new methodology for the development of environmental law in the history of the country. Views and aspirations of a wide range of stakeholders, at national as well as local levels, were solicited and incorporated in the Act. This is a major shift from the traditional centralized mode of policy formulation that did not involve the public. The Act is thus designed to promote a greater public participation in the management of natural resources and the environment in general.

Under the new Environment Management and Coordination Act 1999, the National Environment Management Authority (NEMA) is the overall coordinating agency for all environmental matters in the country. In addition, the Act provides for the establishment of the National Environmental Council whose principal function is to formulate policies and set national goals and priorities for the environmental protection. The environmental departments and agencies of local governments have limited executive powers as well as human resource capacity to effectively undertake the environmental management projects. Moreover, the local authorities lack the desirable financial base to enable them to finance the necessary environmental schemes in the face of growing population.

National Water Policy

Water Act 2002

The National Water Policy is premised on the government policy articulated in both ERSWEC and PRSP, stating the economic growth can only be revitalized if the fundamental reforms are implemented in the management of rural and urban water supplies and sanitation services. The country's key economic sectors - agriculture, industry, tourism, and hydroelectric power generation - are after all dependent on having adequate and reliable supplies of water.

The document provides the institutional foundation and sets out five key policy objectives for meeting the country's water needs. The policy directions include:

- Preservation, conservation, and protection of available water resources.
- Sustainable, rational, and economical allocation of water resources.
- Supply of good quality water meeting acceptable standards and in sufficient quantities to meet the various needs.
- Ensuring safe wastewater disposal for environmental protection.
- Developing a sound and sustainable financial system for effective and sustainable water resources management, water supply, and waterborne sewage collection, treatment, and disposal.

The policy also emphasizes the need to decentralize operational activities from the central government to other players including local authorities, communities, and private sectors. It also tackles issues pertaining to water supply and sanitation facilities development, and the sector's institutional framework and financing.

BOX 4.2: Principles of the Water Act 2002

- Stating ownership of all surface and groundwater resources. Exploitation of such resources requires authority granted by issuance of water permit.
- Management of water resources on catchments basis and not administrative boundaries.
- Stakeholder involvement in management of water resources.
- Equitable allocation of water for all Kenyans.
- Recognition of economic value of water.
- Application of government subsidy and other means to achieve social objectives including supplying the poor with water.
- Accelerating supply and distribution of water in rural areas through special funding.
- Development of water sector strategies for management and development of the sector.
- Protection of quality of water resources.
- Cost recovery as means of sustainable service provision.

Water Sector Strategy

In line with the ongoing reform process guided by the Water Act 2002, the GOK has already initiated a radical transformation of the entire water sector, driven by the national policy on separating the water resources management and development from the water services delivery. With the Ministry's role now focused on policy, this initiative has led to the preparation of two separate key policy documents: NWRMS and NWSS. Backed by the Water Act 2002, these two policy documents are based on the country's PRSP and ERSWEC.

BOX 4.3: Goals and Objectives

The overall goal of both NWRMS and NWSS is to meet the water-related Millennium Development Goals (MDGs) by 2015.
Goal 7 of the MDGs: To ensure the environmental sustainability.
Target 10 of this goal is to "halve, by 2015, the proportion of people without sustainable access to safe drinking water". This target will be monitored through Indicator 29 which points to the " proportion of population with sustainable access to improved water source".

To achieve the MDGs by 2015 in the Water and Sanitation sector, it is envisaged that 80 % nationwide coverage of the safe water supply (96 % for urban and 66 % for rural) and 96 % coverage of the improved sanitation (96 % for urban and 89 % for rural) by 2015 will meet the target population [53].

Water Resources Management Strategy (WRMS)

Kenya's first NWRMS was prepared in 2004, in response to the country's water supply crisis and in recognition of the need for an integrated water resources management as a national priority for the country's socio-economic development. The main challenges addressed by the NWRMS include:

- Drastic degradation of catchments areas, resulting in receding lake levels, heavy silt loads in rivers and reservoirs, degradation of water quality, and reduction of renewable freshwater availability.
- Increased demand and competition for water among water uses, such as environmental, domestic, irrigated agriculture, livestock, industry, energy, and tourism.

- Inappropriate institutional framework resulting in fragmentation of water resources responsibilities and implementation mechanisms.
- Inadequate water allocation.
- Inadequate management and financial skills and poor maintenance of water works and facilities.

BOX 4.4: Principles underlying the NWRMS

- Priority of water allocations for environmental conservation (reserve waters) to secure biodiversity of wetlands.
- Linkage between water resources and economy.
- User pays and polluter pays principle.
- Equitable representation and allocation for users giving special attention to gender and disadvantaged groups (the poor, women, arid land pastors) in water resources management.
- Participatory approach to water resources management, ensuring that water users have access to information at all levels and partake in water resources management and allocation.
- Reduction of social conflict among competing water users.

Targets and Objectives of the NWRMS

The followings are to achieve within next 10 years (by 2015):

- Improved water resources assessment: To achieve more accurate assessment of the annual freshwater safe yield of surface and groundwater resources within next 3 to 5 years. The currently limited coverage of appropriate assessment to be expanded, within next 10 years, to cover the entire country.
- Sustainable yields of renewable freshwater: To ensure that the current estimates of 21 billion m^3 per annum for surface and ground water are maintained and sustained through catchments conservation and preservation.
- Enhanced annual safe yield of surface water through catchments protection measures, water harvesting, and increased storage capacity.
- Enhanced annual safe yield of groundwater through groundwater recharge and water harvesting (subsurface and sand dams).
- Effective flood control management measures.
- Effective and favorable institutional and legislative arrangements on trans-boundary water issues.

- Sustainable water harvesting practices for environmentally sustainable ecosystem and for socio-economic activities.
- Improved water resources management by resolving water allocation conflict among conflicting users through water resources classification (quality, quantity, and use), prioritization, and compromise.

National Water Service Strategy (NWSS)

The availability of and access to the adequate freshwater supply strongly impact on economic growth and social development. Kenya's first NWSS was prepared in 2004 in response to the need for the improved water supply and sewerage services. The NWSS is intended to address the existing key challenges in the sector including:

- Low-level coverage of water supply and sewerage services.
- Impaired water and sewerage infrastructure, resulted from poor operation and maintenance of facilities
- High levels of water unaccounted for.
- Poor management including poor financial skills, leading to low revenue collection and inadequate funding for rehabilitation and upgrading and expansion of water supply and sewerage facilities.

BOX 4.5: Principles underlying the NWSS

- Separation of policy and regulatory functions from service provision.
- Recognition of water as a social and economic good.
- Decentralization of responsibilities and decision making, in line with the principle of subsidized water services, in accordance with the Water Act 2002.
- Application of cost-recovery principle, taking into consideration of the pro-poor pricing policy that meets equity, economic, financial, and environmental concerns.
- Ensuring acceptable standards of service delivery levels.
- Private sector participation.
- Establishing linkage between water supply and sewerage management and development.
- Linkage between water services and economy.
- Promotion of environmentally friendly operations of water services.

Targets and Objectives of the NWSS

The followings are to achieve within next 10 years (by 2015):

- An increase in the urban water supply from the current estimated coverage of 68 % to 84 % of the urban population, in line with the MDG Target.
  - Serving 11 million urban people by 2015;
  - Increasing the available water per person per day from 75 L to 100 L for individual house connections;
  - Compliance with the Kenya drinking water quality standards prescribed by the Kenya Bureau of Standards (KEBS).
- An increase in the rural water supply from the current estimated coverage of 49 % to 74 %, in line with the MDG Target.
  - Serving 23 million rural population by 2015;
  - Increasing the available water per person per day from 25 L to 50 L for individual house connections representing 15 % of rural homes;
  - Compliance with the Kenya drinking water quality standards prescribed by the KEBS.
- A drastic reduction in the amount of water unaccounted for, due to both technical and social losses, from the current estimate of 70 % to 25 % by 2010 to meet the MDG Target.
- An increase in the urban sewerage collection, treatment, and disposal coverage from the current estimate of 28 % to 39 %, in line with the MDG Target [14].
  - Providing waterborne sewerage collection, treatment, and disposal schemes for 3 million people in formal urban setting;
  - Providing cesspool, septic tanks, and other appropriate on-site sewage systems for 2 million people in informal urban settings;
  - Sewerage treatment to be based on the Royal UK effluent standards until completion of the Kenyan standard for treated effluent, already under development.
- An increase in the rural sewerage collection and disposal, for rural homes with individual house connections, from the current 2.4 % to 8.7 % [14].
  - Providing sewerage solutions to 2.6 million rural people, mainly through on-site systems such as cesspits, septic tanks, and other appropriate technology.

Table 4.5 provides a detailed description of the proposed medium- and long-term activities for the achievement of the NWSS targets outlined above.

Table 4.5 Proposed activities for NWSS targets

Target	Detailed Activities	Time Frame (base year: 2005)
Increasing water supply to serve 84 % of urban population (11 million) and 74 % of rural population (23 million) by 2015	• Rehabilitation and augmentation of existing water supply schemes. • Expansion of schemes to areas presently not being served. • Construction of new water supply schemes in urban and rural areas without water supplies (with at least 50 % of those projects completed and operational by 2015).	Within 5 years (up to at least 80 % of the design capacities) Overall: by 2015
Reduction of unaccounted water from 70 % to 25 % by 2010	• Rehabilitation of the dilapidated systems, laying new pipes, standard fittings, detecting and fixing leaks. • Effective metering (including in rural areas) of water delivered to kiosks and households. • Installation of pressure control valves, zonal and bulk meters at key points in the system. • Making water affordable, available and accessible to the poor. • Strict enforcement of regulations to prevent damage to meters and pipelines.	Within 5 years
Increasing urban water borne sewerage collection, treatment and disposal coverage to 39 % (5 million)	• Rehabilitation, augmentation and expansion of existing urban sewerage collection, treatment and disposal systems. • Construction of new urban sewerage collection, treatment and disposal systems. • Construction of appropriate on-site water borne sewerage systems in informal urban areas. • Systematic increase of user connections to cover all potential areas.	Overall: by 2015
Increasing the sewerage collection to 8.7 % of rural population (2.6 million)	• Construction of appropriate on-site sewerage systems in rural areas (cesspits, septic tanks and other appropriate technology developed)	Overall: by 2015

Source: [14]

Water Sector Reforms

In order to rationalize the sector management and overcome the past limitations that led to the poor performance and degradation of both water utilities and resource base, the government formulated a comprehensive legislation for the sector, which was enacted by the Kenyan parliament in 2002. The water sector reforms are enshrined in the new Water Act 2002, which came into operation in March 2003. The Act, which provides the institutional and legal framework for implementing the objectives of the National Water Policy, is the basis of the country's water sector reforms currently under implementation.

Key Constraints to be addressed

The ongoing reforms are expected to have far reaching impacts on the management of water resources and services in Kenya, by addressing the shortcomings of service provisions in the sector, arising mainly from:

- Inadequate skills in the management of existing water resources, resulting in negative impacts including the destruction of water catchments and the pollution and illegal abstraction of water sources.
- Lack of a clear institutional framework in the management and governance of the water services sub-sector, resulting in poor coordination of sector institutions, lack of performance monitoring, and limited cooperation with other development sectors.
- Inappropriate technologies and delivery systems for water and sewerage services.
- Inadequate funds and rapidly declining investment in the sector.
- Limited understanding and involvement of communities in enhancing the sustainable operation and management of water supplies.

The provisions of the Act thus allow for the envisaged reforms: management of water resources and strengthening the institutional framework by establishing a new institutional environment where the management of water resources and water and sewerage service provision is separated for the adequate attention to both areas, focusing the role of government on the policy formulation rather than the direct service provision and providing the mechanisms for financing water resources and services.

Institutional Framework

The Water Act 2002 introduced new institutional mechanisms in the management of water resources and water and sewerage services in the country. These arrangements include:

- Separation of water resources management from water and sewerage services.
- Autonomous regulation of the water sector through the establishment of two autonomous regulatory agencies:

  - Water Resources Management Authority (WRMA) to manage and protect water resources and catchments.
  - Water Services Regulatory Board (WSRB) to manage water and sewerage services.
- Decentralization of services to the regional level:
  - Water and sewerage services planning and provision by seven Water Service Boards (WSBs) established at the regional level.
  - Direct provision of water and sewerage services by the Water Services Providers (WSPs) serving as agents of the Water Services Boards.
  - Water resources management advisory roles by the Catchments Area Advisory Committees (CAACs) established at the catchments level.
  - Cooperative management of water resources and conflict resolution by the Water Resource Users Associations (WRUAs) at the sub-catchments level.
- Focusing the role of the MWI to policy formulation, sector coordination, and financing.
- Establishment of the Water Services Trust Fund (WSTF) to mobilize financial resources to support the development of water and sewerage infrastructure amongst the low-income communities.
- Establishment of the Water Appeals Board (WAB) mandated to handle the water disputes.

4.1.4 Northern Africa: Ethiopia

Environmental Policy and Strategy

Water Resources Management Policy (WRMP)

The Government of Ethiopia (GOE) published the Ethiopian Water Resources Management Policy (WRMP) in 2000, as an essential national policy document to steer the development and management of the country's water resources. The WRMP is based on the socio-economic and environmental development policies as stipulated in the Constitution [25]. The overall goal of the policy is to enhance and promote all national efforts towards the efficient, equitable, and optimum utilisation of the available water resources of Ethiopia for the significant socio-economic development on a sustainable basis.

BOX 4.6: Five Major Water Management Policy Objectives

- Development of the water resources of the country for the economic and social benefits of the people, on an equitable and sustainable basis.
- Allocation and appointment of water resources based on comprehensive and integrated plans and optimum allocation principles that incorporate the use efficiency, the access equity, and the resource sustainability.
- Managing and combating drought as well as other associated on-set disasters through, inter–alia, efficient allocation, redistribution, transfer, storage, and efficient use of water resources.
- Combating and regulating floods through sustainable mitigation, prevention, rehabilitation, and other practical measures.
- Conserving, protecting, and enhancing water resources and overall aquatic environment on a sustainable basis.

Source: [17]

BOX 4.7: The Guiding Principles of the Water Policy

- Water is a natural endowment commonly owned by all the peoples of Ethiopia.
- As far as conditions permit, every Ethiopian citizen shall have access to sufficient water of acceptable quality, to satisfy basic human needs.
- In order to significantly contribute to development, water shall be recognized as both an economic and a social good.
- Water resources development shall be underpinned on rural-centred, decentralized management and participatory approach as well as integrated framework.
- Management of water resources shall ensure social equity, economic efficiency, system's reliability, and sustainability norms.
- Promotion of the participation of all stakeholders, user communities, particularly women's participation in the relevant aspects of water resources management.

Source: [17]

In the event of shortage or lack of adequate funds, the policy gives priority to the water supply and sanitation sub-sector over other water sub-sectors such as irrigation, hydropower, flood control, and other uses.

The followings are the key aspects of the policy for the water supply and sanitation sub-sector [72]:

- Allocation of water resources: envisages a high priority to the water supply and sanitation, for human, livestock, and industrial needs for both economic and social benefits.
- Institutional framework for management: visualizes developing ownership and management autonomy to the lowest possible level with a related emphasis on capacity building and participation of all stakeholders including the private sector.
- Financing, water pricing, and cost recovery policies: envisage a move to the full cost recovery for urban water system and the partial capital cost sharing and full operating and maintenance cost recovery for rural water system.
- Technology and maintenance aspects: envisage the development of appropriate technologies for the local level development and management as well as meeting the appropriate standards.
- Integrated water and sanitation policy: emphasizes the need for an integrated approach to water, sanitation, and hygiene promotion.

Water Sector Strategy

The principal objective of the water sector strategy is to transform the WRMP into action. In this regard, the strategy provides the framework that contains ways and means for attaining the objectives of the policy. More specifically, this strategy sets the road map on how to make meaningful contributions towards:

- Improving the living standard and general socio-economic well being of the Ethiopian people.
- Realising food self-sufficiency and security in the country.
- Extending the water supply and sanitation coverage to large segments of the society, thus achieving improved environmental health conditions.
- Generating the additional hydropower.
- Enhancing the contribution of water resources in attaining the national development priorities.
- Promoting the principles of integrated water resources management.

The strategy also gives the highest priority to the water allocation for drinking and sanitation purposes, followed by the water requirements for livestock. The rest shall be allocated to the uses yielding highest socio-economic benefits.

Water Supply and Sanitation Sub-sector Strategy

The water supply and sanitation sub-sector strategy is one of the six sub-sector strategies included in the water sector strategy. The followings are the key aspects of the water supply and sanitation sub-sector strategy.

Technical and Engineering Aspects

- To identify and promote the development of appropriate, efficient, effective, reliable, and affordable water supply and sanitation technologies, which are demand driven and have a great acceptability among the local communities.
- To develop national standards, specifications, and design criteria which are rational, affordable, acceptable, implemental, and sustainable for design, installation, implementation, operation, maintenance, and inspection of the water supply and sanitation systems.
- To promote the use of sustainable and cost effective technologies and to adopt economically affordable and appropriate wastewater treatment and management systems.
- To develop standards for different types and levels of sanitation systems, including on-site and off-site and non-water dependent and water dependent systems.
- To develop and enforce standards and guidelines for maintaining the water quality in all recognized water uses; e.g., water supply (domestic, industrial, livestock, others, etc.), sewerage, and sanitation.

Financial and Economic Aspects

- To consider the water sector as important as other crucial sectors of the economy.
- To establish financial management rules and feasible arrangement for resource allocation, cost-sharing, and accessing funds for the demand driven water supply and sanitation systems.
- To subsidise the capital costs only for communities unable to cover the cost of the basic services, so as to ensure the social equity.
- To establish and implement the cost-sharing arrangements to share capital and operation and maintenance and capacity building costs between government, local communities, consumers, external support agencies, and NGOs.
- To promote the 'user pays' principle in accordance with the user's willingness and ability to pay for the service.

- To promote the development of site-specific water tariffs based on financial, economic, and social equality consideration, and to involve local communities in the price setting to ensure the tariff structures compatible with the consumer's ability to pay.
- To set tariffs in rural areas with the aim of recovering the operation and maintenance costs, while in urban areas, to aim at the total cost recovery through time (which covers operation and maintenance costs, depreciation, and debit servicing).

Institutional Aspects

- To assign more responsibilities to the local level institutions concerning implementation, management, monitoring, and supervision of the water supply and sanitation schemes, as well as to secure the local level inter-sector coordination.
- To develop guidelines, principles, and norms for streamlining the interventions of external support agencies and NGOs.
- To equip the water supply and sanitation organizations at all levels with the necessary facilities in terms of manpower and equipment.

Capacity Building Aspects

- To develop and implement a comprehensive and well-coordinated training plan to strengthen the technical capacities of national professionals in both formal and informal sectors.
- To strengthen the capacity of water users associations (water committees/water councils) so that they may make independent informed choices.
- To establish the viable public information management systems (including conventional, electronic, and internet-based systems) that could be used to access and disseminate the technical information, documentation, and analysis of data on various aspects of water supply and sanitation systems.

Social Aspects

- To establish and legalize a process for the participation of all stakeholders (formal and informal) to ensure the efficient management of water supply and sanitation systems, and to promote participatory, consultative, and consensus building methodologies so as to enhance the involvement of users at different levels of decision-making.

- To launch public awareness campaigns to educate people about the importance of water supply and sanitation issues and related environmental health risks.
- To pay a special attention to the role of women while establishing the community based structures for the management of localized water supply and sanitation systems.
- To make it mandatory to include the water supply and sanitation services in future urban development plans, especially the housing schemes.

Environmental Aspects

- To protect the water bodies from pollution by industrial wastewater and other wastes, through the strong enforcement of legislative measures.
- To integrate and coordinate the development of industrial water supply and wastewater treatment with other water sector development objectives.
- To integrate and coordinate the development of industrial water supply and wastewater treatment with other water sector development objectives.
- To recycle wastewater when it has been found to be safe for health and environment.
- To promote the improvement of environmental sanitations in urban centres and rural areas, and to protect the water bodies from being polluted and contaminated.

Water Sector Development Programme

The Water Sector Development Programme (WSDP) is the instrument to implement the WRMP. The WSDP defines concrete interventions to achieve the objectives of the WRMP, using the guidelines set under the water strategy. The planning horizon of the WSDP is 15 years (2002-2016) and is divided into three 5-year periods (short-, medium-, and long-term). In summary, the WSDP provides an inventory of the projects to be implemented over the next 15 years with the accompanied investment, and is based on the elaborated consultative process reflecting inputs ranging from the international donors agencies to the local level communities. The WSDP consists of programs and projects grouped into the sub-sectors of irrigation, hydropower, water supply and sanitation, water resources, and institutional and capacity building aspects. These various programs and projects reflect local, regional, and national priorities in the water sector, and have their respective investment schedules, implementation strategies, institutional and coordination arrangements, and monitoring and evaluation mechanisms.

BOX 4.8: The WSDP Focuses on Actions

- To make clean water available for drinking and sanitation.
- To make water available for livestocks in nomadic and other special areas.
- To extend the irrigation for agricultural development to the possible maximum.
- To expand the generation capacity to meet the hydroelectric power needs.
- To provide water for the industrial development.
- To provide water for, among other uses, fisheries, tourism, and transportation.

The WSDP also indicates the followings as the major constraints of the water sector development:

- Absence, until very recently, of a coherent development policy, strategy, and program.
- Low institutional capacity and effectiveness.
- Shortage of financial resources, coupled with immense investment requirements, particularly in cases of large-scale projects.
- Lack of coordination among the various implementing institutions: federal government, regional governments, NGOs, donors, and others involved.
- Lack of appropriate technology at the level of local resources.
- Low level of infrastructure development that would allow easy access to inputs and outputs.
- Absence of involvement of the stakeholders in the development process.
- Inadequate technical capacities.
- Lack of data and information required for the efficient sector planning and management.
- Insufficient public-private partnerships.
- Low water use efficiencies in all water consuming sectors.

Water Supply and Sewerage Development Programme

The Water Supply and Sewerage Development Programme (WSSDP) is one of six sub-sector development programs included in the WSDP. The WSSDP includes goals, targets, and investments requirements on water supply and sewerage.

Goals : The WSSDP aims at enhancing well being and productivity of Ethiopians, by providing them, to the greatest possible extent, with clean, adequate, and reliable water supply and sewerage services, and also at meeting their needs for livestock, industry, and other uses.

The specific objectives in achieving these goals are:

- To provide the potable water to most of both urban and rural populations, and the water for sewerage where conditions permit.
- To provide water for livestock, particularly in such critical areas as nomadic regions and drought-prone areas.
- To make water available for the industrial development.
- To operate and maintain water supply and sewerage services on an efficient and sustainable basis, together with the effective management.
- To ensure protection and conservation of resources and to control pollution and wastage, as parts of the management policy.
- To ensure the sustainable resource development through the development of human resources at all levels, legislation and regulatory framework, and other appropriate means of the capacity building.
- To promote the stakeholders participation in planning, design, implementation, rehabilitation, operation, and maintenance of water supply and sewerage schemes.

Targets: The water supply and sewerage targets were regionally set for the 3 sub-periods of the WSDP horizon. The national target for access to the safe drinking water is 76 % by the end of 2016, and the targets for urban and rural areas are 98 % and 71 %, respectively, whereas the target for the capital, Addis Ababa, is 100 % by 2011 (Table 4.6). To achieve these targets, studies and designs of 391 towns, construction works for 402 towns, and rehabilitation for 112 towns will be undertaken in urban areas, and 4,255 deep wells, 9,329 shallow wells, 27,338 hand-dug wells, 18,908 springs, 222 subsurface dams, and 2,857 rehabilitation works will be done.

Table 4.6 Water supply coverage targets in Kenya (2002-2016) (Unit : %)

Period	Nation	Urban	Rural	Addis Ababa
Existing Situation (2001)	30.9	74.4	23.1	70
Short Term (2002-2006)	45.1	87.8	36.8	75
Medium Term (2007-2011)	60.1	97.3	52.2	100
Long Term (2012-2016)	76.0	98.2	70.9	100

Source: [19]

With regard to the sewerage coverage, even though the WSDP plans the design and construction work for urban areas to improve the coverage, there are no clear targets except that the coverage is expected to be extended by approximately 3.5 % annually. Moreover, although the sanitation issues are mentioned in both WRMP and water strategy, there are no plans or targets on sanitation in the WSDP, especially for rural areas. There seems to be the lack of coordination in preparation of the WSDP between the Ministry of Water Resources (MOWR) responsible for water resources and the Ministry of Health (MOH) responsible for sanitation. Even the Sustainable Development and Poverty Reduction Paper (SDPRP), Ethiopia's most important development plan, does not include targets on the sanitation coverage.

Investment Requirements: Total investment requirements for the WSSDP are estimated to be $ 2,935.8 million. Out of these, the rural water supply projects account for $ 2,086 million (71 %), the urban water supply for $ 819 million (28 %), and the urban sewerage for $ 30 million (1.1 %).

According to the report by the [72], these requirements are about 5 times higher than the current level of allocations for the capital investment in the sector, meaning that a significant increase in resources allocation to the sector is urgent to achieve the targets. On the other hand, there are no investment plans for the rural sanitation.

Constraints: The WSDP suggests the followings as the main constraints within the water supply and sewerage sub-sector:

- Shortage of skilled manpower at all ministerial levels.
- Low community participation in formulation and implementation of development programmes.
- Insufficient capacities in terms of equipment and other material resources.
- Not properly addressed sanitation issues.

Institutional Framework

Federal and Local Governments

Ethiopia's local government is subdivided into 9 regional states, 2 administrative areas (Addis Ababa and Dire Dawa), and about 550 Woreda (districts) local administrations composed of 6-10 Kebeles (villages). After the promulgation of the proclamation No. 41/1993, the responsibility for the water supply and sanitation was transferred to the local governments, while the federal level is responsible for drawing overall policies, guidance, and funding. In case of Addis Ababa, the Addis Ababa Water Supply and Sewerage Authority (AAWSSA) is responsible for the water supply and sewerage services. The roles and responsibilities of the key institutions in the water supply and sanitation sector are shown in Table 4.7.

Table 4.7 Roles and responsibilities of Key institutions in Kenya

Institutions	Main Roles/Responsibilities
Federal Level	
Ministry of Water Resources	To set policies, strategies, goals, regulations and standards on the water sector To facilitate the involvement of the private sector and communities. To provide/facilitate financing for new investment and rehabilitation of existing facilities. To monitor the progress of the sector To provide support to the region
Ministry of Health	To set policies, strategies, guidelines, etc. To promote sanitation and hygiene education at all levels To increase awareness and participation of communities To advocate and promote the construction, use and maintenance of low cost sanitation facilities
Regional Level	
Regional Water Bureaus	To plan, manage, monitor and evaluate programs on water supply and sewerage. To strengthen capacity in the region
Regional Health Bureaus	To plan, manage, monitor and evaluate programs on sanitation and hygiene promotion To strengthen capacity in the region.
Woreda Level	
Woreda Water Bureaus	To promote, plan and implement their own water supply activities. To contract and supervise Local Service Providers at the woreda and community levels.
Woreda Health Bureaus	To promote, sanitation and hygiene activities.

Source: [21], [73]

Water Resource Development Fund

The GOE established the Water Resource Development Fund (WRDF) in 2002, to help the regional administrations implement the Water Resource Management Policy

(WRMP). The WRDF would fund all the water sector projects and provide the long-term loans based on the principles of cost recovery.

Private Sector

The private sector has an important role in achieving the water sector targets in the WSDP. In the past the participation of private sectors was very negligible in the development of the water sector. However, the GOE is now considering the private sector as an important partner and trying to create conditions for their active participation. The private sector is expected to improve the production of key inputs, establish more efficient markets, and bring new investments into the sector [19].

Non-Governmental Organization

"Over 500 local and foreign NGOs operate in Ethiopia and many of them are involved in rural water supply and sanitation and in peri-urban areas in service provision, community sensitization and training in different aspects of rural water supply and sanitation, standardizing equipment, promoting village level operation and maintenance, promoting establishment of water communities with the strong involvement of women, and promoting sanitation [21]."

The WSDP suggests the followings as important functions of the NGOs within the water sector:

- Bringing additional financial resources.
- Strengthening technical capacities of regional bureaus.
- Organizing local communities.
- Undertaking rehabilitation works.

Institutional Challenges

The existing institutional arrangements present a number of challenges that need to be overcome. For example, Ministry of Water Resources, Regional Water Bureaus, and Woreda Water Bureaus are responsible for the water supply, whereas Ministry of Health, Regional Health Bureaus, and Woreda Health Bureaus are responsible for sanitation and hygiene. Due to the lack of proper coordination, the separation of responsibilities on water and sanitation often causes serious logistical and organizational problems. The W

SDP proposes the following as some of the institutional challenges within the wa ter sector: Institutional instability, management problems, lack of institutional coor dination, problems of capacity, limited funds/budget, lack of integrated manageme nt information system, weaknesses in operation and maintenance systems, absence of equipment standardization, low community participation, and policy and legislat ive issues.

4.2 Financial Mechanisms Analysis

4.2.1 Eastern Asia: China

Income Source for Sanitation Management

Pollution levy system

Pollution levy, as an economic tool, charges polluters according to the type, amount, and concentration of the pollutants and encourages polluters to discharge less pollutants. The levy system was first adopted in China in 1985. For the past two decades, there have been significant changes of this system. On July 1, 2003 a new levy system [74] was adopted by SEPA, which expands the fee collection targets from the enterprises to all the intuitions including individual owners, and this new system is in accordance with several transformations in China's pollution control. That is, from the concentration control to the combined concentration-total amount system, from the point sources control to the regional and watershed management strategy, and from the end of point approach to the whole process management and cleaner production. More importantly, the collection of wastewater tariff and the management and use of levy fee are separated, and all the collected tariffs are supposed to be used for the pollution control.

Urban wastewater tariff system

Since 1999, many cities began to collect the wastewater tariff to help the development of wastewater treatment plants. Especially after 2002, wastewater tariff was rapidly increased in many areas in China, from 0.1-0.2 RMB/m^3 to 1.0-1.2 RMB/m^3. In Beijing, the comprehensive water price has been 6 RMB/m^3, among which 1.5 RMB/m^3 is for wastewater [75].

Financial Resources for Construction and Operation of WWTPs

Until the middle of 2004, more than two-thirds of wastewater treatment plants were state-owned enterprises [76]. The main financial sources for construction come from local financial budget, government credit loan, national debts, and pre-tariff for wastewater. The wastewater treatment plants have very weak capacity for cost and benefit management, and government supervision is also very weak. In addition, the wastewater tariff can hardly be used for the normal operation of wastewater treatment plants.

Through the successful pilot practices in Jiangsu and Guangdong, MOC, SEPA, and local governments began to fully open the wastewater treatment plant markets to phase out the limitations from sectors, administrative regions, and ownerships. The different investments are encouraged for the construction and operation of wastewater treatment plants, and both construction and operation must be taken into account for all the new wastewater treatment plants. Ventura capital, joint venture, and cooperation and financing are common tools for construction and operation. Such model as Build, Operate and Transfer (BOT) is promoted to promote for the water market.

Large-scale enterprises and groups were encouraged to buy out the existing wastewater treatment plants and help the development of wastewater treatment sector. Anhui and Shandong provinces claimed to put all the wastewater treatment plants on the market by 2005 [77]. To help the financing, private and group investments, and bank loans are encouraged and the local governments started issuing the infrastructure bonds to develop the market [78]. The market-based mechanism was thus fully introduced into the wastewater treatment sector. In addition, the SEPA will continue pushing the tariff system of wastewater treatment [79]. In 2004, the SEPA required all local governments to begin to collect the wastewater tariff within a predictable timeline. Those cities that have already collected the wastewater tariff should adjust the tariff to a suitable level that will ensure the wastewater treatment plants can make at least some sort of profits, whereas for those who have not recently collected the tariff, the minimum tariff level must be ensured so the wastewater treatment plants can operate normally.

Prospect of the Water and Wastewater Treatment Market

China has the fastest growing water and wastewater market in the world. Under its 5-year plan (2001-2005), the Chinese government projected it needed $ 85 billion in investments to meet its environmental objectives, with a major portion targeted for wastewater treatment and water supply development [80]. Out of 130 privately financed Chinese projects identified by the GWI (representing a total investment commitment of $ 5 billion), 80 % were signed during the last four years. Twenty five projects representing the investment commitment of around $ 1 billion were signed by the international and Chinese developers in 2003 alone [81]. It is show that the China's market for water and wastewater treatment was increased to $ 22.7 billion in 2005 from $ 18.7 billion in 2004 and is expected to reach $ 33.2 billion by 2010. The residential water market reached $ 1.46 billion in 2004 and will be increased to $ 3.3 billion by 2010 and $ 5.48 billion by 2015 [82].

By the end of 2004, 708 urban wastewater treatment plants had been built, with the daily treatment capacity reaching 73.9 million m^3, the drainage pipes stretching as long as 218,900 km, and the wastewater treatment rate climbed to 45.7 %. Compared to 2000, the number of treatment plants, the total length of urban drainage pipes, and the urban wastewater treatment rate was increased by 66 %, 54 %, and 12 %, respectively. In the past four years, the scale of China's grade-two and higher urban wastewater treatment plant has been expanded by 1.55 times, and the urban wastewater treatment industry has entered into the period of rapid development.

According to the 'Implementing the Scientific Outlook on Development and Ensuring the Safety of Urban Water Supply' announced in July 2005, the reform is speeded up, and the urban water market reform and the establishment of supervision system are pushed forward. First, the investment and financing system reform of the water industry is pushed forward. The social funds and the foreign capitals are thus encouraged to be involved in the construction and management of public utilities in all kinds of forms, such as exclusive ownership and equity or contractual joint venture. Second, the efforts are made to promote the property right reform of public utility enterprises. Through the reform, the water enterprises have become the main actors in the market, while the governments are turned into the market supervisors. Third, the reasonable pricing mechanisms have been gradually set up, identifying the principle in which the water enterprises are responsible for the cost and entitled to reasonable profits and polluters pay. Fourth, the franchising operation and management system has been established. Both public utility investors and executing agencies bid for projects and are given the franchising rights by the government, clarifying their obligations and rights. Fifth, the market supervision system has been set up, including the market entry supervision and the supervision on the operational process concerning water quality, cost, price, services, etc., with the aim at preserving the orderly market competition and protecting the interests of citizens and investors.

The gradually increased marketability and the progressive rationalization of the pricing system of Chinese water industry have won more and more international acceptance. As a result, some important multi-national water groups have already entered the Chinese water market. They invest, build, and operate the water facilities in China, in forms of capital investment, technology export, product sales, and so on.

BOX 4.9 : Foreign Investment in China

Some of the recent developments involving foreign investment in China include:
In late 2001, US Filter won a $ 3.1 million contract to supply the city of Karamay, China's new WWTP with biological and clarification technology. In August 2002, Thames Water announced its plan to acquire 48.8 % stake in the Hong Kong-based China Water Co for $ 72 million, thus expanding its operational and technical expertise in China. Ondeo has a contract for the equipment and site supervision of a drinking water purification plant (150,000 m3/d) in Changzou. In May 2002, Ondeo signed two new contracts in China for a total value of almost EUR 460 million. In Qingdao, Ondeo was chosen to manage a 25-year contract to supply drinking water to 2.3 million residents. In Shanghai, Ondeo is re-constructing two drinking water treatment plants located in Nanshi and Yangshupu. Vivendi recently signed a 23-year contract worth $ 307 million with the Chinese municipality of Baoji (population 500,000) for the refurbishment and extension of two drinking water treatment plants and their operation. Vivendi Water has also renovated and now operates the 500,000 m^3/d Lingzhuang Water Treatment Plant in Tianjin through a 20-year concession contract with Tianjin municipal government. Vivendi Water and its Japanese partner Marubeni won the first ever Build, Operate and Transfer (BOT) contract organized with the support of the Central Government in China's water industry, to construct and operate the Chengdu No.6 Water Treatment Plant serving over 3 million people in the city of Chengdu. Further to Beijing's first foreign-funded WWT facility (BOT model), which involved investment from the American Golden State Group Corp Beijing Economy and Technology Investment CoSix, a number of more large-scale projects for sewage treatment are to start in the next five years. Another recent contract worth $ 409 between Vivendi and the municipality of Zhuhai covers two WWTPs - an existing plant and one to be built - and their operation for 30 years.

4.2.2 Southern Asia: Vietnam

Financing Gap

Current Investment in Urban Water Supply and Sanitation

During the last decade, as a result of the high level of priority assigned by the GOV on WSS, more than $ 1 billion has been invested in the urban water and sanitation projects (excluding user contributions). They have been typically carried out by the provincial WSCs with significant ODA contributions (average of over 80 %).

Current Investment in Rural Water Supply and Sanitation

According to the 2004 Workplan of the NTP on the rural water supply and sanitation, the total investment for the rural water supply and sanitation in 2003 amounted to VND 1,600 billion with a predominant community participation. The total GOV investments were VND 236 billion, whereas the international investors counted for another VND 387 billion (Figure 4.1), resulting in the total of USD 40 million. However, this is somewhat lower than the average of USD 50 million during the 1999-2002 period, and no major changes are foreseen in the near future.

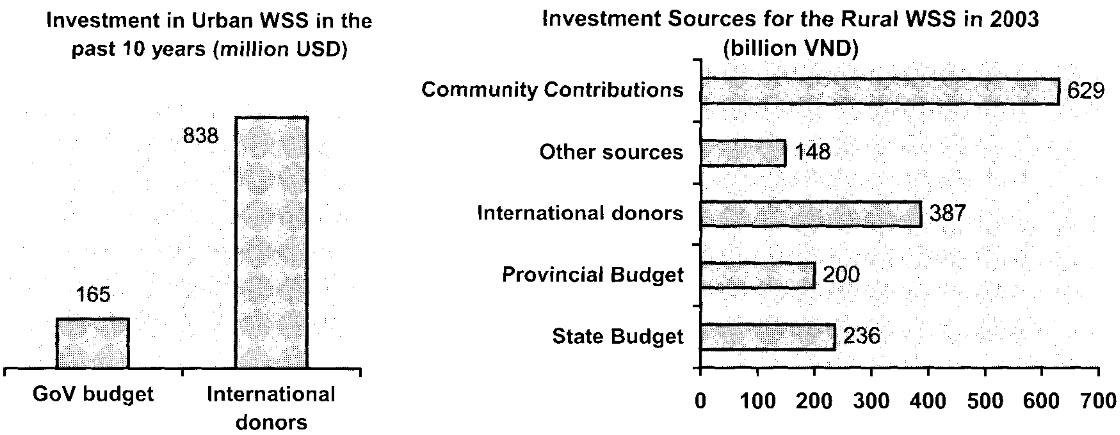


Figure 4.1 Investment sources for the water supply and sanitation in Vietnam

With the current investment level, the budget can meet only 17 % of the officially recognized VND 50,000 billion needed to achieve the target of 100 % of rural population having access to the clean water and environmental sanitation by 2020. With the current mix of ODA and government funds, about 25 % of the rural needs can be funded. Therefore, it is necessary to look for other resources and have an appropriate method to mobilize the local financing to fill the financing gap.

Tariffs and Cost Recovery

The cost recovery for the water supply and sanitation is currently moving in the right direction, together with the increasing tariffs. The GOV's policy is that users shall pay the full cost - however, it has been a challenge to enforce this policy. The real water tariffs generally meet O&M costs but are not sufficient to contribute to the future investment needs, whereas the wastewater charges have only been recently introduced at a nominal level. The GOV Decree 67/2003 introduces a uniform environmental protection charges for wastewater for both industrial and domestic customers, which must not exceed 10 % of the clean water tariff and should be collected by the WSCs. However, there is some confusion about the purpose of this charge. In many developed countries, the wastewater tariffs exceed the water tariffs so a 10 % ceiling on the wastewater tariffs is not sustainable and needs to be revised. For example, in Hanoi, the Hanoi Water Supply Business Company has applied the new price for water consumption since March 2005, as shown in Table 4.8. In comparison, in Hai Phong, the WSCO applied the average water consumption price of 2,400 VND/m^3 from 2000 to 2002, while 2,900 VND/m^3 at present. Hanoi has also been levying a drainage surcharge of 15 % for the water bill, whereas a flat wastewater rate of 300 VND/m^3 has been introduced across all customer categories in Hai Phong.

Table 4.8 Water consumption prices in Vietnam (Unit: VND/m^3)

Consumption Object	Prize
Domestic consumption	2,800
Institutional consumption	4,000
Commercial consumption	7,500

4.2.3 Eastern Africa: Kenya

Financing Strategy

The GOK's average annual development investment in water and sewerage systems in the last five years has been about $ 35 million/year [55]. Table 4.9 presents a summary of financing for development activities channeled by Central Government ministries into the water supply and sanitation sector from 1997 to 2002. 61.5 % of development expenses were financed by Appropriations in Aid (Donor Cooperation channeled by Central Government agencies), while the remaining 38.5 % was financed through the government's general budget. In annual terms, this is equivalent to 0.2 % of GDP. Overall, during the 1990s, about 62 % of the development budget channeled by the central government to the water sector was financed by the donor community, while about 32 % was financed by general revenues of the Kenyan Government.

Table 4.9 Development expenses for water and sanitation (1997/2002) (Unit: US$ mil.)

	MWI	NWCPC	MLG	TOTAL	%
Professional services and other expenses	43	20.4	1.8	65.3	37.2
Rural Water Supply	22.3	16.2	0	38.5	21.9
Urban Water Supply	6.6	10.1	11.5	28.4	16.1
Urban sewerage schemes	0	0	29.8	29.8	17.0
WRM & other projects	13.7	0	0	13.7	7.8
Total	85.7	46.9	43.1	175.8	100
As % total budget	48.8	26.7	24.6	100	-
Financing					
Appropriations in Aid	45.8	31.5	30.7	108.2	61.5
Government Budget	39.8	15.3	12.4	67.6	38.5
Total Financing	85.7	46.9	43.1	175.8	100

Source: [55]

The MWI proposes that financial resources to be used to attain the water-sector related MDGs will come from the following basic sources:

- Loans from development partners
- Grants from various sources
- GOK annual budget
- Water Services Trust Fund (WSTF) established under the Water Act of 2002
- Water revenues from operators
- Financing from private service providers
- Community contributions through water user associations (WUAs)

Table 4.10 Construction costs in Kenya (Unit: US$/capita)

Water Supply	Cost	Sanitation	Cost
Piped systems with house connections	-	Sewerage with house connections	250
Public standposts	30	Small bore sewers	-
Boreholes with hand pumps	39	Septic tank	97
Protected dug wells	24	Wet toilets	50
Rainwater collection	41	VIP toilets	40
		Simple pit toilets	25

Source: [83]

The Funding gap for Water Supply and Sanitation

In order to appreciate the different needs caused by the disparities in service coverage in the country it was decided to consider each region separately. The costing of water and sanitation services has been guided by unit costs reported by various studies and actual on-going projects, which have been applied across the board to cater for lack of specific regional cost data. The unit costs and estimated coverage have been input into the country's MDG Water and Sanitation Model.

Other Country Specific Interventions and Resources (Unit: KShs bil.)

Intervention	Total Required Resources
Water storage & Environmental Conservation	31.1
Capacity building	0.6
Legal/institutional framework	0.3
Water for irrigation	24.8
Fl Flood mitigation	85.3
Total	142.3

Bilateral Funding mechanisms

Kenya has a long record of co-operation with development partners in the water sector including, World Bank, UNICEF, SIDA, DANIDA, JICA, DFID, ADB, KfW/GTZ, AFD, FINNIDA, and EU among others. Table 4.11 presents the total level of funding from bilateral and multilateral agencies, grouped for the periods 1990-2000, and 2000-beyond. Continued pursuit of this bilateral relationship will enhance sustained funding and achievement of the short, medium and long-term strategies for the sector.

Currently, IDA and AFD are interested in helping commercialize water utilities serving main urban centers (including Nairobi and Mombasa), while German cooperation (KfW) is focusing on commercializing water utilities in medium-sized urban centers. JICA is interested in supporting smaller urban centers and rural areas. Denmark, Finland and Belgium aim to cooperate on rural water supply. The ADB is financing projects in urban areas.

Table 4.11 Bilateral donor funding in Kenya (2000-2005) (Unit: US$ mil.)

Sector	1990-2000	2000- Beyond
Rural	54.2	26.1
Urban	171.1	249
Water Resources Management	26.6	0.4
Total	251.8	275.6

Source: [84]

4.2.4 Northern Africa: Ethiopia

Current and envisaged direct financing

Current financing for Ethiopia's water supply and sanitation sector is largely through federal and regional budgetary allocations. Other major funding mechanisms for the sector include non-budgetary sources such as bilateral donors and international NGOs, which provide grants either to the communities or the government at regional or local levels. Until 2001, the Ethiopian Social Rehabilitation and Development Fund (ESRDF) was the major source of financing for community-based rural water supply, with an annual investment of approximately $ 10 million (US Dollars). However, in line with the National Water Policy, the GOE established the Water Resource Development Fund (WRDF) and thus the ESRDF is gradually being phased out.

The main objective of the newly created WRDF is to pool together and appropriately channel resources from the government and bilateral donors. Its primary focus is financing the urban water sector. Thus, the complete phasing out of the ESRDF will have major implications on financing of rural water supply. Thus, new mechanisms will be required to ensure sustainable funding for rural areas. In the long term, it is also envisaged that the WRDF will be used as a tool to mobilize additional resources for the sector to cover both rural and urban areas.

Indirect financing & cost recovery mechanisms

The policy for financing water supply provides a basis for developing a framework for indirect financing and cost recovery. The envisaged mechanisms include:

Tariff setting and cost recovery: the government policy aims at promoting site-specific tariff setting, along with full cost recovery for urban water supply. The policy also envisages full operation and maintenance cost recovery for rural water supply, in keeping with the principle of affordable access for the poor through appropriate mechanisms, including subsidization.

Table 4.12 Channels of finance for development and expenditures (2001-2002)

Channels of Finance	Recurrent (% of total)	Development (% of total)	Total (% of total)	Expenditure (million Ethiopian Birr)
Federal Budget	4.9	9.3	7.4	41.3
Regional Budget	30.8	55.4	44.9	250.7
ESRDF	0	2.0	1.2	6.5
NGOs/Off-budget	0	33.0	18.9	105.5
Internal Generation through User Charges	64.3	0	27.5	153.5
Communities/Households capital contribution	na	0.2	0.1	0.8
Total	100	100	100	558.4
Total Expenditure (in million Birr)	238.7	319.7	558.4	-
Total Expenditure (in million US dollars)	29.1	39	68	

Source: [85]

Enhancing private sector and community financing: the policy seeks to encourage and promote participation of domestic financial institutions, private investors and community based organizations through appropriate government incentives. The National Water Policy proposes general approaches and objectives in financing water supply for both rural and urban areas. These include: to ensure full cost recovery for urban water; and to cover partial capital costs and full O&M costs for rural water. However, these are not elaborately laid out in actual guidelines.

4.3 Existing Technology Evaluation

4.3.1 Eastern Asia: China

Sewage Drainage System

In 1991, the "Industrial Policy for Urban Sewage Drainage System" had the following guidelines: 1) based on the national industrial polices, speed up the construction of urban sewage drainage system and make it in accordance with the urban development; 2) the urban sewage system should be included into the local planning; and 3) polluters should adopt the technical policies such as water-saving, pollution reduction, clean-up, and reuse. To help the implementation of these principles, more guidelines were issued regarding the urban collective wastewater treatment system.

To ensure the safe operation of drainage facilities, more guidelines were issued in the following years, such as "Urban Sewage Drainage Permission Guideline" and "Monitoring Methodology of Urban Wastewater". The national urban sewage monitoring network was also established, and members of the network must be certified. On the other hand, the water pollution prevention and control act requires that the urban sewage system must be built and the use of such system should be charged. The specific fund should also be arranged for construction, maintenance, and operation of the sewage system. According to the "Technical Policy for Water Pollution Prevention and Control" and the "Implementation Guidelines for Water Pollution Prevention and Control", except for a few large-scale enterprises and those companies far from the urban settings, which are supposed to treat the wastewater to a certain level for the reuse of discharge, all other enterprises must gradually transform from the individual wastewater treatment to the collective and regional treatment plan.

Construction and Operation of Urban WWTP

According to the "Tenth Five-Year Plan" by 2005, the urban domestic wastewater treatment rate in China would reach 45 % and those cities with the population over 0.5 million would reach 60 %. By 2010, the national average would be no less than 60 % and for the mega cities (capital, provincial capital, and tourism city) it would be no less than 70 %. Unfortunately, this objective seems too ambitious and certainly cannot be achieved for this year.

History of Wastewater Treatment

Since 1970s, China began to pay attentions to the urban wastewater treatment. Some cities made use of pond, billabong, scrap river way, and swampland to build the stabilization pond to treat the urban wastewater. According to the survey, there were about 38 stabilization ponds in the whole country, with the capacity of 1.73 million m^3/d, among which the domestic wastewater was about 50 % and other wastewaters came from oil, chemical, paper and pulp, printing, and dyeing industries. In 1980s, with the rapid urbanization, the urban water pollution was put into as the major agenda of the government. The municipal governments were allowed to use loans from international financial organization, foreign government, and equipment suppliers. This promoted the establishment of several wastewater treatment plants in China in 1982, including the Tianjin Jizhuanzi WWTP that was completed in 1984 with the capacity of 260,000 m^3/d. Owing to the success of this project, a number of wastewater treatment plants were also built in Beijing, Shanghai, Guangdong, Jiangsu, and other regions.

In the "Eighth Five-Year Plan", the watershed management and the comprehensive urban environmental management were two driving forces for the rapid development of wastewater treatment plants. By 1995, the total drainage pipe length was 110,062 km, indicating the sewage pipeline coverage rate of 64.8 %, based on the service areas. Compared to 1990, the drainage pipeline was increased by 54,373 km, with about 10,874 km growth per year. The number of wastewater treatment plants was 169 (including 116 secondary biochemical treatment plants), with the capacity of 1.749 billion m^3/yr, indicating the treatment rate of 8.69 %. Compared to 1990, the number of wastewater treatment plants increased by 89 (including large- and middle-scale wastewater treatment plants such as Beijing Gaopaidian WWTP, East suburb WWTP of Tianjin, Shijiazhuang Qiaoxi WWTP, Guangzhou Datansha WWTP, Wuxi Lucun WWTP, and Jinan WWTP), and the growth rate was about 17 new plants per year.

During the "Ninth Five-Year Plan", the water pollution treatment programs in "3 river" (Huaihe, Haihe, and Liaohe), "3 lake" (Taihu, Caohu, and Dianci), and "Bohai bay region" were initiated which attracted a significant technical and financial support from the central government. Twenty two wastewater treatment plants were built from 1996 to 1999, with the investment of 5.958 billion RMB and the capacity of 3.717

million m^3/d. There were also 109 projects under construction, with the investment of 16.183 billion RMB and the capacity of 8.32 million m^3/d. During the "Tenth Five-Year Plan", the collective wastewater treatment was strongly supported by the central government, not only on the construction but also the operation. By the end of 2003, the total investment for wastewater treatment plants amounted to 38.6 billion RMB, and 516 wastewater treatment plants had been built with the capacity of 32.84 million m^3/d.

Reform of Wastewater Treatment Plant in Jiangsu Province

Since 1980s, the rapid economic development and population growth in Jiangsu have been coupled with the water quality deterioration in the region, and this is especially true in its southern part. During the "Ninth Five-Year Plan", the construction of wastewater treatment plants was still very difficult, and even though there was a wastewater treatment plant, its efficiency was very low. In addition, the lack of financial resources was the biggest challenge. In recent years, the provincial government started the reform on wastewater treatment by increasing the tariff level, and such reform provided incentives for different investors to work with the government to develop the wastewater treatment plant. In 2002, the wastewater tariff levels in Nanjing, Wuxi, Changzhou, Suzhou, and Zhenjiang were increased from 0.6 to 1.05-1.15 RMB per m^3. Since then, the significant achievements have been made. Such market-based mechanisms as BOT and TOT have been introduced into Jiangsu, and many investors have had surprising interests to invest not only in big cities but also at small cities and established townships. In addition, the local governments in the southern part of Jiangsu have provided positive policies to help the construction of urban infrastructures. For example, in Jiangyin County, for those townships that would like to build wastewater treatment plants, the municipal government will provide a compensation of 2-3 million RMB for every 10,000 m^3 treatment capacity. For those who would like to invest on the sewage drainage system, certain compensation will be also provided. Similar policies are currently available in such other cities as Wujing and Yixing.

According to the "Tenth Five-Year Plan" for the water pollution prevention and control in the Taihu Lake watershed, 77 wastewater treatment plants must be built in the southern part of Jiangsu, and 53 of them have been built and 17 are currently under construction. Therefore, over 90 % of planned wastewater treatment plants can be completed by the end of this year. Some cities are actually building more wastewater treatment plants than the original plan. For example, even though there should be 12 wastewater treatment plants in Jiangyin County, 26 wastewater treatment plants have been built. The development of wastewater treatment plants in other cities in this region, such as Zhangjiagang and Changshu, is greatly supported by the government as well.

4.3.2 Southern Asia: Vietnam

As mentioned in Chapter 2, the urban drainage system in Vietnam is a combined system that had been constructed for about 100 years, and the additional construction has been implemented unsystematically, resulting in not meeting the development requirement of the cities. Even nowadays, the storm water in this combined drainage system is discharged with sludge and rubbish, possibly resulting in a number of lakes and ponds becoming wastewater keepers. Table 4.13 shows the sanitation coverage, including projections, in Vietnam. The proportion of various types of on-site treatments for household wastewater in Vietnam is shown in Figure 4.2.

Table 4.13 Sanitation coverage and projections in Vietnam (Unit: %)

Access to hygienic toilets	1993	2002	Annual growth	2010*
Urban coverage	44.9	68.3	4.8	99.2
Rural coverage	1.8	11.5	22.9	59.8
Average national coverage	10.4	25.3	10.4	55.8

*Projected coverage.

Note) Based on CSO data. "Towards the Vietnam Development Goals for Water Supply and Sanitation", 2004

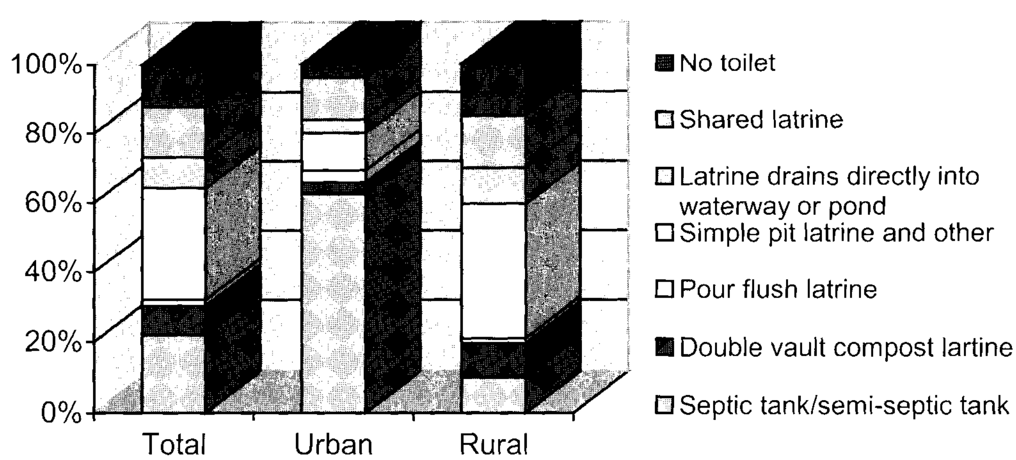


Figure 4.2 Proportion of on-site treatment in Vietnam

BOX 4.10 : Wastewater Treatment Plant in Urban Area

According to the field survey results, the 1st period of the Ha Noi Drainage Project has been carried out since 1996 to 2003. For wastewater treatment, there have been only Kim Lien and Truc Bach WWTP.

Kim Lien WWTP has a capacity of 3,800 m^3/day. Treated wastewater meet the A standard of TCVN 5945-1995 (BOD_5 = 20 mg/L, the sediment content is below 30 mg/L, coliform is below 10.000 MPN/100 mL), discharges to Lu River.

Truc Bach WWTP has a capacity of 2.400 m^3/day. It was built in a crowded area with 0.4 ha. The figures of the in and out water, and the steps of treatment are similar to ones in Kim Lien. The treated water discharges into Truc Bach Lake which is a place for water entertainment activities around West Lake area. Therefore, the mentioned treatment technology is not suitable for Truc Bach basin.

4.3.3 Eastern Africa: Kenya

Kenya (e.g., Mombasa, Kisumu, and Nakuru), have large and rapidly growing informal settlements (slums) and suffer perennial water shortages and poor utilities. Kisumu, which has recently been granted the city status, has not experienced consistent running water for decades, in spite of being on the waterfront of Lake Victoria, Africa's largest freshwater lake. The sewerage facilities in the city are also massively impaired and the current access is estimated at 51.8 % for water and 87.7 % for sanitation.

Mombasa, Kenya's second largest city, is surrounded by the Indian Ocean. Waters from many upcountry rivers are directed into the Indian Ocean but the clean water is still a rare commodity for the town's residents. The current access for water and sanitation is estimated at 86.4 % and 96.8 %, respectively. The situation in Nakuru is similar, with the access estimated at 64.1 % and 93.9 % for water and sanitation, respectively.

BOX 4.11: The 'Flying Toilets' of Kibera

In 1997, the assessment of community priorities carried out in Kibera identified the excreta disposal as a top priority. There are a few sewered toilets and most households rely on the traditional pit toilets. The community members consulted through the assessment pointed out that the existing toilets are inadequate and insufficient for the population: up to 150 people share a single pit toilet, filling up quickly. The problem is further exacerbated by the limited access to the exhaust services, with about 30 % of the toilets unusable.

The shortage of pit toilets is also brought about by the lack of space for new construction and because the landlords are unwilling to incur the additional expense. Due to the scarcity of toilets within the settlement, those excreta-filled plastic bags, referred to as "flying toilets" (otherwise known as the wrap-and-throw-method), are the most common means of excreta disposal for many households. A majority of the participants (69 %) identified the flying toilets as the primary mode of excreta disposal available to them.

Source: [86]

BOX 4.12: Vacu-Tug in Kibera

In 1996, the United Nations Centre for Human Settlements (UNCHS) – now UN-HABITAT – selected a consultant to develop and test a toilet emptying vehicle which could prevalently function in informal settlements and would have the capital cost low enough to encourage the private sector to operate the service. At the same time, it had to be designed for the local manufacture and repair, and affordable for the consumers. The 'Vacu-Tug' prototype was provided to an NGO in Kibera for trial, and it illustrated the viability of the technology but also highlighted the importance of establishing adequate institutional arrangements and financial management systems as a basis for sustainability of the system.

The Vacu-Tug consists of: (i) a vacuum tanker which is fabricated from mild steel with a nominal volume of 500 L (equivalent to one load) mounted on a steel frame; and (ii) a tug which comprises a small 4.1 kW petrol engine which can propel the vehicle at speed up to 5 km/h. When connected to the vacuum pump, it is capable of exhausting at least 1,700 L airflow/min. The pump can be reversed to pressurize the tank to assist the discharge of sludge to the sewer or to raise it to be discharged into the transfer tank. The vehicle is fitted with motorcycle throttle and braking system, and equipped with 75 mm diameter PVC hoses connected to the tank.

Source: [87]

4.3.4 Northern Africa: Ethiopia

BOX 4.13: Sanitation Status in Gondar Town

Admassu et al. surveyed the sanitary status in Gondar town, an unplanned old town with a rapidly increasing population. According to the survey in 1999, the population was 112,000 with 1,516 households. According to the survey results, only 50.9 % of the households had toilets (79.1 % traditional, 11.7 % VIP, and 9.2 % water-flush toilets). About 65 % of the toilets were individually owned and the rest were communal (32.5 %) or public (2.9 %). The main reasons for not having toilet are the high cost (48 %) and no space (40 %).

With regard to the water supply, about 96 % of the households were using the municipal piped water, but about 56 % of the households were using the public distribution points. The average water consumption was 12 litres per capita per day. About 4 % of the households were using such home-based water treatment methods as boiling, chlorination, and filtration. The sanitation coverage (50.9 %) in 1999 was almost the same as in 1994 (50 %), meaning the sanitation receiving a low priority from both government and communities.

Source: [88]

5 Guidelines for Sanitation Management

Water is an indispensable resource for human survival and development. As a viewpoint of the environmental engineer, the impacts of untreated wastewater on environment can be divided in three types. First is the impact on such receiving water bodies as rivers and oceans, second, on the human health, and finally, on the economy. When pollutants are discharged into nearby water, they affect the natural water environment, especially the water body directly receiving them. Their effects may be subtle or drastic. For example, by drinking the contaminated water or using the products from it, these pollutants may cause a number of problems such as waterborne diseases. In order to solve these problems, economic losses and needs resulted from the increased health care costs and additional treatment costs for the drinking water are required (Figure. 5.1).

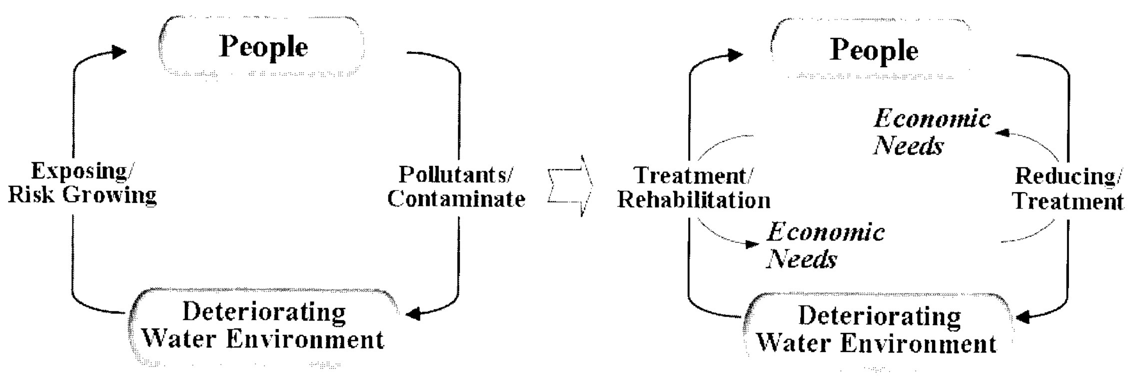


Figure 5.1 The affecting cycle between people and contamination

Recently, 'water stress' is emerging as an important parameter for measuring and assessing the regional water demand. It can be defined as the one combined with 'water quality' and 'price' for the regional water need. As previously mentioned, discharging the untreated wastewater, flowing along the sewer system, into the treatment works or directly into the nearby receiving water body may cause a gradual deterioration of water quality. As for a better quality of water, the price for drinking water treatment will go up. It has been reported that the water price could be represented by a function of either the increased cost to treat water or the cost for increased morbidity and mortality [91]. Therefore, a holistic approach to water and sanitation should be considered and adopted. This concept is also being used as a policy and economic driver in many countries.

Table 5.1 Current and projected water stress and income levels

Water Stress Level	1995			2025	
	Income	Pop.(mil)	Example Countries	Pop.(mil)	Example Countries
High (> 40 %)	High	19.74	Kawait, Israel	30	Kawait, Israel
	Med-high	63.44	Saudi Arabia	200	Saudi Arabia, South Africa
	Mod.	137.91	Libya	1,500	India, Egypt, Libya
	Low	238.07	Egypt	500	**N.Africa** , W. Asia
Sub total:		459.16		2,230	
Med-High (20-40 %)	High	181.25	Germany	1,000	U.S., France, Germany
	Med-high	137.30	Mexico, S. Africa	200	Mexico, Poland
	Mod.	165.33	Poland	1,600	**China**
	Low	957.70	India	500	
Sub total:		1,441,58		3,300	
Moderate (10-20 %)	High	514.41	U.S., France, Japan, UK	500	Japan, UK
	Med-high	13.10		50	Turkey
	Mod.	285.95	Turkey	300	
	Low	1,265.89	**China**	500	**Vietnam**
Sub total		2,079.35		1,350	
Low (< 10 %)	High	108.44	Canada, Sweden	100	Canada, Sweden
	Med-high	258.95	Brazil	300	Russia, Brazil
	Mod.	542.40	Russia, Bolvia	500	Bolivia
	Low	806.18	**Vietnam**	300	
Subtotal		1,715.97		1,200	
Totals		5,686.06		8,080	

Source: [91]

Note) High (> 40 %) Serious scarcity, urgent need for intensive management of supply & demand; Water becomes a limiting factor to economic growth
Usually an increased dependence on groundwater which is drawn faster than it is replenished and desalination is often required if proximal to sea water source

Med-High (20-40 %) Management of supply & demand required to ensure sustainability; Need to resolve human users
Major investment needed to improve water-use efficiency; substantial portion of GNP allocated to water management

Moderate (10-20 %) Availability is becoming a limiting factor
Significant effort & investment needed to increase supply

Low (< 10 %) Generally no stress in respect to available fresh water resources

The earth population has been reported/projected to reach 8 billion by 2025, under moderate population growth scenarios [93]. This situation will further put lots of pressure on such developing countries/regions as China, Vietnam, and North Africa. In fact, the environmental problems including water stress have already become increased in these areas. Except for some countries with the high annual average of available water per capita, many others are already facing or soon will face water stress (1,700 m^3 or less per person annually), or scarcity conditions (1,000 m^3 or less per person annually) in case of Africa. The Johns Hopkins University (1998) reported that 14 countries in Africa are subject to water stress or water scarcity, with those in Northern Africa facing the worst prospects. In addition, 11 more countries will join them in the next 25 years. Table 5.1 shows some representative countries with the water stress and projected for the water scarcity in the next 25 years. This table shows the large scope of human water stress and its clear impact on demands for the water and wastewater treatment and the sanitation management strategies.

5.1 Analysis and Evaluation

Currently, more than 2.4 billion people lack access to the adequate sanitation and are forced to dispose of their excreta in unimproved and unsanitary conditions. It has been reported that for the last three decades, the world population has been doubled to 6 billion, the world economy has been more than doubled, and the level of urbanization has been increased, especially in developing countries [89]. Rapid expansion and population growth in developing countries have placed high demands on water supply and sanitation to meet the growing domestic, industrial, and commercial needs, as clean water and proper sanitation are prerequisites for the economic growth in developing countries. In fact, about 70 % of people admitted to hospitals in developing countries are resulted from the effects of water-related diseases. The lack of sanitation-related wastewater management may cause serious human health problems directly in developing countries such as the research areas, because sanitation is strongly linked with good health and human survival.

As mentioned in Chapter 1, in this report, the term 'sanitation' is defined as the water originated from the wastewater that includes domestic and industrial wastewater, sewage, and urban run-off. The variation in wastewater quality is mainly determined by water consumption, climate, and state of the sewerage system. Especially, the composition of domestic wastewater depends strongly on the level of water consumption. About 60 to 85 % of water consumed per capita becomes wastewater [90], and it is expected that the lower percentages are applicable to the semiarid region and to the lack of environmental infrastructures in developing countries as well. The quantity of available water is decreasing and its quality is getting worse because of the poor sanitation-related wastewater management. Since the lack of policy and legal structure, of technical and institutional infrastructures, and of investment in the sanitation-related wastewater management, most developing countries are facing the water shortage. These situations can be even worse by frequent droughts.

5.1.1 Non-Technical Sector: Policy and financing mechanisms

China

Although a great improvement has been made in policy and legal framework of the sanitation management, the following reforms are still needed.

BOX 5.1 : The implementation of Policy, Legal Framework in China

Strengthening of central government policy and implementation guidance

The existing legal instruments need to be reviewed and those inconsistent with the reform agenda should be modified.

Regulation should be strengthened

The effective economic regulatory arrangements should be in place before the government losing control, particularly in monopolistic activities. Policies and regulations dealing with the pricing of water are vague, sometimes contradictory, and difficult to be implemented by the local authorities. These policies and regulations need to be clarified and the decision-making process for agreeing on the water price setting needs to be reviewed to ensure transparency and accountability.

Developing the system of standards (better coordinated with legal system and sector development)

It is proposed to divide the system of water-related standards into two parts:

mandatory technical codes by the government and instructive standards by the sector associations. The instructive standards or the codes of best practice should be produced, separately from the government, by the associations of those organizations who are responsible for the delivery.

Improving legislation involving resource fees

The appropriate pricing of water resources is important for their conservation and allocation. Although there are a number of local water resource fee systems, these are not supported by the legal framework.

Policy development should be better coordinated

The number of legal organizations dealing with water is increasing. This framework should be comprehensive and consistent with both the reform agenda and the special characteristics of the water sector. During implementation, in particular, the governments at all levels should ensure that the structural reform of water and wastewater sectors is carefully designed and the implementation is well planned.

Establishing an effective framework for government functions

The coherent frameworks for government functions on policy, planning, regulation, and asset ownership should be developed. This should, most desirably, include the separation of the functions on policy, ownership, operations, and regulation (although policy and regulation may be combined during transition to the more mature sector arrangements).

Developing an effective regulatory arrangements

All the cultivation of market initiatives should be subject to appropriate and effective regulation monitoring and enforcement. Regulators need to be competent and sufficiently powerful, and the regulatory decisions should be "scientific" and protected from the undue political influence.

Sustainable financing and tariff arrangements

Those responsible for setting the tariffs should develop strategies for moving towards the full-cost pricing, based on the user/polluter-pays principles, as quickly as possible.

Introducing competition and developing a coherent policy framework for the sector

The cultivation of market of water and wastewater services needs to be guided by the coherent policy and legal framework. Competition is the main driving force for the benefits from cultivation of market. It is regularly pointed out that the high sunk costs of networks bring a high degree of natural monopoly to water and wastewater services. The government should develop sector policy, regulatory, and institutional arrangements that promote the introduction of competition and facilitate new investors and operators to bring the capital and the increased efficiencies and technology to the sector. Benchmarking should be introduced to facilitate the competition by comparison.

Public participation

Water sector leaders and managers should provide and encourage the public participation through the increased transparency, including publishing the performance information, and the formal mechanisms for soliciting the consumer opinion and dealing with the complaints.

Experiences in China tell that constructions and operations of the large scale wastewater treatment plants will bring significant profits to private and international investors, after the BOT model puts into use in big cities. Indirectly, it improves the local investment environment and promotes the local economic development. As to small cities and towns, the wastewater disposal fees cannot be fully collected. Even if the fees could be collected, the plants cannot afford high operational costs without the financial support from governments or other possible ways, even in many developed areas in China. It has fallen into a malignant cycle that the investors cannot make profits from the investment in wastewater treatment plants in town and townships in China, the lack of financial sources for the constructions of plants and pipelines hinders the realization of wastewater disposal, and then the wastewater cannot be treated, and the water pollutions are so serious that it threatens the drinking water safety of local residences. Therefore, actions should be taken on the wastewater disposal, as mentioned above, not only in big cities but also in small cities and towns, because the cost of water pollution is enormous and it will hold back the local development in many aspects, even making negative influences on people's health from a long-term viewpoint. Although the constructions of wastewater treatment plants sometimes cannot make direct profits, they contribute more to the real improvements of the economy and the whole society.

Recently, the establishment and improvement of urban water supply and wastewater treatment market supervision system in China has been accelerated. The MOC will continue to push forward industrialization and cultivation of market of water supply and other public undertakings to expand the investment channels, to speed up the infrastructural construction, and to constantly improve management and services. Various investments such as non-public economies and foreign capitals are encouraged to get involved in the construction and operation of public utilities. Multi-channel, multi-form, and pluralistic investment mechanisms involved by both government and market are established. The public utility institutions are guided to break up the monopoly, and relax the market entry conditions by bringing in the competition mechanisms, resulting in accelerating the establishment of franchising operation and management system and promoting the market operations. Also, the MOC will continue to improve the water market supervision policies, which mainly cover such aspects as market entry, cost and water pricing supervision, and water quality and services supervision, to protect the lawful rights and interests of the public and the investors.

A number of leading European suppliers are successfully establishing themselves in the Chinese market. The Vivendi Water for instance has already invested more than 500 million Euro in China, and in 2001, Ondeo's managed turnover in Greater China was over 400 million Euro. Furthermore, the outlook for the global water companies looks even more promising [99]. Obviously, China will rely heavily on foreign capital to invest in construction and management of wastewater treatment, water supply, and reuse projects, according to the market analysts, but a number of barriers stand in the way. The biggest barrier is probably the low fee that the utility customers generally pay for the water and wastewater services in China. Another major problem is China's bureaucracy. Additionally, the lack of intellectual property laws in China poses risks for companies. China's current financial laws also make it difficult to take investments or profits out of the country. However, the market reforms have been coming, albeit slowly, on all of these fronts, especially after China's entry into the World Trade Organization (Geneva) in 2001 [100].

Vietnam

As previously mentioned, although Vietnam has abundant water resources, most of them originate from the neighboring countries and are with the risks of running out and of being contaminated. Therefore, in order to achieve and use the water resources in a sustainable manner, Vietnam must act as follows. First, the water resources must be exploited systematically according to the river basin and water structures, but not according to the administrative divisions. Second, water resources exploitation and use must be coupled with the protection from scarcity and contamination. From the financial viewpoint, the challenges faced by Vietnam to meet the Vietnamese MDGs in water supply and sanitation are not unlike those found in most developing countries. Investment needs are huge, compared to the revenue base. The low tariffs make it impossible to expand services using the internally generated funds. In general, the low-income countries cannot afford the capital-intensive conventional, engineered solutions: investments should be step-by-step (choosing the best possible within the limited resources).

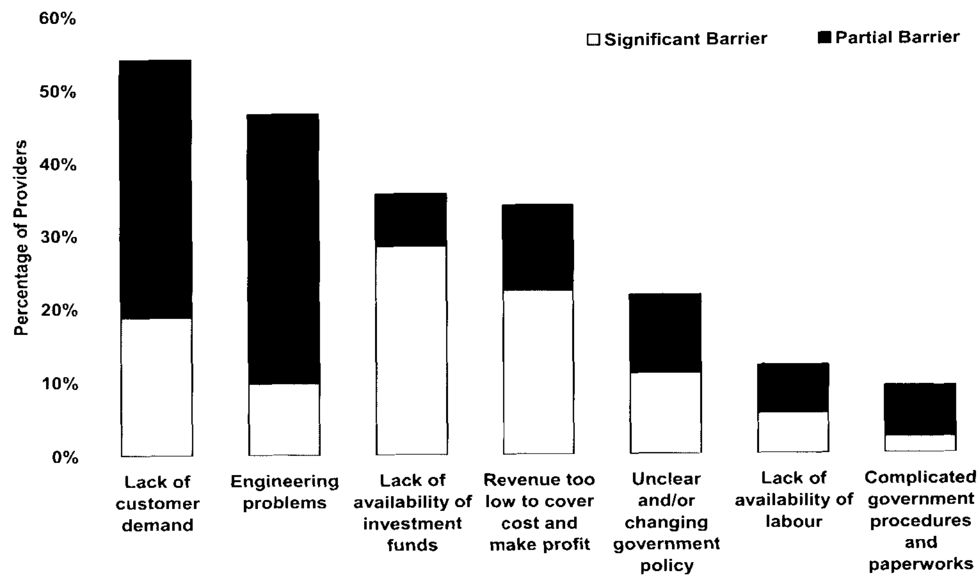
BOX 5.2 : Establishing Long-Term Sanitation Management Strategy

Allocation of investment funds:

A forward-looking detailed development plan for the sector is needed where public investment and recurrent expenditure are linked and the scarce resources are efficiently and effectively allocated. Currently, the relatively wealthy urban areas receive 84 % of the ODA funds whereas the rural areas, where 75 % of the total population resides, enjoy only 13 %.

It is necessary to look for other resources:

- Sub-sovereign bonds.
- Local Development Infrastructure Funds (LDIF): HIFU, the HCMC-based LDIF.
- Micro-credits: Some estimates state that three quarters of households get credit in one form or another. Many organizations are involved in supporting the micro-credit sector.
- The private sector has developed businesses by providing services at a free market rate. But there were many barriers, as shown in the following figure.



Tariffs and cost recovery:

The key to the success of the sector is the higher but realistic and affordable tariffs. Introducing and enforcing a uniform tariff mechanism for the whole country is a step toward the right direction. On the wastewater side the government should review Circular #67 (2003), which caps the wastewater fees at 10 % of water tariffs. Given that wastewater operations and investment typically cost more than the equivalent water services, such constraints will further diminish the sustainability of the wastewater sector. The wastewater tariffs should at least fully recover the operation and maintenance (O&M) costs, as well as the depreciation of short-lived assets. Currently, the tariff affordability and the willingness to pay do not seem to be an issue in the water supply in Vietnam.

Boosting sanitation:

Establishing a profit and loss entity for the provision of sanitation services, with a defined customer and revenue base, is the immediate step in the sanitation reform.

Considering the limited resources, step-by-step improvements in the urban sanitation are more appropriate than building up the expensive WWTPs and the extensive separate collection systems. Evaluating and prioritizing capital expenditures in the sector will be important as a major factor, since the sanitation progress has been the scale of wastewater projects and their high costs. The successful and sustainable urban sanitation improvement programs have generally relied on the extensive user involvement in planning and choice of service levels, scale of investments and charges, and cost recovery structures. The urban facilities should be installed after the consultation with users and should ensure the optimum benefits together with the resources for the ongoing O&M. Raising public awareness and education on the linkages between sanitation and health would support the success of interventions.

Kenya

In case of Kenya, although the GOK has established laws and policies in most of the key environmental sectors, the enforcement of these laws has been generally week.

BOX 5.3 : Effective Implementation of NWRMS and NWSS in Kenya

Effective government participation and coordination through the MWI

The GOK, through the MWI, shall be expected to play the lead role in the implementation of the water sector reforms including the two water strategies.

Operation of the established sector institutions

The water sector institutions, established under the 2002 Water Act, will be responsible for the implementation of NWRMS and NWSS through a management system whose approach is based on a decentralized management with well-defined linkages.

Engagement of NGOs and CBOs

NGOs and CBOs will need to be encouraged and provided with an enabling environment to ensure their active participation in the implementation of NWRMS and NWSS.

Participation of the private sector

A number of activities shall be undertaken to encourage the private sector participation in the reform implementation process.

Establishment of efficient and sustainable financial mechanisms

The efficient, effective, and sustainable financial mechanisms shall be established to promote the implementation of reforms and strategies.

Capacity building
This will involve the establishment of an efficient and productive workforce, also well-trained, motivated, and provided with adequate physical infrastructures and financial resources for the management of new institutions and the implementation of water sector reforms.

Promotion of applied research and technology
The promotion of applied research and the dissemination of findings in supports of sound water resources and services management will be necessary to achieve the sector reform agenda.

Appropriate nationwide campaigns, education, and communication
This will entail the promotion of national water campaigns and public education for the sound and sustainable water resources and services management.

Source: [51]

One of the issues that have always been cited as a key constraint for achieving the sustainable water supply and sanitation management in Kenya is the inadequate financial resources and inappropriate financing. In addition, the lack of accurate and up-to-date data over the years has made it very difficult to reliably establish the exact funding requirements for the sector. Therefore, the GOK has begun (in 2005) an exercise to establish more accurate estimates by developing the basin based water management approach. Based on this approach, it will be possible to develop a more reliable and up-to-date breakdown of infrastructures and other funding requirements.

The water and sanitation services in Kenya has been hampered by the inefficient management and the lack of proper facilities and trained staffs in government. To overcome these challenges, the Kenyan government is pursuing the water sector reforms. The Water Act 2002 was enacted in March 2003 to give the government the legal framework for implementing the reforms. Under the Act, the role of government is redefined to focus in the regulatory and enabling functions, while direct service provision and executive authority on the water supply and sanitation is devolved to a new institution-the Water Services Regulatory Board (WSRB). The Act further provides for the regulation of water provision services, which can only be undertaken under the authority for a license to service providers. The WSRB is responsible for regulating the water and sewerage services provisions, including issuing the licenses, setting up the service standards and guidelines for tariffs and prices, and providing the mechanisms handling complaints.

The Water Service Boards (WSBs), under the regulation of WSRB, are responsible for the provision of water services. However, the direct provision of services is to be undertaken by the Water Services Providers (WSPs) that operate as licensees of the WSBs, and these service providers may be community groups, non-governmental institutions, or autonomous entities formed by the local authorities. The Nairobi Water and Sewerage Company (NWSC) launched in August 2004 is the principal services provider to the city's three million people. Other water services providers have been licensed in Eldoret, Nyeri, Nakuru, and Kisumu. The NWSC will streamline the revenue collection by reorganizing the chaotic water billing system that has, for many years, been crippled by the corruption but is expected to generate a tidy surplus for investment and general improvements in the sector.

Ethiopia

The GOE has developed and implemented many policies and programs to increase the water supply and sanitation coverage, even though the progress has been very slow over the last 30 years. The water supply and sanitation coverage has been increased only about 0.8 % and 0.2 % per year, respectively, since 1970 [101]. The water sector strategy (2001) suggests the followings as most important actions and measures, for the short term, to achieve objectives of the water supply and sanitation sub-sector:

BOX 5.4 : Important Action of Water Sector Strategy in Ethiopia

Identification of appropriate and reliable technologies
To identify the most appropriate, efficient, effective, reliable, and affordable WSS technologies, which are demand driven and show a great acceptability among the local communities.

Development of national standards, specifications, and design criteria
These should be rational, affordable, acceptable, implemental, and sustainable for design, installation, implementation, operation, maintenance, and inspection of the WSS systems.

Procedures and processes formation
To carry out routine and special operation and maintenance activities for different types of WSS systems.

Promotion and encouragement of water conservation
To promote and encourage the water conservation through such regulatory and demand management measures as water pricing and public awareness.

Development of progressive tariff system
To determine a 'social tariff' for the poor communities, which minimally covers the operation and maintenance costs, and to establish the progressive tariff rates in the urban areas, which are tied to the consumption rates and simple and easy to implement.

Development of advanced training plan
To develop a comprehensive and well coordinated training plan to strengthen the technical capacities of domestic professionals, both in formal and informal sectors, enabling them to deal with the different aspects of WSS systems.

Capacity building
To initiate a capacity building program to strengthen the capacity of water users associations so they may make independent informed choices and remain and serve as focal points in the WSS management structure.

Participation of stakeholders
To establish and legalize a process for the participation of all stakeholders to ensure the efficient management of WSS systems.

Appropriate nationwide campaigns, education, and communication
To pay a special attention to the role of women while establishing the community based structures for the local WSS systems management, and to make it mandatory to include the WSS services in future urban development plans, especially the housing schemes.

As shown above, most African countries are in similar situations in terms of water supply and sanitation. They are short for the financial resources enough to develop the water resources and sanitation infrastructure. They are also facing with the lack of human resources, the lack of relevant regulations and policies, and the rapid growth of urban populations, far exceeding the current capacity for water supply and sanitation and wastewater treatment.

5.1.2 Technical Sector: Existing Environmental Facilities

China

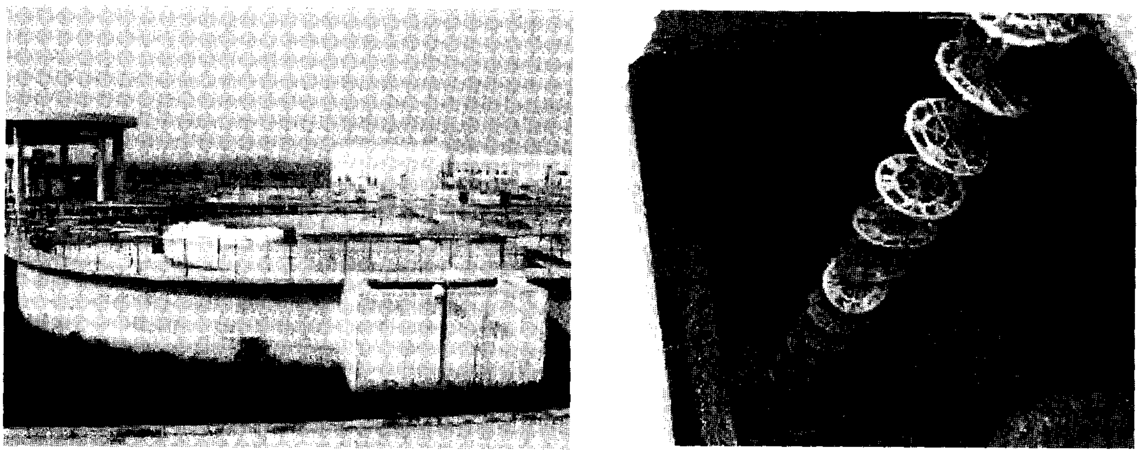
In case of urban areas, most big cities in China have a well functioning sewerage system comprised of sewers and wastewater treatment plants. Nevertheless, the existing wastewater treatment plants are still not capable of properly treating the wastewater, both quantitatively and qualitatively (while parts of the sewer network overloaded). As the survey showed previously, Shenyang has decent environmental facilities. However, only about 60-70 % of the domestic wastewater generated in Shenyang (1.57 million m^3) was treated at the wastewater treatment plants before discharged, and the rest discharged directly into Hun River, resulting in the seriously polluted water quality in Hun River. Therefore, how to deal with that amount of wastewater is a big issue, considering the great environmental pressures actually placed, in Shenyang.

The rural areas in China cover a large land, with two-third of the nation's population. The low educational and poor economic states make it hard to process self-protection and management. In the surveyed area in Henan, there was no wastewater treatment plant put into use as of 2004, and the sewer lines are not well organized. The big issue for the currently planned wastewater treatment plant is the collection system not included in the plans. For example, the feasibility study completed by Xiangcheng County in 2002 did not consider the wastewater collection system sufficiently. This will lead to serious problems after the wastewater treatment plant run.

As shown in the above survey, no wastewater treatment plants were built in those areas, and even when some plans had been set up, the application of those plans is doubtful, considering the financial situation and the low capacity of governance. The population in those 13 counties are predicted to be 1.7 million in 2010 [97], and 200 m^3 water (to be used in the prediction research as a experience factor) are generated in the township for one person every day. If calculated with the urbanization considered, more than 0.34 million m^3 of wastewater would be generated every day in the surveyed area. Then similar to Shenyang, how to deal with that amount of wastewater will be a big problem, considering the actual environmental pressures placed in Henan and the Huaihe River basin. In addition, no separate drainage system for wastewater and rainfall exists yet, increasing the difficulty of wastewater collection and treatment to some extent.

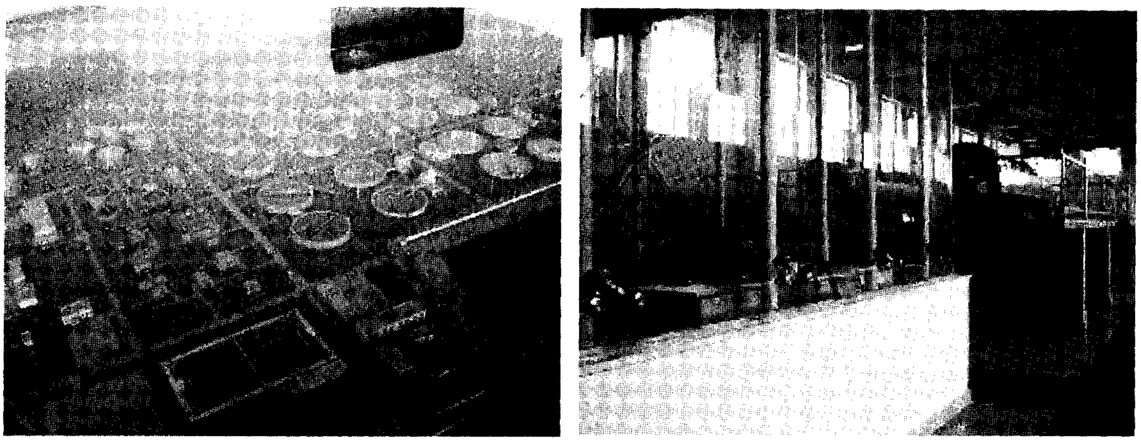
Gaochun, another surveyed area and a county in Nanjing, has one wastewater treatment plant, the Gaochun WWTP (capacity, 20,000 m^3/d) with the first stage construction finished. Despite the advanced wastewater treatment process was applied, this wastewater treatment plant was not functioning well as a wastewater treatment plant, due to the unprofessional operational manpower and the immature operation and management. (The operational personnel not possessed with any fundamental knowledge of the relevant environmental engineering and their management are not only a problem for Gaochun but also considered as a general situation for the wastewater treatment plants recently under construction in local cities and their suburbs). Yinghu Vacation Village, a large entertainment and meeting center in Gaochun County and located a bit far away from the town center, generates wastewater which cannot be connected all the way to the wastewater treatment plant due to the cost. Thus, this vacation center invested (total, 300,000 RMB) in its own wastewater treatment facility to treat the self-generated wastewater (Figure 5.2).

The total capacity of this facility is 3,000 m^3/wk, which can satisfy the discharge from this center. From this case, it is possible that not all the wastewater need to be collected together and some kinds of decentralized facilities can treat the specific wastewater by themselves. The cost can also be controlled to the acceptable level and the effluent can reduce the environmental pressure as well. As mentioned before, the sewer networks are like the blood vessels of human beings, thus without which, the wastewater treatment plants cannot be well run. For some reasons, the sewer networks were not well constructed or reconstructed compared to the construction of wastewater treatment plants, especially in small cities and towns. Some local governments have recently realized the importance of sewer networks construction and had the detailed plans to construct the sewer networks matching well with the operations of wastewater treatment plants. In some towns, however, still not enough emphases have been on the problems, probably due to the lack of financial capacities. For some areas in Nanjing, the sewer line was never worked well and only existed in open channels because of the narrow and crooked streets and the below standard housings and plumbing (Figure 5.5).



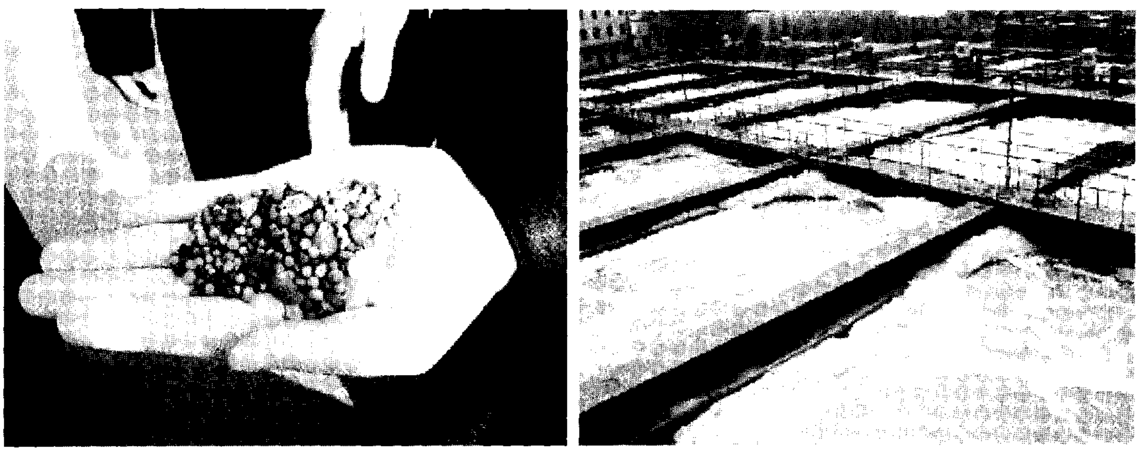
a) Main basin in Gaochun WWTP   b) Bio-media frame in Yinghu vacation village

Figure 5.2 Small-scale WWTPs in rural area (Nov. 2005)



a) Bird's-eye view   b) Control room

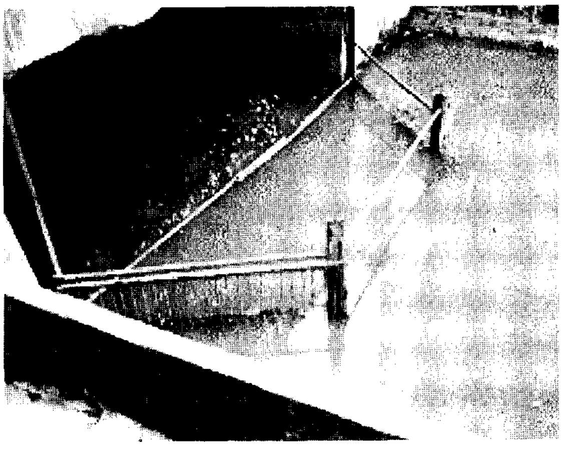
Figure 5.3 WWTP in the northern part in Shenyang (Apr. 2006)



a) Media   b) Aerobic basin

Figure 5.4 Shenshui estuary WWTP in Shenyang (Apr. 2006)

a) Outfall and open channel



b) Screen in open channel

Figure 5.5 Sewer systems in Nanjing (Nov. 2005)

Vietnam

Briefly, all the urban areas have no wastewater treatment plants and there are only local small-scale wastewater treatment facilities such as septic tanks, playing the role of wastewater treatment plant in the city. Especially, the old septic tanks with bad conditions and quality could easily leak the wastewater out, and many tanks have no accesses or holes, resulting in the sludge remaining inside from the beginning till now. In addition, the septic tank was not effective because not withdrawn regularly. According to the surveyed data by the Center for Urban and Industrial Environment Technology (Hanoi University of Civil Engineers), 60 % of septic tanks in Kim Lien show the sludge treatment efficiency of 30-50 %, 25 % with the efficiency below 30 %, and the remaining 15 % showing the efficiency of zero or below zero (the sludge content in wastewater output exceeding the input).

The drainage system in urban areas has an important relationship with exploiting and using such surface water resources as lakes, irrigations, rivers, and coasts, as the place to receive, keep, and drain the city wastewater, and to contribute to treat the wastewater in the combined drainage system by cleaning naturally. The typical drainage system in urban areas of Vietnam is the combined system which drains domestic and industrial wastewater and storm-water. This system was constructed with the main responsibilities of storm-water drainage, flood protection, and combining the wastewater to the sewer, so it has a small gradient. Most of them were constructed about 100 years ago, with the main responsibility of storm-water drainage. They had not been repaired and maintained, resulting in a bad condition at present. Moreover, repair and strengthening have not been complied with the long-term plan so cannot reach the urban development demands.

Currently, the storm-water from the combined drainage system is discharged with sludge and rubbish, and the untreated wastewater with large rubbish, organic substances, and heavy metals severely pollutes the water resources.

In Vietnam, those problems related to wastewater usually occur in dry season. With the contiguous ocean and the terrain featuring lots of rivers, the drainage system of the cities is mainly based on the crossing rivers or inner channels and then discharged to rivers and sea. The regulation and drainage ability of channels, ponds, and lakes played important roles in the drainage system, but have been reduced by the lack of rehabilitation and dredging. Almost no investments have been made to boost the construction of pumping stations. About 10 % of households in special cities and class I, 30 % of households in urban areas and class II, and others used toilets, 2 cells toilets, or public toilets. The septic tanks are too old, damaged, not repaired, and overloaded, and their sludge was untreated and pumped out frequently. There only exist some local small-scale wastewater treatment plants in the cities. The domestic, industrial, and medical wastewaters, even along with fecal and solid wastes were discharged directly to drainage system, ponds, lakes, and rivers. In such important cities as Hanoi, Ho Chi Minh City, Hai Phong, and Da Nang, the drainage network covers only 40 % of citizens, whereas the coverage is less than 30 % of inhabitants in other smaller cities. Even in the areas where the drainage network already existed, the service quality was still very bad. Once the flood occurred, the wastewater ran over road surfaces or unsanitary open channels.

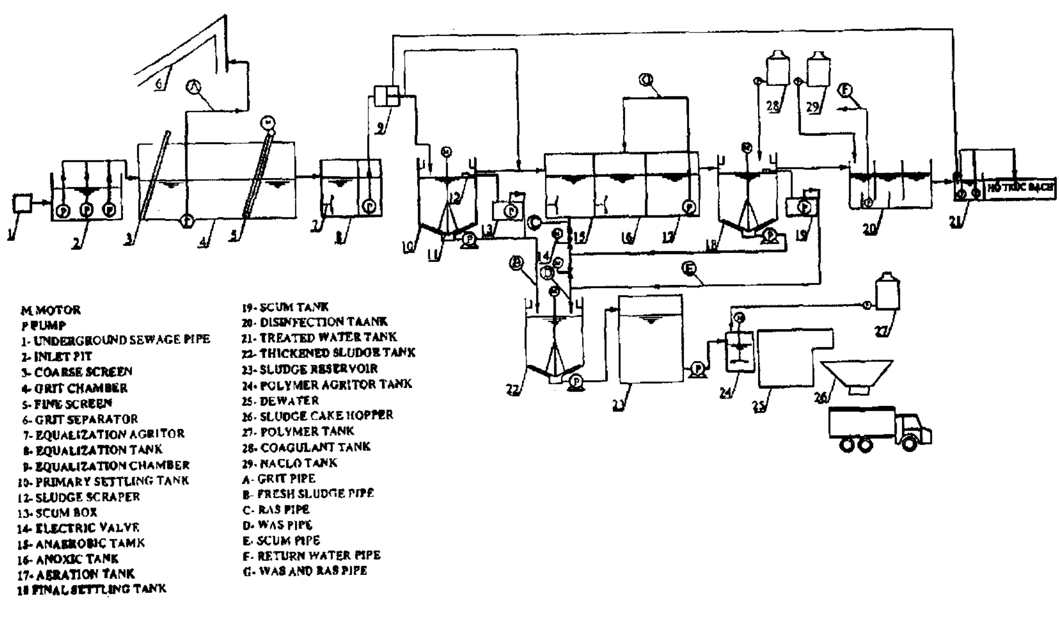


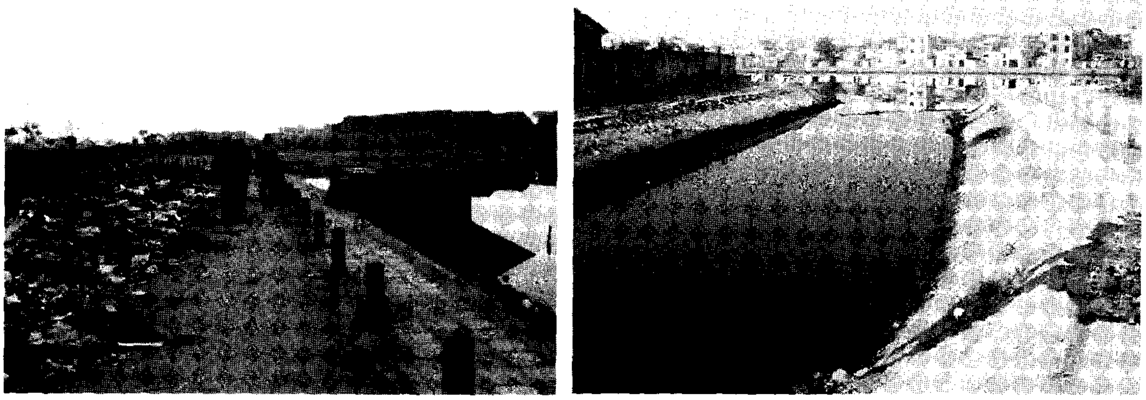
Figure 5.6 Schematic of WWTP (A_2O process) in Truc Back in Hanoi

Figure 5.6 shows the schematic of the Truc Back WWTP in Hanoi, which adopted the A_2O process, modified from the A/O process, for the nutrients removal. From the perspective of eutrophication control, this process is considered desirable for Vietnam for a long term. However, it should be considered that more wastewater treatment capacity is required for Hanoi because those existing wastewater treatment plants are overloaded. Currently, there exist not many wastewater treatment plants in Vietnam, except some will be constructed under new ODA projects or under the industrial zone project with such different technologies as stabilization pond, lagoon, conventional activated sludge process, and oxidation ditch. It will depend on the condition of each city, but in general the most important aspects when adopting technologies are the investment not very expensive and the cheap cost for operation and maintenance.

For the industrial zones, mainly constructed since 1994-1995, the organization of drainage system is same as the typical form throughout the world. The wastewater flow (200,000-263,000 m^3/d) from the service and industrial zones usually makes up more than 55 % of the total wastewater volume of Hanoi. This flow has separate characteristics depending on each industry, but generally exceeds the allowable standard of TCVN 5945-1995 and needs to be treated. However, only a small percentage of this kind of wastewater has been treated (4.4 % or 11,523 m^3), and the main reasons are as follows:

- There are still many industrial establishments using outdated production technologies.
- The industrial groups and enterprises are scattered everywhere.
- The investment in wastewater treatment is still perfunctory.
- The management measures and the treatment for violations are still ineffective.

Except for some communes surrounding the big cities, the existing conditions of environmental sanitation in rural areas of Vietnam are very poor. The sewerage and drainage system has been widely existed in Vietnam for a long time and mostly are the combined sewer system. However, during the field trip to rural areas, it was found the sewerage and drainage system was not well connected to any wastewater treatment facilities in many small cities. They discharge the wastewater directly to the surface water system through the open channels, contributing to the serious pollution. As previously mentioned, there are no proper sewerage systems such as sewers and treatment facilities but such on-site treatment systems as pit toilets and septic tanks are used as common sanitation facilities. Most households in rural areas use pit toilets and septic tanks, whereas only a few public buildings use toilets with modified septic tanks. According to the field survey result on rural areas, it was considered that there are strong needs to enhance the pollution control via any potential effective means, and among them the construction of a small-scale wastewater treatment plant is one of the most effective solutions.



a) Junk yard beside the lake b) Polluted channel

Figure 5.7 Environmental situations in Hai Phong (Nov. 2005)

Kenya

As mentioned in Chapter 3, the Waste Stabilization (WS) Ponds/Sewage Stabilization Ponds (SSP) system has been accepted in Nairobi. The SSP is a low cost sewerage treatment system that uses three mechanisms of anaerobic, facultative, and maturation ponds to remove organic matters and nutrients from sewage. In comparison, the M/B WS Ponds can be defined by the combination of mechanical and biological stages incorporating trickling filters, and consist of anaerobic pond, trickling filter, facultative pond, and maturation pond (see more details in Chapter 4). The sewage treatment occurs through the anaerobic digestion in 1st pond, followed by the aerobic degradation in 2nd, and finally algal activity and microbial death in 3rd pond. The ponds are occasionally, in every 2-3 years, de-sludged when there is sludge accumulation. The daily wastewater flow into the Dandora Sewage Treatment Works (STW) is about 250,000 m^3, with the domestic wastewater comprising about 180,000 m^3 and the rest industrial wastewater. More treatment capacity is required for Nairobi because those existing facilities are overloaded. Therefore, the measures for rehabilitation and expansion of the existing Dandora treatment works have been recommended to provide more treatment capacity and to meet the long-term sanitation access target for 2015.

Compared to other regions of Kenya, Nairobi enjoys a high access to the improved sanitation level, estimated at 99 %. Despite this high access level, however, the provision of sanitation in many parts of the city is still frequently affected because of the perennial water shortage. Depending on the socio-economic levels of various households, sanitation in the city is accessed through conventional sewerage, septic tank, pour flush toilet, ventilated improved pit toilet, pit toilet, and "flying toilets" [119]. The rest of the population mainly relies on such on-site sanitations as pit toilets and septic tanks. Unlike sewers, managing these on-site facilities is usually the responsibility of households. The pit toilets, whether improved or not, form the most common sanitary means for the excreta disposal among the city's low-income residential areas, as revealed by the Kenya Demographic and Health Survey of 2003. Many of them use communal or shared pit toilets, and in some densely populated slum settlements of Nairobi, many poor households still use the 'wrap-and-throw method' or 'flying toilets'.

The overall state of sanitation and health in rural areas has been very poor over the years, due to the lack of basic sanitation facilities and practices - lack of quality water, open sewers, disposal of waste and feces in open areas and drains, prevalence of stinking toilets, no rubbish collection, lack of public health facilities, and poor hygiene practices. Majority of the population in the remaining areas are exclusively served by such on-site facilities as septic tanks, pit toilets, and VIP toilets. The most commonly used facility, however, remains the pit toilets, available in all areas (Figure 5.9), and only a small portion of the population uses the VIP toilets (Figure 5.10).

Figure 5.8 Status of sanitation in Kibera slums (June 2006)

Figure 5.9 Pit toilet in Kibera slums (June 2006)

Figure 5.10 Community VIP toilets and water tank in Kibera slums (June 2006)

The existing situation on industrial wastewater in Kenya is not well documented. There is very little data available on the number of industries and the amounts of water used, treated, and discharged. From the perspective of sewer systems, the replacement of existing smaller diameter sewer pipes with relatively larger ones and the overall expansion of the sewerage network are recommended to improve the sewerage system.

Ethiopia

In case of Ethiopia, although located in the northern Africa, water resources are abundant. However, the population growth along with the rapid urbanization and the expanding slum to meet the current sanitation will all generate and increase problems resulted from the wastewater pollution.

In Africa, the problems related to the sewerage systems could be divided into the following situations. First is related to a non-technical situation. Most African communities desire raw waterborne sewage systems as their first choice, even though with the inadequate sanitation, resulted from the unavailability of adequate funds to provide this system to all in need of sanitation facilities. Therefore, these communities have developed an increasing interest in alternative technologies. Second is related to a technical restriction. In terms of water consumption in urban areas, a number of proportion are connected to the sewer ending up discharged into the municipal sewer, but the proportion of sewerage return flow in most areas is very low. In case of Ethiopia, the piped sewerage is not feasible because the systems require large volumes of water. Instead, the on-site facilities should be developed and promoted. These treatment systems such as pit toilets are the common sanitation facility in Ethiopia, except for Addis Ababa where only a few use toilets with the septic tank. These toilets sometimes overflow by flooding and the groundwater underneath may cause severe health problems. On the other hand, about 90 % of the rural population uses an open field for defecation and urination.

As mentioned in Chapter 3, the access to the sanitation facility is less than 19 % in urban areas and barely 4 % in rural areas, and the percentage of sewer connections in rural areas remains zero. Consequently, except for Addis Ababa and a few urban centers, the sanitation facilities are basically nonexistent. This is why it is feared that if poor people are added in great numbers, the resultant reduced sewer flows could upset the operation of the sewer system because of too little water to keep waste flowing.

5.2 New Guideline for Sanitation and Wastewater Management

As previously mentioned, the reasons why the developing countries have failed to control and manage the sanitation-related wastewater sector can be summarized as follows:

- Inappropriate institutional framework
  - Lack of relevant regulations and policies
  - Inadequate maintenance
- Inadequate financial resource and inappropriate financing; Funding limitations
  - Inadequate cost-recovery framework
  - Ill-equipped operating agencies creating continuous drain on government resources
  - Disincentive to governments and donors contemplating further sector investment
- Inappropriate designs and neglect of user requirements
  - Non-involvement of stakeholders
  - Problems in operation and maintenance due to insufficient experts
- Others
  - Insufficient health education and campaign efforts

In order to overcome and effectively control the low level of sanitation management in developing countries, the international communities, aside from each government within those countries, have set several goals and made some progress to achieve them. However, the progress has not yet been enough and too many things still remain to overcome these situations. Based on the result from this research, limitations and solutions to improve the level of sanitation management in developing countries are illustrated in Figure 5.11.

Although the field survey results cannot directly provide the standardized conclusions and guidelines, this report still shows the detailed investigation on how those environmental concerns are treated in developing countries. This chapter considers all aspects of planning, including politics and economics, to discover how the environmental factors influence on making plans and choosing alternatives for selecting the most appropriate technology.

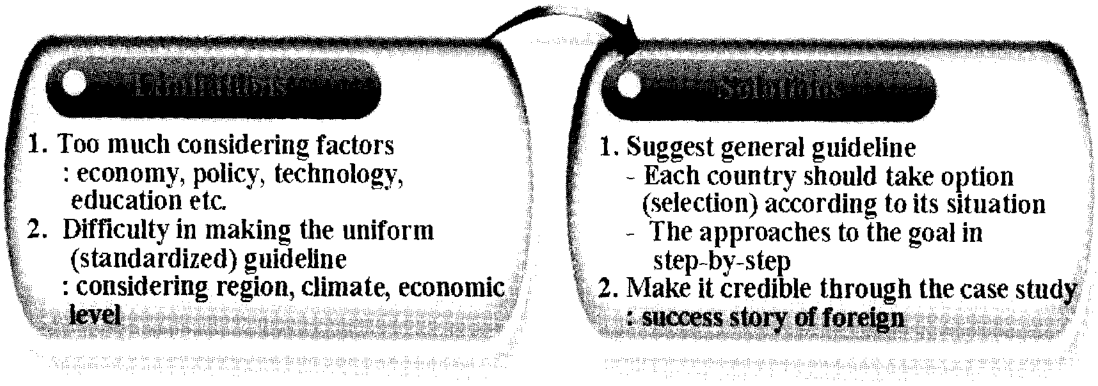


Figure 5.11 Limitations & solutions for sanitation management in developing countries

5.2.1. Development of Strategic Framework

In general, the initial demand for provision or improvement of sanitation and environment may come from various groups and communities such as local people, officials, and government departments. However, the larger projects needed for the strategic framework may depend on the government initiative or a local NGO. Thus, the government should be responsible for the strategic planning of the sanitation improvement and coordination. The most desirable way toward the master plan for sanitation improvements, in fact, should be carried out in accordance with the national or regional development plans by the central or local government within the country. Political leaders and decision-makers are needed to achieve the relevant goals and targets at different levels. To do so, the government must strengthen institutions and legal framework, secure sufficient financial resources, build capacities for the sanitation management, and equitably involve all stakeholders in the design and implementation of sanitation management plans and framework. From the viewpoint of scope and range, the sanitation-related wastewater management has been affected by the changes in socio-economic conditions and environmental situations, especially political will and willingness to pay. That is, the government and its politics will be based upon the perceptions on environment, encouraging the central and local people to have willingness to pay voluntarily in order to improve the environmental condition, which subsequently will lead to a better understanding of the sound environmental infrastructure.

In this research, depending on the field survey result for the respective research areas, a new strategic framework for the sanitation management in developing countries is proposed. This strategic framework has been developed to provide a practical guidance on how to develop the regionally appropriate and environmentally sound sanitation management. The main target groups of the guidelines are political leaders and decision-makers, regional organizations, and professional operators. The four phases of the strategic framework is illustrated in Figure 5.12. The strategic framework is generally key elements for the success of any organization in achieving its objectives. This strategic framework for the successful sanitation management covers financing resources, policy issues, and management approaches, especially the available technology selection.

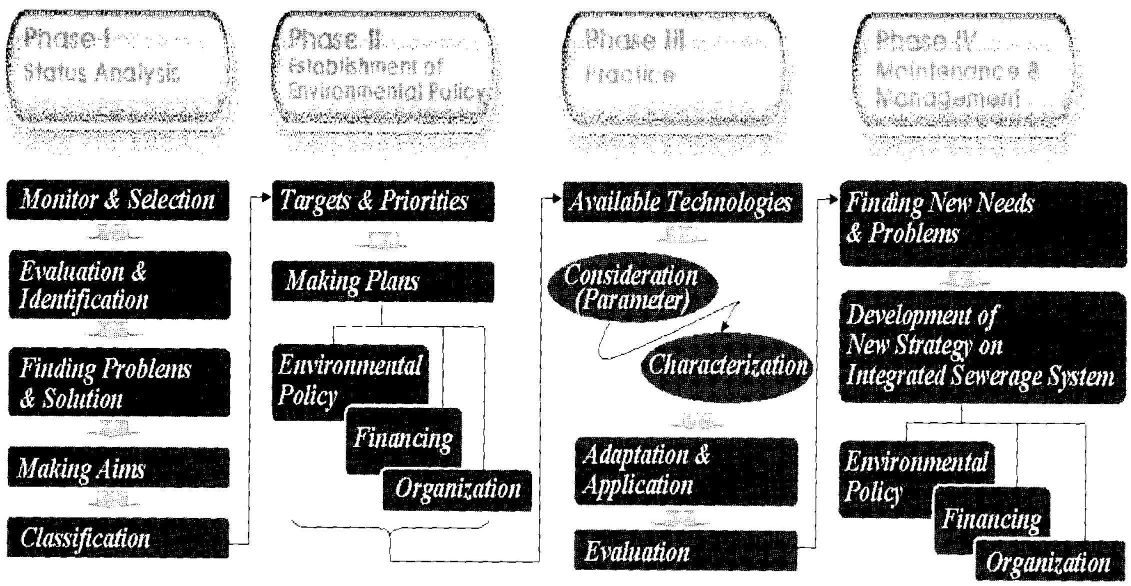


Figure 5.12 Procedures of strategic framework in developing countries

In phase I, the strategic framework requires an understanding of the current environmental situation. The organization is then able to establish making plans to manage its operations, along with its targets and priorities, which can be pursued to achieve the objectives. In phase III, on the other hand, practice and action for the sanitation management provide inputs to the organization's overall management plan prepared under the department of central and/or local government's guidelines. This strategic framework is intended to assist both political leaders and decision-makers at the regional level, in understanding the issues and making the informed decisions for the benefit of all citizens and stakeholders.

1) Phase I: Status Analysis

Governments, water companies, and regulators are all likely to play a role in providing for the public participation in Phase I (Figure 5.13). In this regard, the participatory, consultative, and consensus building methodologies are promoted so as to enhance the involvement of users at different decision-making levels. Before any plan and/or action for the improvement of sanitation management in developing countries can be decided, there is a need for the analysis of the current environmental situation of sanitation in each country. Based on the available information for the current environmental situation, some major problems facing sanitation could be analysed. Especially, the political leaders and the decision-makers need to be more active in compiling and analyzing the sector data. This information will then allow for better understanding and more informed decision-making on the sector policy.

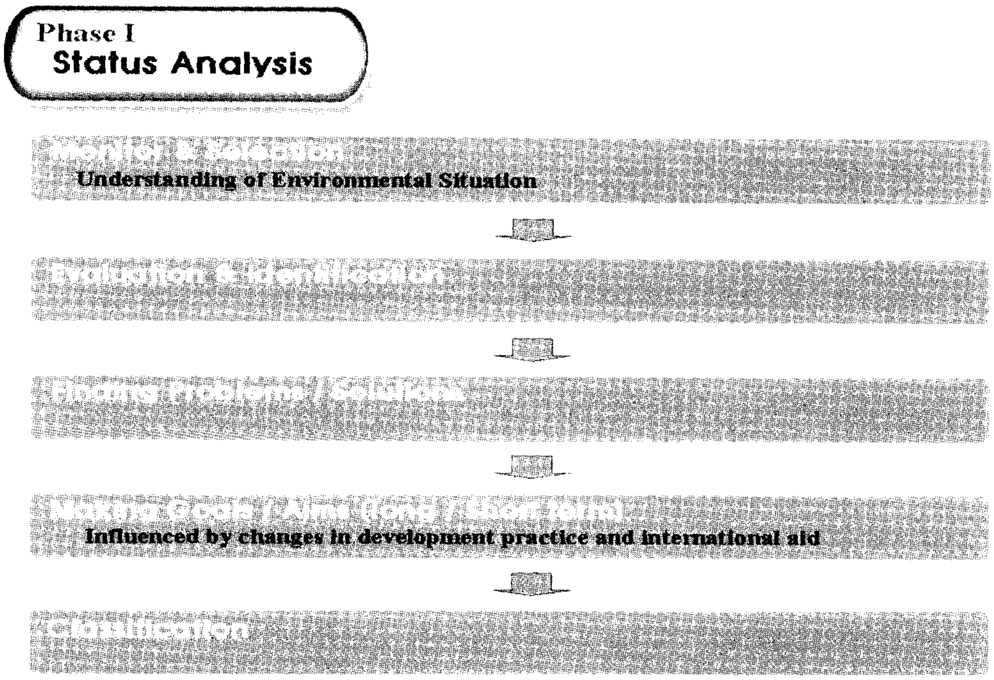


Figure 5.13 Procedures of status analysis in Phase I

The "Monitor and Selection" step is required to review the sub-sector and to develop and keep the updated comprehensive and reliable data. The mapping of access, providers, and institutional responsibilities will allow a better planning. In "Finding Problems and Solutions" step, the word "problem" involves the notion of 'unsatisfactory' for the current situation and the problems are the difference between the desired situation and the current situation. In general, the definition of problem also involves identifying goals, objectives, and constraints, leading to the process of delineating and evaluating the alternative plans. These goals, objectives, and constraints are sometimes termed "evaluative factors" [92]. In the next step, "Making Goals and Aims", the process identifying and making goals is often complex due to the number of affected groups such as a variety of stakeholders, since the technical and social decisions are closely interrelated. Above all, therefore, the importance of these groups should be recognized at the start of project. In order to establish firm partnerships, the continuous, targeted, and transparent communication among all groups is required [89]. 'Stakeholder' is defined as the people, groups, or institutions that are likely to be affected by a proposed project, or a house that can affect the outcome of the project. It has been increasingly recognized that whatever project to be truly sustainable requires the active involvement of civil society [102], [121].

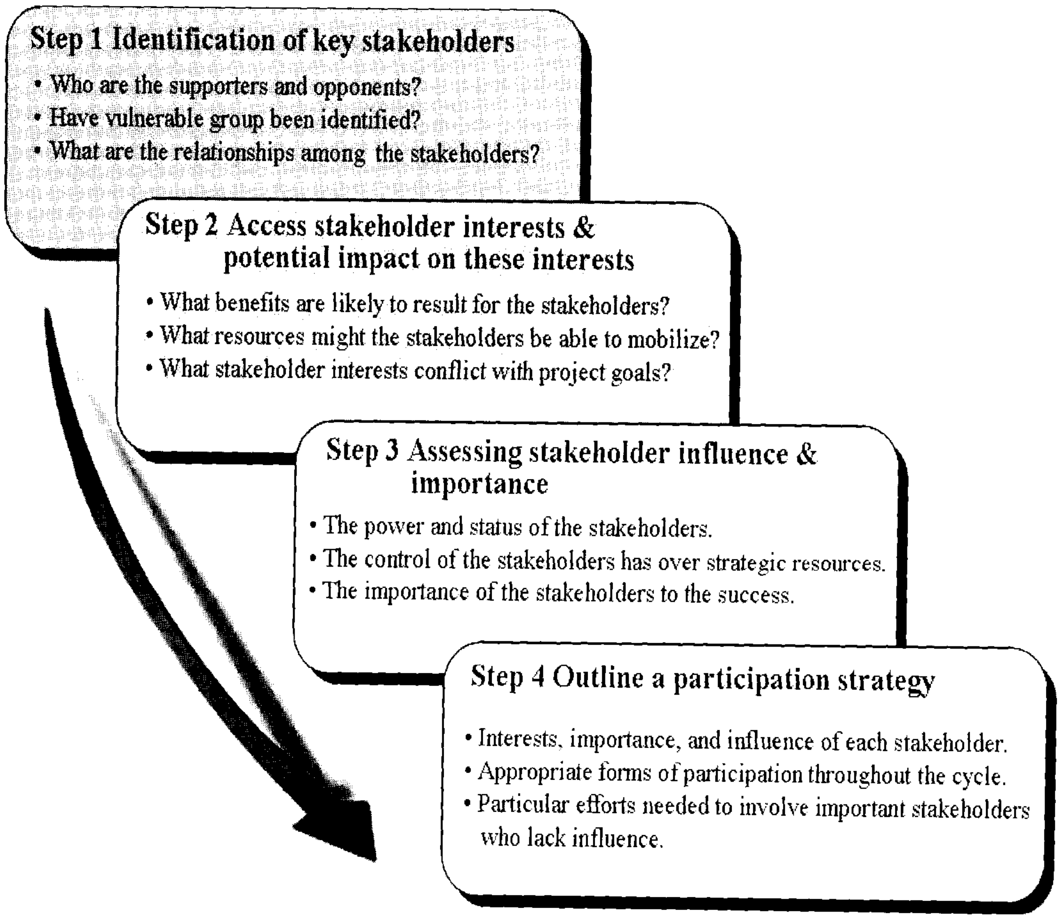


Figure 5.14 Steps of stakeholder analysis (source: [102])

Regardless of being an active or passive involvement, the public participation by the different stakeholders in the decision-making process introduces a range of ideas, experiences, and expertise that motivate the development of alternative solutions.

Benefits of the stakeholder involvement include the followings:

- Ensure transparency in management and decision-making processes
- Reduce conflicts and make wealth of information throughout the whole stages of the project
- Participate, as a partner, in building and improving infrastructures
- Provide administrative services

The appropriate approaches for involving stakeholders with various levels of influence and importance can be divided and listed, as shown in Table 5.2.

Table 5.2 Approaches for involving stakeholders

Position of stakeholder	Item
High influence / High importance	These stakeholders should be involved throughout preparation and implementation of the project
High influence / Low importance	These stakeholders are not objectives for consideration (But these groups could be involved, to oppose the proposed project)
Low influence / High importance	These stakeholders require special efforts to ensure that their needs are met
Low influence / Low importance	These stakeholders are unlikely to be closely involved in the project and require no special participation

Source: [102]

In this report, the stakeholder participation should be considered in the followings:

- To clarify the responsibilities of different agencies and to develop agreements and inter-agency procedures for cooperation
- To establish the coherent and clear lines of responsibility and accountability
- To develop and formalize the effective governance arrangements
- To consolidate the responsibilities for delivering the whole water services

2) Phase II: Establishment of Environmental Policy

As previously mentioned, the government is responsible for strategic planning and inter-sectoral coordination, including the collaborative efforts with development agencies, civil society, and private sector [89]. Both political leaders and decision-makers need to consider that the environmental policies and regulations often influence the decisions on major development projects such as construction of sewers and wastewater treatment plants in developing countries.

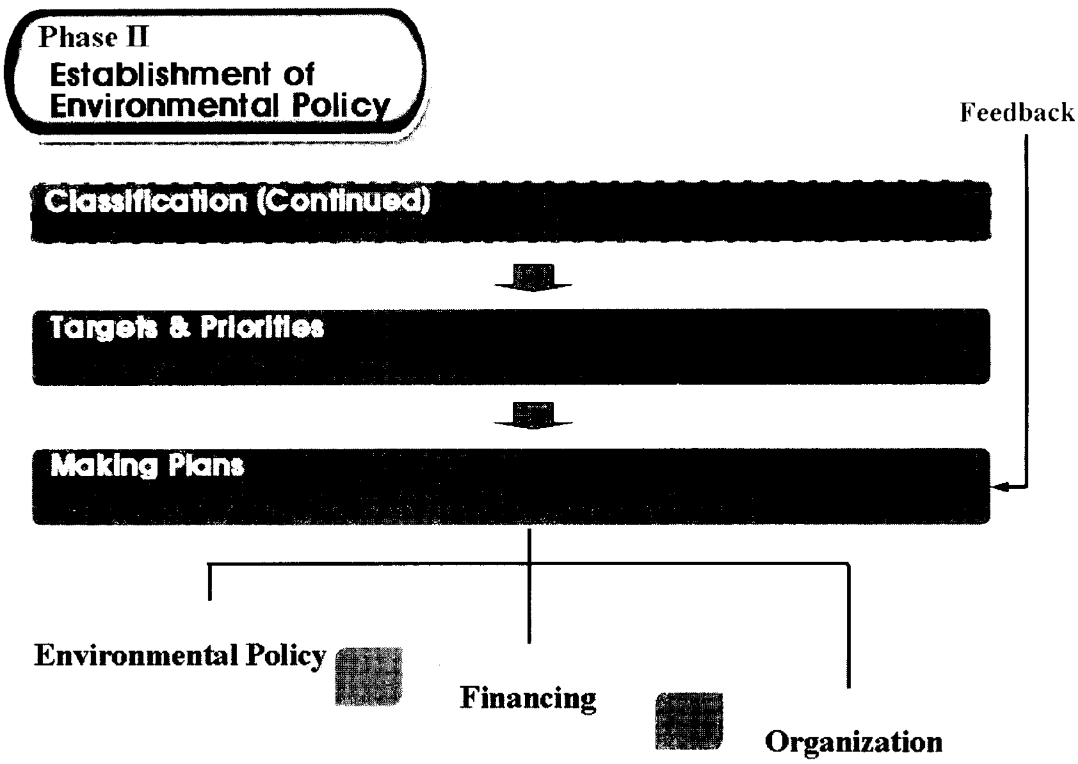


Figure 5.15 Procedures for establishment of environmental policy in Phase II

In the phase II, decision-makers or planning team should first undertake a comprehensive review of available data and information on the status analysis. After the status analysis is reviewed and evaluated, agency or decision-maker will set up targets and priorities for pollutants and areas, and develop a draft recommending new environmental policy. In "Targets and Priorities" step, the decision-makers or the planning team should consider the different targets and priorities in relation to the alternative options, and make rough assessments as to how the alternative scores for each of the selected targets and priorities. In the following "Making Plan" step, depending on the proposition, whether sound and sustainable sanitation-related wastewater management, a draft of the master plan should be established and carried out for the following objectives.

Environmental Policy Sector

Approaches and policies, including demand-driven, opportunity-driven, and integrated management approaches

Financing Sector

Financing options, including sustainable and economical allocation of water resources, and private capital and public-private partnership

Organization Sector

Institutional arrangements, including public participation and new partnerships, and technical options, including steps for choosing the most available technology for on-site treatment and sewage collection, treatment, and disposal

In this step, the developed plan should cover sanitation including both water supply and wastewater treatment. In addition, the number of facilities and people should be provided and served in each district on a yearly basis during the planning period, and the requirements for both internal and external funding should be considered.

In cases of low-income countries, the changes in development practice and international aid influence goals and priorities of the national project with respect to different sectors. Therefore, decision-makers and planning team in these countries must consider how the change is brought about and what changes made are important. In terms of tariff, the principle of financial mechanisms for the sanitation management should be divided and applied for the developing countries. In general, the employment of such principles as 'polluter pays' and 'water user pays' is required to achieve the sound and sustainable sanitation-related wastewater management with the efficient cost-recovery systems. These principles should thus be applied in an appropriate environmental infrastructure of such middle-income countries as China, compared to that of such low-income countries as Kenya and Ethiopia, because these principles need a socially acceptable way, considering solidarity and equitable sharing of costs by all citizens and facilities [89].

3) Phase III: Practice and Action

In the phase III, the decision-makers or the planning team should select the most available technology in accordance with the national or regional development plans. The financing may not be the determining factor limiting the selection of the most available technology, and also depends on the complex pattern of other interactions with the environmental situation. It may be the most desirable to select a range of treatment technologies within a particular group, from which the regional political leaders and the community decision makers can make a choice according to their own needs and priorities. It should be considered that each community including households could choose the most feasible and convenient technology to provide the protection of environment and public health in developing countries.

These considerations lead to the seven criteria that concern the selection and maintenance of available technologies in developing countries. Technologies ensuring that the human activities stay within finance limits and carrying capacity of each country should be selected. In selecting and developing the available technologies, there is a need to follow the seven criteria outlined below. These criteria can play key roles in determining the alternative plans for the available technology selection if they are introduced early in the planning process.

Criteria for selecting available technology

1. Simple 2. Doable 3. Easy to implement
4. Low cost involved in operation and maintenance
5. Trouble free 6. Need no operator or minimum
7. Sustainable development

In "Available Technology Selection" step, selecting the most available technology requires a thorough analysis of various parameters including the economical level of community, the social environment, and the cultural characteristics. Decision-makers and planning team need to consider that the most appropriate, efficient, effective, reliable, and available technologies should be identified prior to the technology selection. It is expected that the evaluation of past schemes could sometimes help this identification. For example, with the ever-increasing development of land, both suburban and rural, the large central sewerage systems have not always been cost-effective or available in unsewered areas in low-income countries. Many homeowners in these countries still rely on such individual on-site treatment systems as septic tanks to treat and dispose of household wastewater.

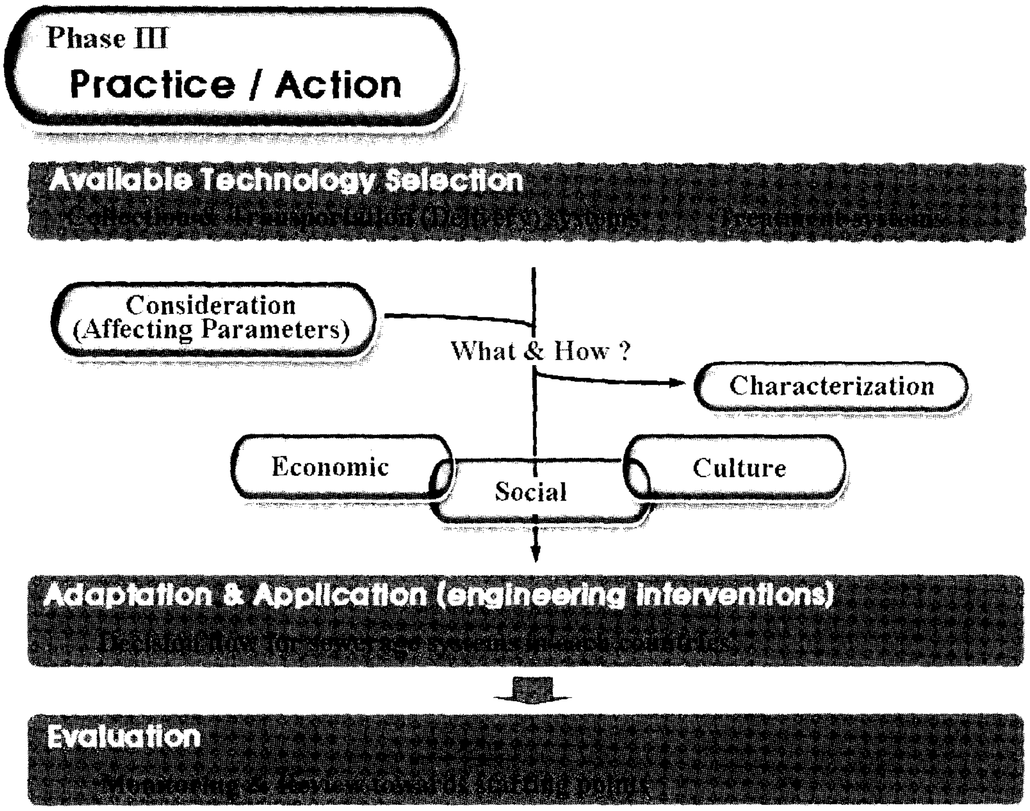


Figure 5.16 Procedures of practice and action in Phase III

What technology is the most available and when it is selected are decided in "What" and "How" step. Depending on the current status and plan within the countries, some criteria could be more important than any other parameters. The cycles in which the different stages of planning and development may be considered at various levels of sanitation are illustrated in Figure 5.17. Planning involves consideration of the various affecting parameters leading to the identification of specific sanitation goals. The stages of formulating the alternative plans, evaluating alternatives, environmental impact, and cost-benefit analysis, and selecting the available technology are carried out. Evaluation takes place on completion, and sometimes at the intermediate stages. If fully acted, the "What and How" step could lead to a shift to the available technology selection with the supply matching the demand and with the environmental impact minimized to be within the levels acceptable by the environmental and socio-economic conditions.

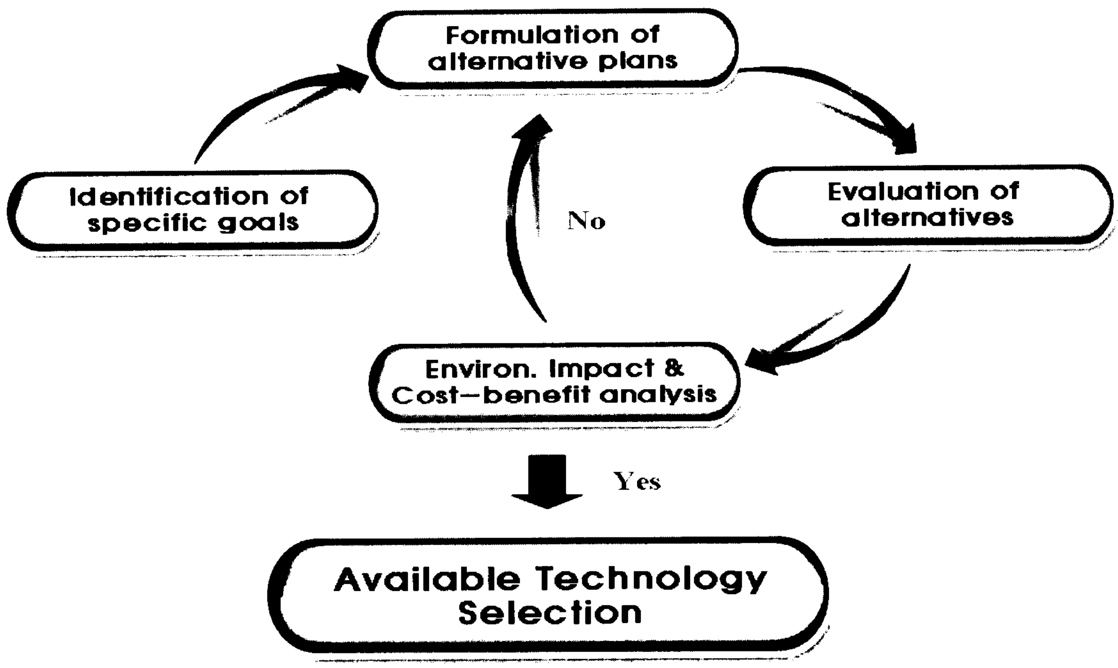


Figure 5.17 Components and procedures in "What and How" step

In order to improve the sanitation level in developing countries, the construction of wastewater treatment plants is a most viable option, but the water conservation, the efficient use of existing water supplies, and the development of new water resources must also be evaluated. At present, the water reuse allocation will usually govern the wastewater treatment needed, and the degree of reliability required for the treatment process and operation should be considered. Since the water reuse including the wastewater reclamation entails the provision of a continuous supply of water with the consistent water quality, the reliability of the existing or proposed treatment processes and operations must be evaluated at the planning stage of available technology selection [90], [114]. Practices of water reuse vary among countries, as the target applications and the technology options differ significantly depending on socio-economic circumstances, industrial structures, climate, cultures, religious preferences, as well as the policy readiness.

Selection principles for available wastewater treatment technology

- Priority given to the Environmentally Sound Technologies (ESTs)
- Determination of the water and sludge reuse after treatment
- Suitable utilization of the diluted river and seawater
- Simple O&M

Available Technologies Selection

The questions of what kind of technology is available and how this technology can best be introduced in developing countries are very important because the introduction of sanitation-related wastewater management systems is more important than the application of simple engineering techniques. From the viewpoint of technical sector, the knowledge on source control, collection, pumping, and transportation must be understood and studied by the decision-makers and the planning team, especially the technical expert team, if the truly integrated sanitation-related wastewater management systems are to be designed and practiced. The major elements of sanitation-related wastewater management systems and the associated engineering tasks are listed in Table 5.3.

Table 5.3 Elements of wastewater management systems and engineering tasks

Element	Engineering task
Wastewater generation	Estimation of the quantities of wastewater, evaluation of techniques for the reduction of wastewater, and determination of wastewater characteristics
Source control (pretreatment)	Design of systems to provide partial treatment of wastewater before it is discharged to collection systems (principally involves industrial dischargers)
Collection system	Design of sewers used to remove wastewater from the various sources of wastewater generation
Transmission and pumping	Design of large sewers (often called trunk and interceptor sewers), pumping stations, and force mains for transporting wastewater to treatment facilities or to other locations for processing
Treatment (wastewater & sludge)	Selection, analysis, and design of treatment operation and processes to meet specified treatment objectives related to the removal of wastewater contaminants of concern
Disposal and reuse (wastewater & sludge)	Design of facilities used for the disposal and reuse of treated effluent in the aquatic and land environment, and the disposal and reuse of sludge
Small systems	Design of facilities for the collection, treatment, and disposal and reuse of wastewater from individual residences and small communities

Source: [90]

The decision-makers and the planning team, especially the technical expert team, should be aware of the social, economic, and cultural context of engineering interventions. In this step, such decision-makers as government and local officials need some kind of technical matrix for making decision. An overview of the impacts of municipal wastewater on the environment and the optional methods for wastewater treatment are summarized in Table 5.4 and Table 5.5, respectively.

Table 5.4 Major contaminants of municipal sewage

Contaminant	Impact on the environment	Gross parameter
Suspended solids	Suspended solids increase the turbidity of water, reducing the available light for light dependent organisms like seaweeds, sea grasses, and corals. After sedimentation, suspended solids can cover benthic species.	TSS (Total Suspended Solids)
Biodegradable organics	Increased Biochemical Oxygen Demand (BOD) can result in anaerobic conditions which lead to fish death and bad smell (H_2S,NH_3).	BOD (Biochemical Oxygen Demand)
Nutrients	Although essential for the primary production, the excess of nutrients will result in eutrophication that will stimulate the algal growth, resulting in a strong oxygen production during daytime. Respiration during night and degradation of dead algae will lead to anaerobic conditions (killing fish). Eutrophication also stimulates the generation of nuisance and toxic algae (e.g., cyanobacteria, red tides).	N (Kjeldahl Nitrogen) & P (Total Phosphorus)
Toxic compounds	Can be concentrated in shellfish and fish tissues, resulting in unacceptable high concentrations for consumers (e.g., mercury pollution). Can interfere with microbiological processes in sewage treatment plants.	Activity tests of indicator organisms
Pathogens	Water-related diseases (e.g., gastro-intestinal typhoid, shigellosis, hepatitis, and cholera) are among the main health concerns worldwide. Can directly affect humans by causing illness and possible death. Contamination often occurs through the contact with water or food (e.g., irrigated agricultural products, fish/shellfish).	Bacteria (Faecal Coliforms 100 ml^{-1}), viruses, worm eggs

Source: [94]

Table 5.5 Optional methods for WWT

Treatment objective	Treatment process	Treatment method
Suspended solids (SS) removal	Sedimentation	Septic tank Free water surface constructed wetland Vegetated submerged bed
	Filtration	Septic tank Effluent screens Packed-bed media filters Mechanical disk filters Soil infiltration
Soluble BOD & ammonium removal	Suspended aerobic bioreactors	Extended aeration Fixed-film activated sludge Sequencing batch reactors(SBRs)
	Fixed-film aerobic bioreactor	Soil infiltration Packed-bed media filters Fixed-film activated sludge Rotating biological contactors(RBC)
	Lagoons	Facultative and aerobic lagoons Free water surface constructed wetlands
Nitrogen (N) transformation & removal	Biological Nitrification(N) and Denitrification(D)	Advanced activated sludge Fixed-film and/or filter bio-reactor Submerged vegetated bed Free-water surface constructed wetlands
	Ion exchange	Cation exchange (NH_4–N removal) Anion exchange (NO_3–N removal)
Phosphorus (P) removal	Physical/ Chemical P removal	Infiltration by soil and other media Chemical flocculation and settling Iron-rich packed-bed media filter
	Biological P removal	SBRs
Pathogen removal	Filtration/Predation	Soil infiltration Packed-bed media filters
	Disinfection	Hypochlorinate feed Ultraviolet(UV)
Grease removal	Flotation	Septic tank Grease trap
	Adsorption	Mechanical Skimmer

Categories of wastewater treatment technology and efficiencies of wastewater treatment methods are compared in Table 5.6 and Table 5.7, respectively. While there are certainly many sub-categories within each of these, it is clear that the wastewater treatment technology has an almost bewildering array of complexity, and it is beyond the scope of this specific research to address each of these individually. Instead, it is likely the duty of decision-makers and planning team to develop strategies for one or more of these technologies. In order to treat wastewater, it is necessary to treat the raw wastewater to meet the national water quality standards and public safety.

Table 5.6 Categories of the WWT technologies

Delivery Equipment Sewer lines & Channel Pumps Other *Biosolids Equipment* Dryers Dewatering Incinerators Other *Disinfection Equipment* Chlorination Ozone treatment UV/AOP Other	*Separation Equipment* Sedimentation Filtration Coagulation & Flocculation Membrane technology Liquid/gas *Destruction Equipment* Biological treatment process (including dynamic conditions) Enhanced Biological treatment process (including Membrane Bio-Reactor) Anaerobic digestion Thermal treatment Advanced oxidation process Other

Table 5.7 Comparison of effects of WWT methods

Item		Biological	Physio-chemical	Others (membrane)
Removal Efficiency	BOD	H	H	M
	SS	M	H	VH
	Color	L	M	H
	Odor	M	M	H
Operating / Management	Load variation	O	O	O
	Stability (long-term)	O	O	O
	Maintenance	easy	difficulty	easy
Equipment	Area	L	M	S
	Noise	decrease	M	X
	Odor	good	X	X
	Appearance	good	Good	excellent
Sludge Treatment	Sludge production	O	O	X
	Sludge characteristic	organic	inorganic	-
	Dewaterability	good	good	-
Cost	Initial cost	1	1 – 1.5	1.2 – 2
	Operating cost	1	1.5	1.5

Note) VH: very high H: high, M: middle, L: low efficiency O: existence, X: non-existence

From the viewpoint of public health, both decision-makers and planning team should consider that the most appropriate technology might be selected for the effective disinfection, based on the evaluation of advantages and disadvantages. The untreated wastewater may cause a serious risk of such water-borne diseases as cholera, typhoid, dysentery, plague, and helminthiasis. The use of wastewater for irrigation, not including the reuse of excreta as a fertilizer, may also contribute to the incidence of excreta-related diseases. In many countries where the demand for water is greater than the supply, the use of wastewater for irrigation can have a major impact on public health. Table 5.8 shows the removal of helminth ova by different treatment processes.

Table 5.8 Effect of treatment process on reduction of excreted pathogens

Treatment process	Helminth ova/eggs removal
Waste Stabilization ponds	Excellent
Waste storage and treatment reservoirs	Good
Constructed wetlands	Good
Primary sedimentation	Medium
Advanced Primary treatment	Excellent
Anaerobic up flow sludge blanket	Medium
Activated sludge + secondary sedimentation	Good
Trickling filter + secondary sedimentation	Good
Aerated lagoon or oxidation ditch + settling pond	Excellent
Tertiary coagulation flocculation	Excellent
High rate or slow rate sand filtration	Excellent

Source: [114]

From the technological point of view, the concept of 'available technology selection' could be divided into two sectors, on-site treatment and wastewater treatment. This division is based on the fact that the sewage management (related to the wastewater treatment) in underdeveloped countries is determined according to the free use of water (wash water) and the presence of established facilities for transport and treatment of sewage generated. Therefore, in order to select the technology applicable in underdeveloped countries, the individual technology selection tree divided by these two limiting elements is needed, which can be solved by utilizing the separate pre-decision tree (DT) for the available technology selection (Figure 5.18). The pre-decision tree proposed in this report provides aids to users, on selecting the optimal matrix group (DT

I vs. DT II) applicable in a region or country where the introduction of wastewater treatment technology is needed.

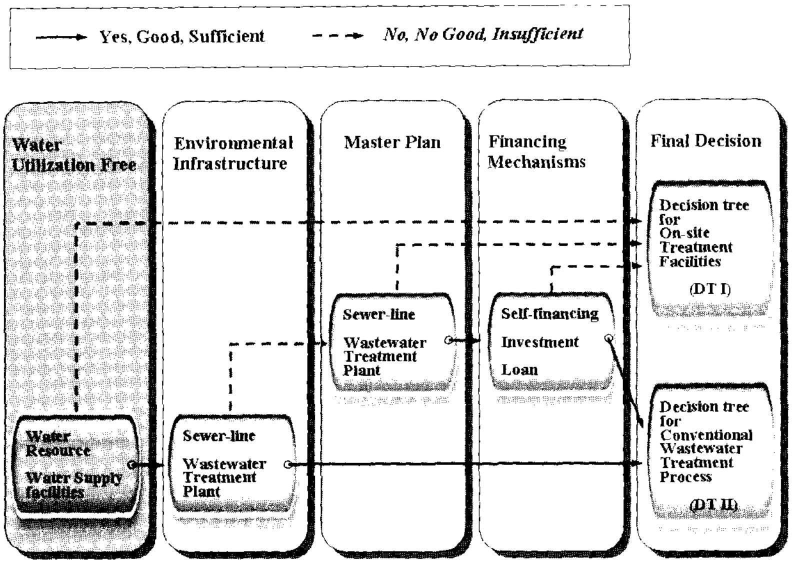


Figure 5.18 Flow in pre-decision tree (DT)

According to the field survey results, research areas widely vary in abilities of the economical investment and the time availability to improve the level of sanitation management, and have their own priorities. For the communities in African countries, there has been a considerable awareness for the problems of sanitation management, including the wastewater treatment and disposal, receiving less attention than the water supply needs, because the costs for the short term of an apparently "low-cost" system in this area may be too high when set against their need for food. Nevertheless, the WHO emphasized that the on-site disposal and treatment, dealing with excreta deposited, can provide a hygienic and satisfactory solution for communities in developing countries, lack of the adequate sanitation.

There are a number of alternatives and options to improve the level of sanitation and it is not possible to describe them all in this report. Thus, those planning on-site facilities and conventional wastewater treatment technologies should adopt and combine the major options described in a way that will produce the best solution. This section will combine the general information on on-site treatment and conventional wastewater treatment technologies, and the purpose is to provide the specific models the reader can use to craft their technology strategy for the available technology selection.

Technologies for the sanitation and wastewater treatment, like others, have been and continue to be developed. Although the design and construction of on-site sanitation facilities and conventional wastewater treatment plants are not covered specifically in this report, those materials presented in various references [90], [95], [96], [105] are applicable as well.

Selection of On-Site Sanitation Facility Using DT I

In 1986, the WHO study group formally adopted the meaning of sanitation by defining it as "the means of collecting and disposing excreta and community liquid wastes in a hygienic way so as not to endanger the health of individuals and the community as a whole" [96]. Although many methods are used to provide or improve the on-site sanitation, a new decision tree (DT) for the available technologies is proposed in this report, as shown in Figure 5.19. In order to get a clear overview of characteristics and capabilities and advantages and disadvantages, it is useful to use so called decision tree for the on-site treatment facilities (DT I).

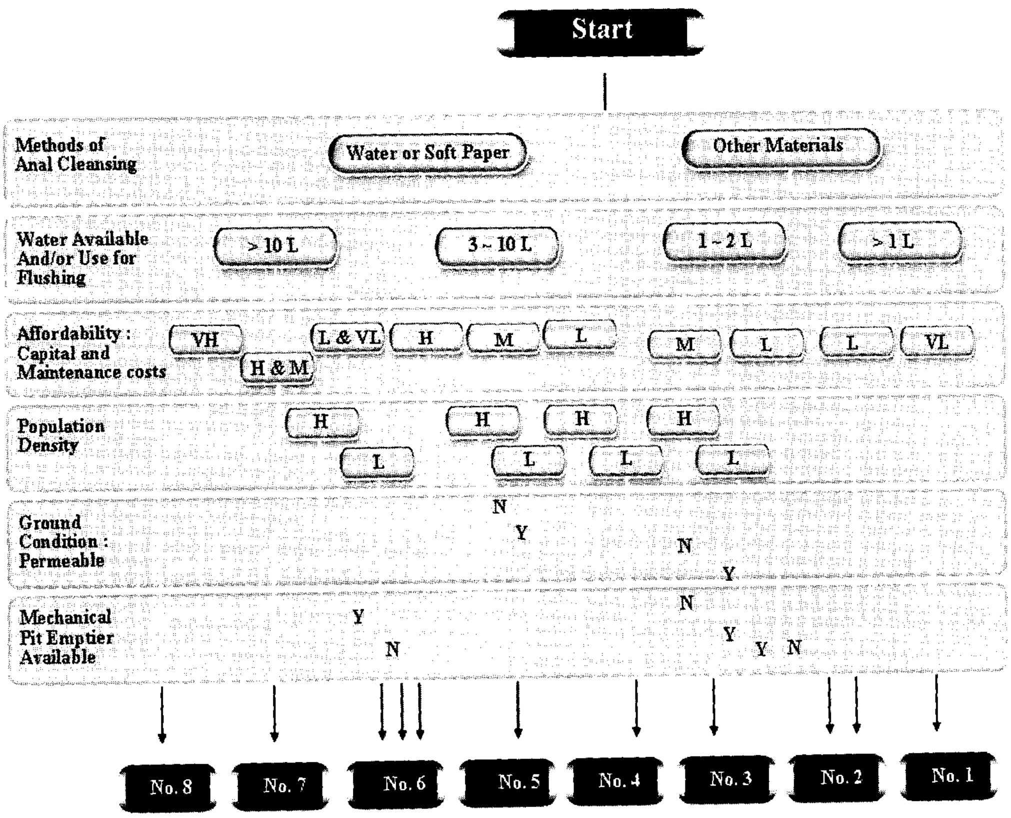


Figure 5.19 Decision tree I (DT I) for on-site treatment facilities (modified from [89])

The first limitation gives an overview of the different methods for anal cleansing, while in the second limitation, availability and quantity for the flushing water would be considered. The third limitation provides information and identification about affordability within the communities. For this identification, a three-point scale can be used, with five degrees such as Very Low (VL), Low (L), Middle (M), High (H), and Very High (VH). The fourth and fifth branches concern the information about population density and ground condition, respectively. Finally, the last branch provides the information of the mechanical pit emptier availability within the community. In this decision tree, the best available technology for on-site treatment that the decision-makers have divided and identified is entered. All the contents of this decision tree have been modified and developed from various technical reports and texts [90], [96], [102]. The classification of on-site treatment facilities is shown in Table 5.9.

Table 5.9 Classification of on-site treatment facilities

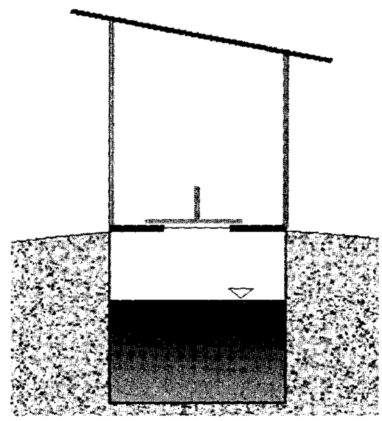
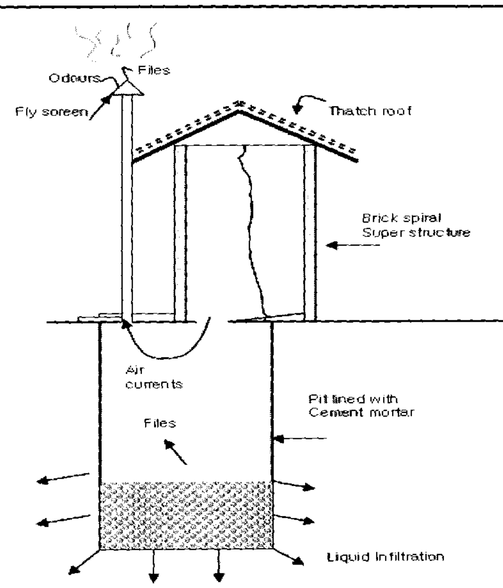
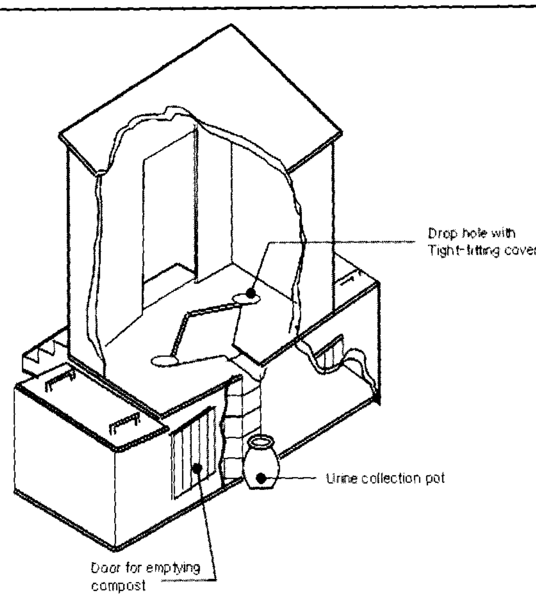
Class	Advantage/Disadvantage	Figure
1. Simple pit toilet	• Low cost • Can be built by household • Needs no water for operation • Considerable fly nuisance (mosquito nuisance if the pit is wet) • Smell	
2. Ventilated pit toilet	• Low cost • Can be built by household • Needs no water for operation • Does not control mosquito • Extra cost (vent pipe)	
3. Composting toilet	• A valuable humus is produced • Careful operation is essential • Urine has to be collected separately in the batch system • Debris must be added regularly	

Table 5.9 Classification of on-site treatment facilities (Continued)

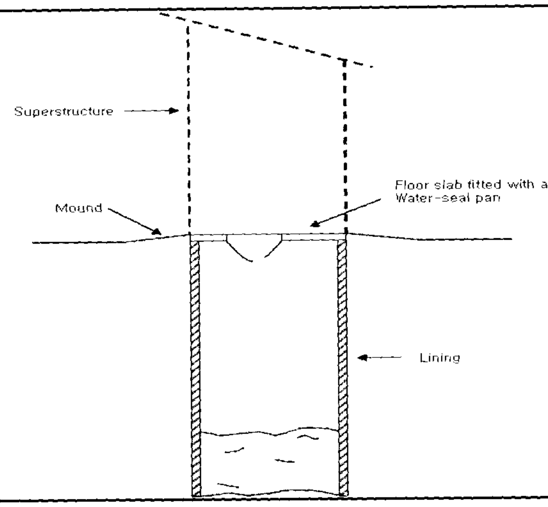
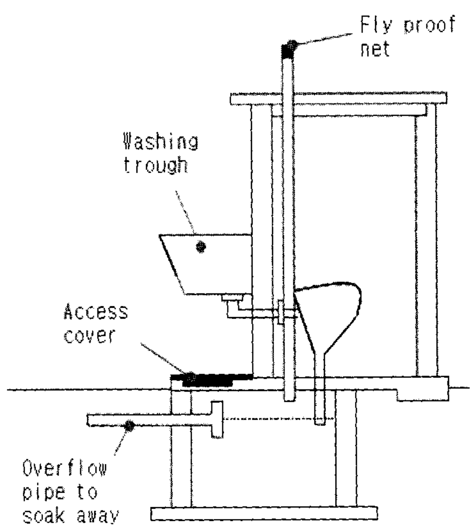
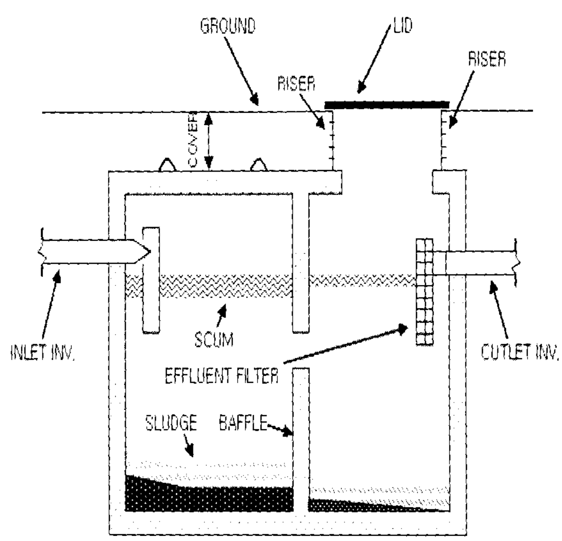
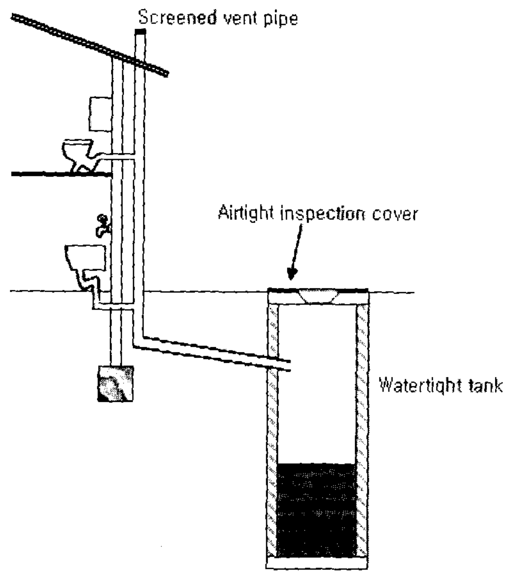
Class	Advantage/Disadvantage	Figure
4. Pour-flush toilet	• Los cost • Control of flies and mosquito • Can be in house • Absence of smell • Can be upgraded by connection to sewer • A reliable water supply must be available	
5. Aqua-privy	• Does not need piped water on site • Less expensive than a septic tank • Water must be available nearby • Regular sludge removal required • Permeable soil required to dispose of effluent	
6. Septic tank	• Gives the users the convenience • High cost • Reliable and ample piped water required • Only suitable for low-density housing • Permeable soil required	

Table 5.9 Classification of on-site treatment facilities (Continued)

Class	Advantage/Disadvantage	Figure
7. Cesspits	• Satisfactory for users (Under a reliable collection service)	
	• High construction and collection costs • Irregular collection can lead to tanks overflowing • Efficient infrastructure required	
8. Sewerage	• User has no concern after flushing • Treated effluent can be used for irrigation	
	• High construction costs • Efficient infrastructure required for sewer system • Ample and reliable piped water supply required	

Various types of on-site treatment facilities are widely used in most developing countries. Their health benefits and convenience depend on the quality of design, construction, and maintenance. In some parts of Africa, one of alternative technologies is the settled sewerage system, a system or network of pipes designed to convey the liquid portion of sewage to a central treatment and disposal point. The solids in sewage are settled out in a septic tank upstream of the pipe network. A vacuum tanker removes the sludge at intervals and transports it to the treatment works. It has been reported, however, that this system has some disadvantages as pointed out during its evaluation. There is a restriction in access to the septic tanks and the cost of emptying tanks could be substantial over time. In addition, there is still a lack of understanding of the system among operators. The small bore sewer systems are designed to receive only the liquid portion of household wastes for the off-site treatment and disposal. All the troublesome solids are separated from the waste flow in the interceptor tanks upstream of the connection to sewers. The accumulated solids are periodically removed for the safe disposal. These systems have been proven suitable especially to the following situations in the region. One is the sewered pour-flush toilet system and the other is the sewered septic tank system. Examples of such systems are abound in the peri-urban settlements of major towns and cities in the region; 30 % of Addis Ababa, parts of Greater Lagos, Kibera in Nairobi, and the squatter settlements of Gaborone fall into this category [98].

Selection of Conventional Wastewater Treatment Technology Using DT II

In many developing countries, the density of residential development has been increased to the point where the continued use of on-site treatment systems is no longer feasible. Under these conditions, some kind of conventional wastewater treatment technologies for middle- and large-scale wastewater treatment plants is needed, and the conventional activated sludge (CAS) process has traditionally been adopted worldwide. However, in many developing countries the use of CAS process may not be politically and economically feasible especially for the nutrient removal.

Choosing the available technology for different situations is one of the most important steps for the wastewater treatment plant construction. The available technology can not only improve the treatment efficiencies but also lower the disposal cost, whereas the unavailable technology perhaps will lead to the waste of money or the closure of plants. Therefore, the economic, financial, and technical feasibility should be carried out in accordance with the available technology selection. There have been many unsuccessful examples especially in small cities and towns in developing countries because of the improper technologies taken by the wastewater treatment plants, but still with a lot of high-cost technologies planned in small towns and villages in developing countries. It will perhaps lead to the enormous wastes of money, especially the cost for process operation and maintenance, in the coming years. Therefore, the decision-makers and the planning team should pay a great attention to finding the available technology and encouraging the research on such related infrastructures as sewerage networks. Figure 5.20 proposes a new decision tree for the conventional wastewater treatment technology selection that can be used when decision makers and planning team determine the appropriate technology.

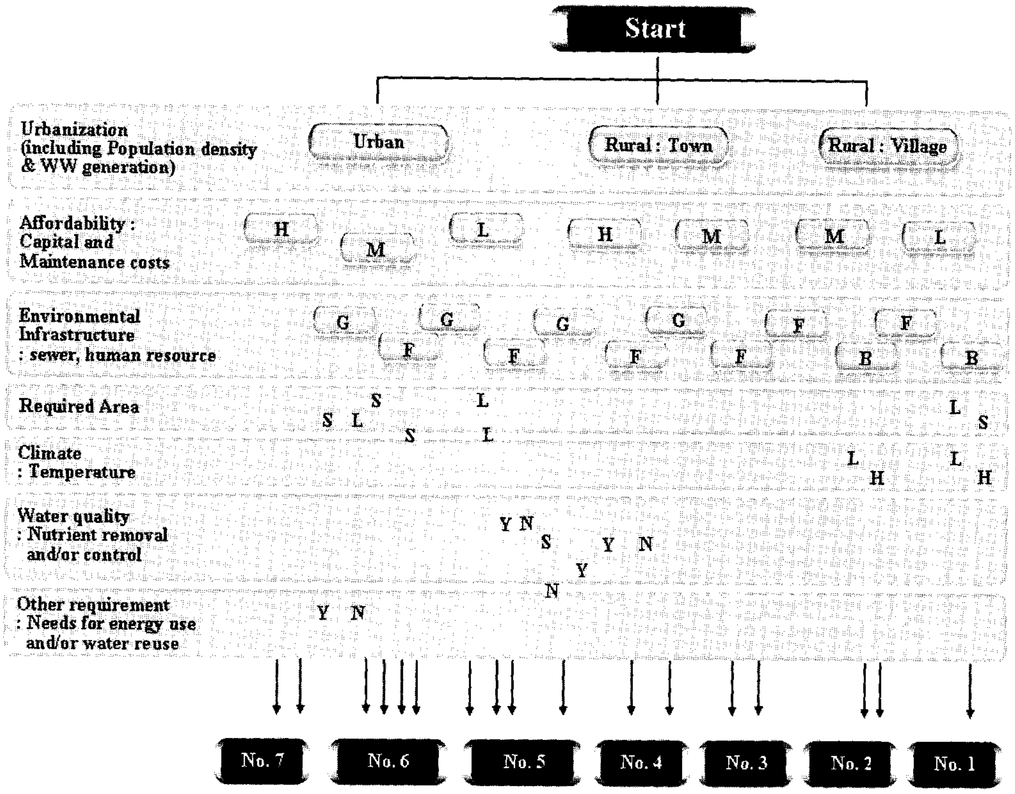


Figure 5.20 Decision tree II (DT II) for conventional WWT process

In this section, a number of conventional wastewater treatment technologies are introduced with brief descriptions for their suitability to particular situations, the constraints on their use, and their disadvantages. Table 5.10 lists the classification of conventional wastewater treatment technologies.

Table 5.10 Classification of conventional WWT technologies

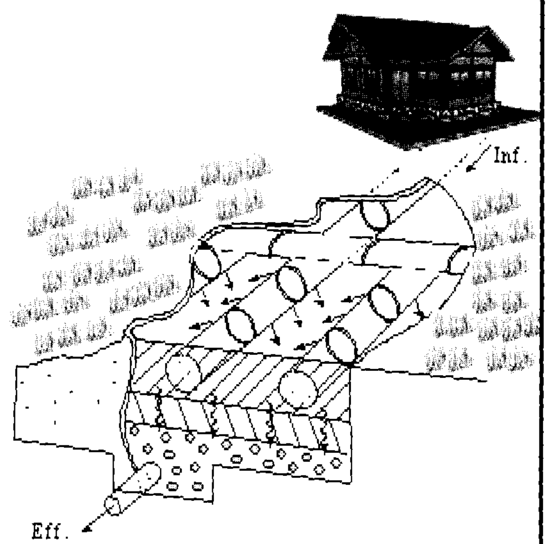
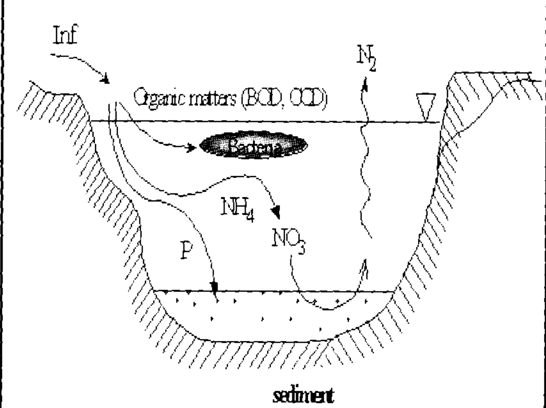
Class	Advantage/Disadvantage	Figure
1. 1st treatment	• Can be built by householder (Low cost) • Simple to operate & maintain • Less time to transfer solids	
	• Considerable fly & mosquito nuisance (Smell) • Extra cost (excavation) • Low solid concentration	
2. Soil trench (Natural Treatment System)	• Low cost • Can be built nearby village • No needs for operation • Absence of smell	
	• Does not control soil Conditions (soil pollution) • Extra cost (pore pipe)	
3. Lagoon (Natural Treatment System)	• Environmental friendly • Effective in treating WW • Low construction & operation costs	
	• Careful operation required • A reliable area • Long HRT • Other requirements (e.g., oxygen, temp., energy)	

Table 5.10 Classification of conventional WWT technologies (Continued)

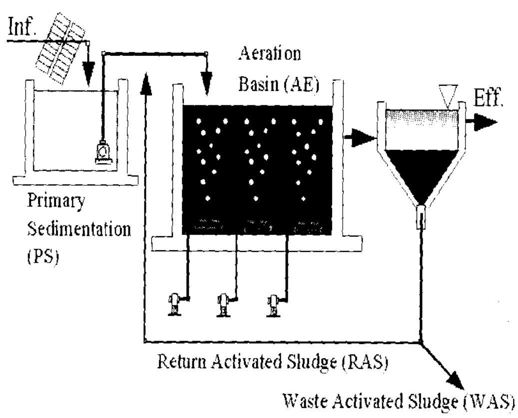
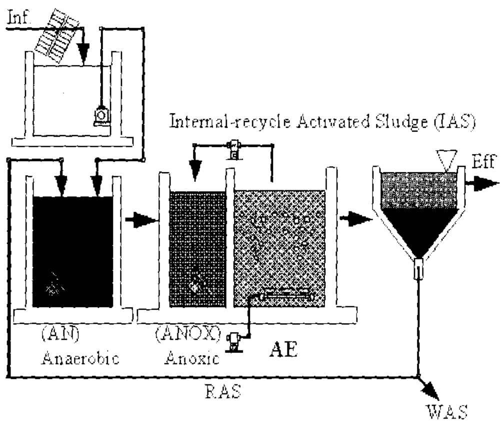
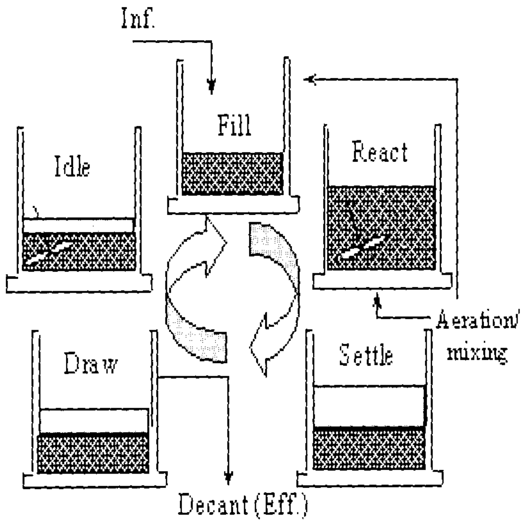
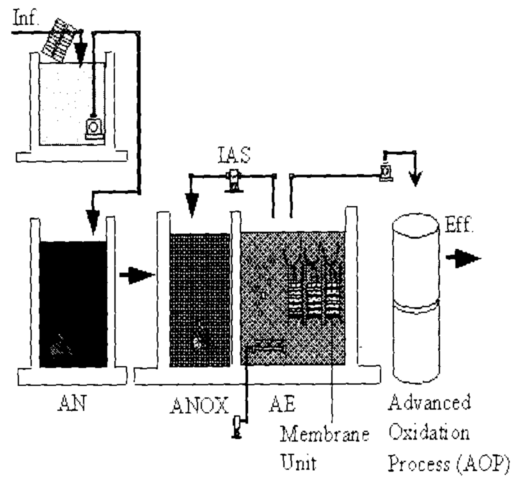
Class	Advantage/Disadvantage	Figure
4. Conventional activated sludge	• Control of BOD, SS • Absence of smell • Can be upgraded by hybrid technologies • Automated operation	
	• No control nutrient in WW • Efficient infrastructure • High energy requirement • High operation & maintenance cost	
5. BNR (type of continuous flow; A_2O)	• Control of nutrients • Absence of smell • Can be upgraded by hybrid technologies • High phosphorus contents as valuable fertilizer	
	• Requires a larger land area than the SBR type • Uncertain performance under cold weather • More complex than A/O	
6. BNR (type of batch; SBR)	• Operating flexibility and control • Potential capital cost • savings by eliminating clarifiers • Can be upgraded by hybrid technologies	
	• Requires a higher level of sophistication • Requires a higher level of maintenance • Suitable only for smaller flows	

Table 5.10 Classification of conventional WWT technologies (Continued)

Class	Advantage/Disadvantage	Figure
7. Advanced treatment (including MBR, AOP process)	• Control of nutrients & toxicity • Water reclamation • Cost-effective • Eliminate noxious odor • High construction & operation costs • Requires a higher level of sophistication & maintenance • Safety regulation required (Highly corrosive & toxic) • Increases in dissolved solids & compounds	

Note) MBR; Membrane Bio-Reactor, AOP; Advanced Oxidation Process

In general, the treatment of wastewater, including municipal and industrial, employs a combination of primary, secondary, and tertiary treatment. The preliminary and primary treatments are usually physical processes such as simple screening, and settle large particles and skim off floating grease and oils. The secondary treatment may utilize such biological processes as stabilization pond, trickling filter, oxidation ditch, and activated sludge, and removes organic matter and nutrients, such as nitrogen and phosphorus, in wastewater. The tertiary and advanced treatment is an additional treatment for the higher-level removal of specific pollutants to limit the microorganisms and other pathogens in the effluent by such advanced unit technologies as membrane filtration and some forms of disinfection using chlorine, ozone, and ultraviolet light [105]. A summary of the purposes and sample technologies of each treatment process is given in Table 5.11.

The advanced wastewater treatment is defined as the additional treatment needed to remove special materials and species such as nutrients remaining after the conventional secondary treatment [90]. Discharges containing nutrients such as nitrogen and phosphorus may accelerate the eutrophication of lakes and reservoirs. Therefore, the control of nutrients in wastewater, including the effluent of wastewater treatment plants, is becoming increasingly important in the water quality management. Since the early

1970s, lots of new advanced wastewater treatment facilities have been studied and increased significantly, especially with respect to the removal of nutrients from wastewater. The reactions involved in the biological removal of nutrients from wastewater can be conveniently classified into the removal of organic carbon, nitrogen, and phosphorus.

Table 5.11 Generalized sample technologies for WWT

	Purpose	Sample Technology	
		Low-Cost WWT	Conventional WWT
Preliminary/ Primary	Removal of big size solids and particles /Removal of SS	• Anaerobic ponds • Aerated lagoons	• Screening & Settling • Sedimentation
Secondary	Biological treatment & removal of common biodegradable organic matters in wastewater	• Facultative ponds • Maturation ponds	*Low-rate Process* • Stabilization ponds • Aerated lagoons *High-rate Process* • Activated sludge • Trickling filters • Rotating Biological Contactor (RBC) • Secondary sedimentation
Tertiary & Advanced	Removal of specific pollutants (nitrogen or phosphorus, color, odor, and specific materials)	Wastewater storage & treatment reservoirs for polishing and pathogens removal	• Chemical coagulation • Sand filtration • Membrane Bio-Reactor • Ozone treatment • Activated carbon

Source: [115]
Note) AN: Anaerobic, AE: Aerobic and/or aerated

In case of the CAS process, the organic carbon in wastewater is removed as either additional biomass or CO_2 gas in the aerobic basins. However, this process cannot remove nitrogen and phosphorus compounds present in wastewater. In comparison, the biological nutrient removal (BNR) process can remove these species efficiently. In order to remove nutrients, the BNR process is designed to provide dynamic conditions for microorganisms; nitrogen can be removed in a two-step process, nitrification and denitrification under the aerobic and anoxic condition, respectively, and phosphorus is also removed in a two-step process, so called P-release and luxury uptake under the anaerobic and aerobic condition, respectively. Therefore, the advanced wastewater treatment technology including the BNR process has been more considered in terms of the process operation and maintenance compared to the CAS process. The removal efficiencies for typical BNR processes are compared in Table 5.12.

Table 5.12 Comparison of removal efficiency for BNR processes

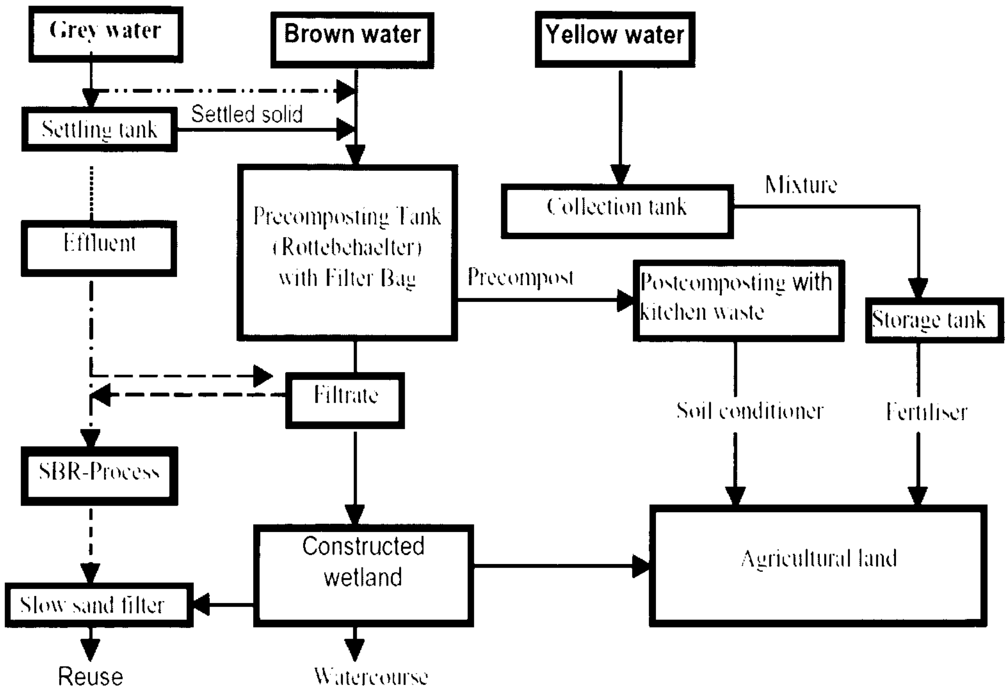
Items	Removal efficiency (%)							
	Bio-chemical		A_2O		SBR		Media	
	Min	Max	Min	Max	Min	Max	Min	Max
BOD	85	95	90	95	85	97	90	96
SS	85	95	85	99	85	97	90	96
TN	20	90	40	95	30	90	60	90
TP	10	95	50	96	30	90	50	90

BOX 5.5 : Case Study – The development of alternatives sanitation concept

Most low and middle-income countries have not yet really invested in the environmental infrastructure for sanitation. Below is an overview of alternatives which can be used to formulate a new strategic approach to the sanitation-related wastewater management.

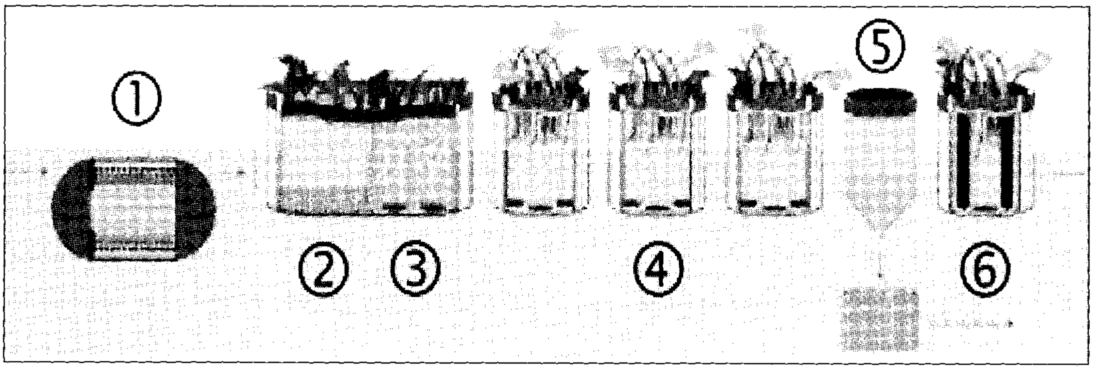
Source separation at household

"Don't mix – feces, urine, water" concept of Uno Winblad has given a new paradigm in sanitation. Larsen and Gujer proposed the collection of urine. A vision of separating household wastewater into three streams is based on the fact of very different characteristics of grey water, yellow water (urine with or without flush water), and brown water (toilet water without urine). The typical characteristics of the streams of household wastewater clearly reveal that urine contributes about 87 % of nitrogen, 50 % of phosphor, and 54 % potassium to the domestic wastewater, whereas grey water, despite its very large volume compared to urine, contributes only about 3 % of nitrogen, 10 % of phosphor, and 34 % potassium. Therefore, the domestic wastewater without urine avoids the costly nitrification - denitrification process. Furthermore, greywater can be treated with simple biological methods and reused for many purposes. Feces, which is 10 times smaller in volume than urine, contains high organics and pathogens which kill some millions of people annually worldwide. The source separation at household is based on the separation toilets with two bowls, front one for urine and rear one for feces, and many applications of the separation toilets can be found in Sweden.



Wastewater Treatment Technology - The Living Machine®

The Living Machine® is an emerging wastewater treatment technology that utilizes a series of tanks, which support vegetation and a variety of other organisms. The Living Machine® has sometimes been referred to as the "Advanced Ecologically Engineered System" or AEES. The Living Machine® incorporates many of the same basic processes (e.g., sedimentation, filtration, clarification, adsorption, nitrification, and denitrification, volatilization, and anaerobic and aerobic decomposition) that are used in conventional biological treatment systems. What makes the Living Machine® different from other systems is its use of plants and animals in its treatment process and its unique aesthetic appearance. From the analysis of cost comparison with "conventional" treatment systems, it is concluded that the Living Machines® are typically more cost competitive than most conventional wastewater treatment systems, at the flow volume up to 1,000,000 gpd, if they are located in a warm climate where a greenhouse is not necessary. However, if the climate cannot support the plants year-round and a greenhouse must be constructed, their construction costs will be increased. The addition of a greenhouse structure makes the Living Machine® more cost competitive than conventional systems, up to the flow rate of around 600,000 gpd.



(1) anaerobic reactor, (2) anoxic reactor, (3) closed aerobic reactor, (4) open aerobic Reactors, (5) clarifier, and (6) ecological fluid bed

Decentralized systems technology – Aerobic treatment

Historically, the aerobic treatment was not feasible on a small scale and the septic tanks were the primary treatment device, but the recent technology advances have made individual aerobic treatment systems efficient and affordable. Since the newer aerobic treatment units are pre-engineered and operated at a high level of efficiency, the effluent can be discharged to the subsurface as in a septic tank leach field, or, in some cases, discharged directly to the surface. One of the most common reasons to select the aerobic wastewater treatment units is to replace the failing septic systems, are a major source of groundwater pollution in some areas. If a failed septic system needs to be replaced or if a site is inappropriate for a septic system, the aerobic wastewater treatment may be a viable option. The installation costs for both suspended growth and fixed film systems of 1,892 and 5,678 L/d are typically in the range of \$ 2,500 to \$ 9,000, and maintenance cost, on average, \$ 350 per year. In addition, since many of these systems are being installed to replace the failed septic systems, the additional costs may be incurred to account for site conditions and additional piping.

Source: [102], [113], [114], [117], [118], [120]

Selection of Collection and Transport Technology

Sewerage is a water-borne human, domestic, and industrial waste, which cannot be prevented from arising in some form and is always objectionable. However, the sewerage and drainage systems are indispensable parts for the wastewater transport and disposal. They are often underground, thus the government, especially political leaders and decision-makers, sometimes put less emphases on them than on the wastewater treatment plants construction. In fact, they are like blood vessels of the sanitation management so could not be ignored. The collection and transport systems are defined as the carriage of wastewater from its point of origin to the treatment plants. There are two types of sewage transport system used worldwide, combined and separate sewer systems. In the combined sewer system, both wastewater and storm water are carried in the same sewer, whereas the separate sanitary sewer system is designed to carry only wastewater to the treatment plant and the storm water is carried in a separate storm water system and is not transported to the treatment plant. In general, the combined sewer system could be considered mostly appropriate in (i) the old center area in big city and (ii) the area where the street has a big slope, while the separate sewer system is adopted in a newly developed urban area or coastal area. It also depends on many other conditions such as characteristics of the urban master plan, the type to collect wastewater, and the natural condition. The main difference between two sewer systems is summarized in Table 5.13.

In some middle-income countries, as mentioned before, the density of residential development has been increased and the use of on-site treatment systems is no longer feasible. Therefore, some kinds of collection and transport systems are needed instead. Many different types of wastewater collection and transport systems exist as follows; conventional gravity sewers, small-diameter variable-slope sewers, pressure sewers, and vacuum sewers [90]. In fact, in case of developing countries, the cost for building the conventional collection and transport sewer systems can be prohibitive especially if the density of development is very low. The problems and solutions related to sewers are compared in Table 5.14, and further information on the combined sewer overflows (CSOs) and the infiltration/inflow (I/I) control methods can be found elsewhere [90], [106], [110], [111], [112].

Recently, in case of China, the separate sanitary and storm sewers are planned in many new districts built in the urban area, and the existing combined sewers are to be replaced with the separate sewers, through the infrastructure replacement and the sewer capacity upgrading programs, especially in large cities. In Vietnam, the combined sewer systems exist widely in most cities and towns in order to prevent and control flood under the rainy seasons, and it is clear that the reconstruction of sewers in urban areas would become a main issue of the sanitation management in the near future. Building another sewer system to collect the storm water usually requires a large amount of money, and at present, it is considered that the combined sewer system could be the most desirable and feasible solution in urban areas where with the excessive housing densities. The improvement of combined sewer systems in developed countries can provide some meaningful examples, as shown in Figure 5.21, implying that the costs for reconstruction are not so high and the effects are pretty good so it can be used in developing countries, especially Vietnam.

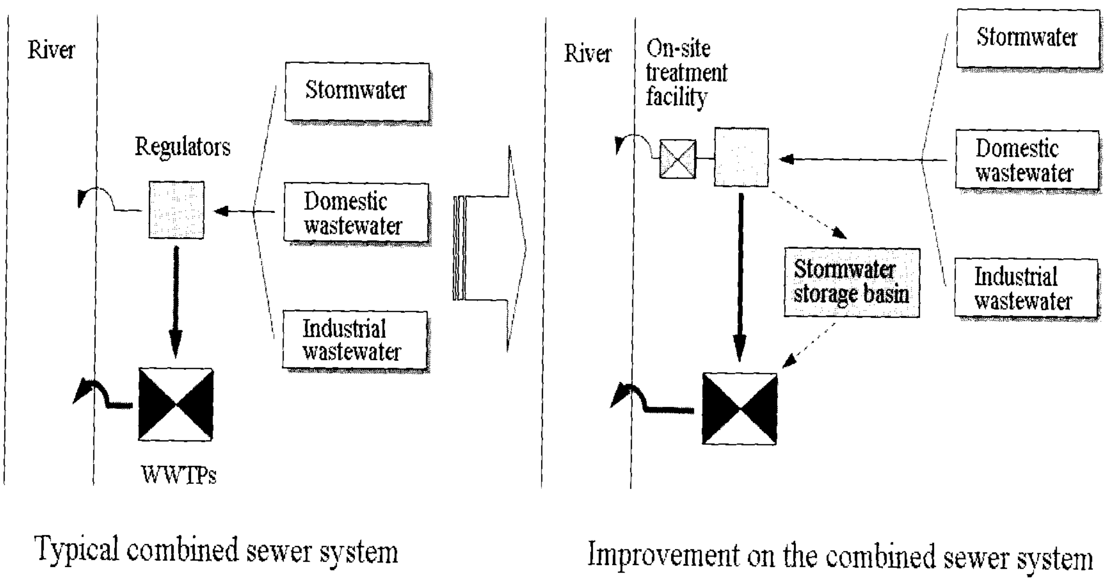


Figure 5.21 Improvement on the existing combined sewer system

Table 5.13 Classification and comparison of sewer systems

	Combined sewer system	Separate sewer system
Description	• Domestic and industrial wastewater, rainwater are collected & transported in a single sewer	• Domestic wastewater & runoff water are collected & transported in separate sewers
Application & constraints	• Appropriate for densely populated urban areas • When an appropriate receiving environment exists, which is capable of taking the surplus wastewater removed by the CSOs	• Suitable for large urban areas • If the area to be serviced is far way from the treatment plant, this system is more suitable than the combined sewer system
Advantages	• Single sewer to construct & manage • More economical operation & less frequent cleaning • Simpler and lower cost for individual connections	• Avoids the risk of wastewater overflowing into the nearby waterbody • Allows better control of flows & pollution concentrations • Better adaptation of capacity of the treatment plant • Easily expandable
Disadvantages	• Monitoring quantity & quality of discharges is more difficult • Bigger structures	• More expensive and complex due to two sewers installed • Collection of subsequent sewer work is more complex • Risk of the rainwater system to be incorrectly used by the local population

Table 5.14 Classification of sewer problems and solutions

	Definition	Control method
CSOs	Wastewater volume in a combined sewer system can exceed the capacity of the sewer system or treatment plant during periods of heavy rainfall or snowmelt. These overflows, called CSOs, contain not only stormwater but also untreated human and industrial wastes, toxic materials, and debris.	• Source control (best management practices) - Porous pavements - Flow detention - Area drain & roof leader disconnection - Runoff control (soil & solid) - Pollution control - Snow removal & deicing control - Sewer line flushing & identifying and/or eliminating cross-connections • Collection system controls - Complete or partial sewer seperation - Infiltration/inflow control - Regulating devices & backwater gates - Storage (in-system, surface and off-line) • Physicochemical & biological treatment - Filtration, vortex & disinfection
Infiltration/ Inflow	*Infiltration* : penetration of water through the ground surface into subsurface soil or penetration of water from the soil into sewer or other pipes through defective joints, connections, or manhole walls. *Inflow* : Entry of extraneous rain water into the sewer system from sources other than infiltration, such as basement drain, manhole, storm drain, and street washing.	• Source control - Sewer line monitoring & identifying - Eliminating cracks & cross-connections - Runoff control • Sewer re-construction • Sewer rehabilitation & renovation - Off line replacement (open cut, trenchless) - On line replacement - Repair - Renovation (structural, non-structural)

4) Phase IV: Maintenance and Management

From the viewpoint of environmental infrastructure nowadays, the sanitation-related wastewater management well planned and operated supports the public sanitation and related activities in developed countries. It is considered that the effective sanitation management is essential for maintaining the ecosystem integrity dependent on the concept of environmentally sound and sustainable development. In Phase IV, both technical and non-technical sector have been formed for maintenance and management (Figure 5.22).

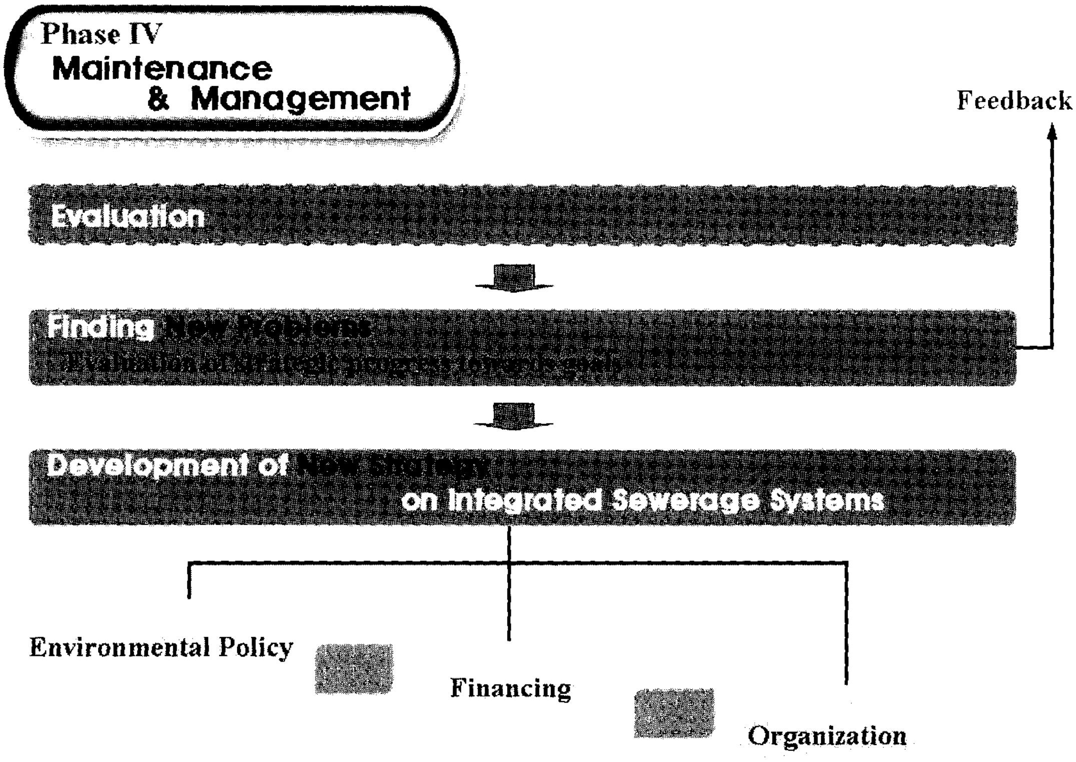


Figure 5.22 Procedures of maintenance and management in Phase IV

Point Source Control and Management: On-Site Treatment Facilities Management

According to the results from paper review and field survey, from the viewpoint of environmental preservation, many on-site treatment facilities in developing countries have failed prematurely, although the on-site treatment systems require very little management and maintenance. The reasons could be divided into no selection of available technology and no formation of on-site treatment facility management districts. When the on-site treatment systems in such small areas as towns and villages in developing countries fail, it can pose a serious problem and public health problems in some cases. To ensure that the on-site treatment systems will function properly in small areas, it is usually necessary to change the strategy on their management and maintenance, depending on the changes of public responsibility. The formation of special staffs, such as on-site treatment management districts, has been proven to be successful for this purpose (Table 5.15).

Table 5.15 Functions of special staffs for on-site treatment

Function	Responsibility
Approval and Inspection	Design and construction of on-site treatment systems
Issuance and Scheduling	Operation, monitoring, and maintenance

Point Source Control and Management: Process optimization

Nowadays, the skill of process operation, maintenance, and optimization is significantly more important than the construction of wastewater treatment plant, compared to the old days. The operation of wastewater treatment plants has to set a goal related to the effluent water quality and the costs providing the specific level of effluent quality. The quality of a wastewater treatment plant operation is commonly defined in terms of the effluent quality, measured as concentrations of pollutants in effluent, and the quality of the effluent is the degree to which the effluent meets the specification defined [119].

- Statistical process control (SPC)
  : The SPC is recognized as a generic tool for the quality management. It is used to monitor processes and to identify causes for the lost quality. The SPC is widely used to ensure that the processes are meeting standards.
- Basic statistical process control tools
- Advanced tools
  : Model based diagnosis (Steady state models, State estimation, Recurrent parameter estimation, etc.), Knowledge based systems (Alarm trees, Fault trees, Fuzzy logic, etc.)

Point Source Control and Management: Process Renovation and Retrofitting

Traditionally, the CAS process has been adopted for the wastewater treatment worldwide. However, this process cannot remove nutrients efficiently. For the purpose of nutrients removal, therefore, retrofitting the CAS process into the advanced treatment process, especially the BNR process, is on the increase. The term "process renovation and/or retrofitting" implies that some biological wastewater treatment processes need to be improved to perform a better nutrient removal with less cost but with better process stability. Depending on the effluent quality requirement, whether stricter or less strict, retrofitting requires a major change of the process system to ensure meeting the strict effluent standards, whereas a renovation requires a minor operational mode change in the system to meet the less strict effluent limitation [103].

In recent years, the desirability and benefits of water reuse including wastewater reclamation have been well recognized by several countries, especially the water shortage regions. In these regions, the uneven distribution of water resources and the periodic droughts have been forcing political leaders and engineering experts to search for the new sources of water utilization. In many developed countries, it is already an important element in the water resources planning. As shown in Table 5.16, the wastewater reclamation can be applied for various beneficial purposes such as agricultural irrigation, industrial processes, and groundwater recharge.

Table 5.16 Categories of water reuse

Category of reuse		Applications
Urban	Unrestricted	Irrigation of park, school yards and playgrounds
	Restricted	Irrigation of areas with infrequent and controlled access
Recreation	Unrestricted	No limitation on body contact
	Restricted	Non-contact recreational activities
Agricultural		Irrigation for crops, fibre, flowers
Environmental enhancement		Artificial wetlands creation and stream maintenance flow
Groundwater recharge		Groundwater replenishment & salt water intrusion control
Industrial reuse		Cooling and boiler system water and construction water
Residential use		Cleaning, laundry, toilet, and air condition

Source: [102], [116]

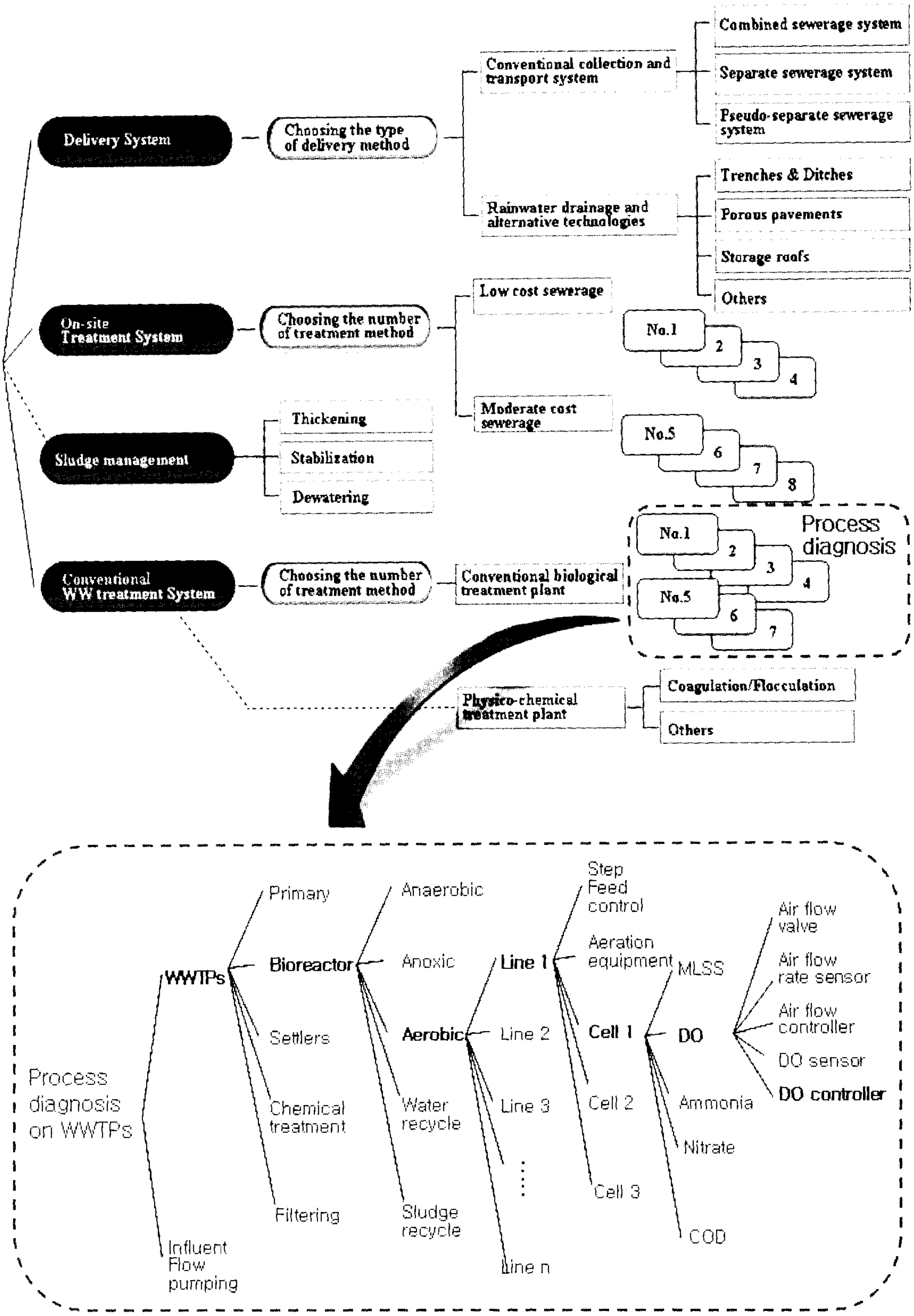
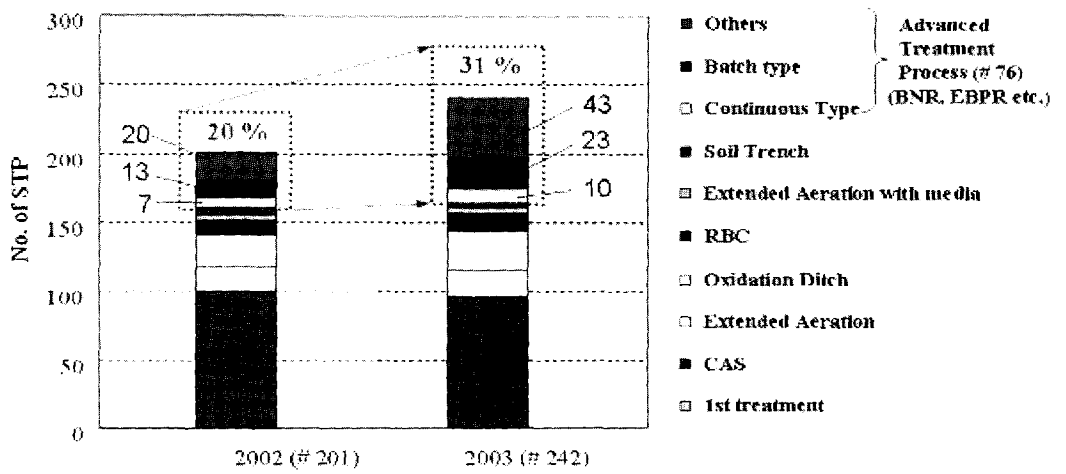


Figure 5.23 Summary of diagnosis categories

BOX 5.6 : Case Study - Need for the process retrofitting and renovation in Korea

In recent years, the various types of advanced biological wastewater treatment processes have been designed and some are under construction in Korea. In most municipalities, the CAS process has been adopted. In these processes, nutrients (N and P) are hardly removed. Therefore, the Ministry of Environment (MOE) has determined for a policy requiring the removal of nutrients from municipal wastewater. This policy mandates municipalities to convert the existing processes to an advanced tertiary treatment process through renovation and retrofitting. According to the MOE, as of 2004, 242 municipal WWTPs are in operation and 31 % (76 facilities) of them had been renovated or retrofitted to the nutrient removal process in Korea, and it is considered that this trend will be gradually increased.



Source: [95]

Point Source Control and Management: CSOs Control

Most of the time, the combined sewer systems transport all of their wastewater to a sewage treatment plant where they are treated and then the effluent is discharged to a water body. During the periods of heavy rainfall or snowmelt, however, the wastewater volume in a combined sewer system can exceed the capacity of the sewer system or the treatment plant. For this reason, the combined sewer systems are designed to overflow occasionally and discharge excess wastewater directly to nearby streams, rivers, or other water bodies. These overflows, called combined sewer overflows (CSOs), contain not only storm water but also untreated human and industrial waste, toxic materials, and debris (Table 5.17).

Table 5.17 Comparison of characteristics of CSOs (Unit : mg/L)

Parameter	Mecalf & Eddy [90]	ASCE [110]	Holbrook et. al [111]	Hajas et. al [112]
BOD_5	60-220	59-222	33-800	24-320
CODcr	260-480	264-481	98-2190	-
SS	270-550	273-551	72-5072	53.4-1055
T-N	4-17	4.3-16.6	4-17[a]	1.94-29.2[b]
NH_3-N	-	-	0.06-12	0.31-28.9
TP	1.2-2.8	1.23-2.78[c]	0.8-10	0.12-25.89 [c]
Oil & Grease	-	-	-	2.7-302
Phenols	-	-	-	0.009-0.42
Pb	-	0.14-0.6	0.14-0.6	0.21-1.1

Note) a: Organic-N, b: TKN, c: PO_4-P

Their presence in CSOs and the volume of their flows can cause a variety of adverse impacts on the physical characteristics of surface water, impair the viability of aquatic habitats, and pose a potential threat to the drinking water supplies. As shown in Table 5.14, there are a number of methods for the control and management of CSOs. Nowadays, they are a major water pollution concern for the combined sewer systems [109]. Historically, the control of CSOs has been proven to be extremely complex. In case of U.S.A., the EPA issued the National Combined Sewer Overflow Control Strategy on Aug. 10, 1989. This strategy reaffirmed that the CSOs are point source discharges subject to the National Pollutant Discharge Elimination System (NPDES) permit requirements and to the Clean Water Act requirements.

Point Source Control and Management: Practice of Sewer Management & Maintenance

Since the sewerage and drainage systems are mostly underground infrastructures, their constructions and maintenances become more difficult than other environmental infrastructures. Cleaning and inspecting the sewer lines are essential to maintain a properly functioning system. The sewer management and maintenance works are listed in Table 5.18, and further information on the sewer maintenance can also be found elsewhere [116].

- Inspection and investigation
  : For the sewers of 800 mm or larger diameter, an inspector enters the sewer to conduct the visual inspection, while the ones of smaller than 800 mm diameter, the CCTV is used as well as the visual investigation from manholes.
- Cleaning and dredging
  : The high-pressure water supplied by the cleaning vehicle is ejected from the nozzle to gather sand in the downstream manhole, followed by the collected sediment suck up.
- Repair and rebuilding
  : Repair means the replacement of a part of the target facility or the recovery of a damaged part of the facility.

Table 5.18 Categories of the sewer management and maintenance technologies

Category	Items
Grasp of present condition	Preparation of sewerage ledger, Petrol & inspection, Investigation of pipes, Investigation of inundation areas
Preservation of function	Cleaning, Urgent measures, and Repair
Improvement	Improvement work and Installation of public inlet
Safety management	Measures for safety, Preparation of safety equipment, & Training
Others	Permission and Public relations

Source: [107]

BOX 5.7 : Case Study – Sewerage Systems in Developed Countries

Currently, more countries or regions such as Australia, Japan, Korea, Hong Kong, Singapore, and Taiwan have separate systems for sewage in the new development areas. As development and urbanization have continued to increase, the pollution load due to the storm water overflow has been found to be significant as well. Many communities in the developed countries, therefore, provide some degree of treatment for the storm water overflows or to store storm water for treatment at the sewage treatment facilities.

Sewer systems in Australia

In Australia, the community collection system comprises a network system serving the individual household properties. The sizes of pipes, generally gravity ones, are such that the system can readily accommodate changes in the residential development densities. More recently, the vacuum collection systems have been introduced in West Australia. For local communities, the reticulation system conveys wastewater to a central treatment and reuse/disposal facilities. For large community systems, there is generally a main sewer system that conveys wastewater to a large central treatment and reuse/disposal facility. The main sewer system is developed as the catchment grows, and its capacity can be increased to accommodate the flows.

Drainage systems in Japan

Among two different systems for draining wastewater, the combined and separate systems, the combined system was developed first in Japan. However, to prevent the contamination of the receiving water, at present the separate system is primarily used. In Japan, it is common to establish a five-year medium term plan for structures such as sewers. The proportion of sewered population in Japan has been increased very quickly. In 1965, only 8 % of the population was sewered. By 1970, the sewered population had been increased to 16 %, to 36 % in 1985, and to 49 % in 1993. Based on the progress made during those previous successive five-year plans, the sewered population in Japan is now estimated to be about 65 %, and the total length is about 11,858 km, with sizes from 200 to 5,000 mm.

Sewer rehabilitation project in the Han River watershed in Korea

The purpose of this project is to spread the advanced sewer rehabilitation model which will be developed through the projects of 9 cities or counties in the Han River watershed and to help achieve the water quality standards in the Paldang lake by the comprehensive measures for the water quality management. The major activities consist of five parts; 1) establishment of projects through the investigation and feasibility study, 2) gradual installation of the sewer rehabilitation, 3) presentation of methodology and standards for the sewer rehabilitation, 4) accumulation of data related to sewers such as guideline, standard specification, etc., and 5) development of the advanced model by assessing the projects. Two different outcomes for the sewer rehabilitation were achieved; the improvement of influent water quality meeting the goals of water quality in the Paldang lake and other rivers, and the new model and guideline for the nationwide sewer rehabilitation.

Category		Total		'01-'05 (1st)		'06-'10 (2nd)	
		Budget (USD)	Length (km)	Budget (USD)	Length (km)	Budget (USD)	Length (km)
Total		1,233		681		552	
Construction		785	1,374	410	697	375	677
Rehabilitation	Sewer	235	188	176	151	59	37
	Drainage	213	82	95	42	118	40

Non-Point Source (NPS) Control and Management

The NPS pollutions could be defined as the pollutions not coming from an identifiable source but coming from many different sources such as urban runoff, farm, junk yard, and industrial complex [90], [104]. The NPS pollutions are generally caused by rainfall or snowmelt moving over and through the ground during wet weather periods (Table 5.19).

Others: Campaign & Education

In Phase IV, education and awareness of sanitation management and environment should be carried out, following 4 main tasks as below:

- To improve people's awareness through the public communication medium such as broadcasting station, radio station, television, newspapers, and magazines
- To carry out the public awareness campaigns such as anniversary of the world environment day, clean water and environment week, clean and green month, clean and green city, exhibit, pictures, etc.,
- To bring the environment education in the national education system
- To educate human resources for the sanitation and environmental management

Table 5.19 Source and pollutants related NPSs

Source	Pollutants
• Agricultural lands • Residential areas	• Excess fertilizers • Herbicides • Insecticides
• Urban runoff • Energy production	• Oil & Grease • Toxic chemicals
• Improperly managed construction sites • Crop and forest lands	• Sediment
• Irrigation practices • Abandoned mines	• Salt • Acid drainage
• Livestock & Pet wastes • Faulty septic systems	• Bacteria • Nutrients
• Atmospheric deposition • Hydromodification	

Table 5.20 Classification of NPSs control methods

Type	Method	Efficiency (%)			
		BOD	SS	TN	TP
Detention /Retention	Sewers, Artificial constructed wetlands; Detention ponds or vaults, Retention ponds, Wetlands	10-60	40-90	10-60	10-60
Infiltration practices	Infiltration trench and open channel, Pave	50-80	50-90	50-80	50-80
Vegetated open-channel practices	Lawn conversion, Grass selection, Mowing management, Fertilization, Weed control and tolerance	30-50	30-50	10-30	30-50
On-site facilities	Storm-filter, Storm-ceptor, Sand-filter, Swirl	20-60	20-80	5-30	5-70
Filtering practices	Wetlands filtration	65-85	70-90	15-40	45-80
Treatment Plants	Rapid coagulation and flocculation, biological treatment	80	85	20	85

6 Conclusions

According to the World Panel on Financing Water Infrastructure in 2003, $ 72 billion was needed annually to achieve the target on sanitation in the target year of 2015. Especially $ 56 billion out of this is required for the wastewater treatment alone, meaning that the amount is 4-5 times more than the one currently being spent worldwide. Also, there is an important difference between the rural sanitation component and the urban improved wastewater treatment component. In order to reduce this difference, the technology selection is crucial on the ground that the use of each different technology can affect the cost which is directly linked to the financial gap.

The available and sustainable technologies should be applied in different regions with different conditions in developing countries. When adopting the technologies, cost should be taken more into account than effectiveness, especially in the area with the weak financial capacities. The field survey result shows that there is a positive relationship between the financial capacities and the level of environmental conditions and the problems are serious especially in developing countries with a low-income and in rural areas. Figure 6.1 shows the cost estimates for different levels of environmental infrastructure and available technologies, from a basic level (left) to a higher level (right). Considering the limited resources, the step-by-step improvements in sanitation are more appropriate than building up expensive wastewater treatment plants and extensive sewer systems such as the separate sewer system.

The environmental gap between the urban and rural areas in developing countries has been shown become more increased and it is urgent to understand about this issue and find a solution. Unfortunately, there is no single solution to the problems of lack of sanitation management, because of a number of variations in economic, social, cultural, and physical characteristics in these countries. Instead, the common constraints on improving the sanitation in developing countries in terms of political, economic, social, and cultural conditions could be briefly summarized as follows:

- Inappropriate institutional framework
- Funding limitations
- Inadequate cost-recovery framework
- Problems of operation and maintenance due to the insufficiency of experts

- Insufficient health education and campaign efforts
- Non-involvement of stakeholders

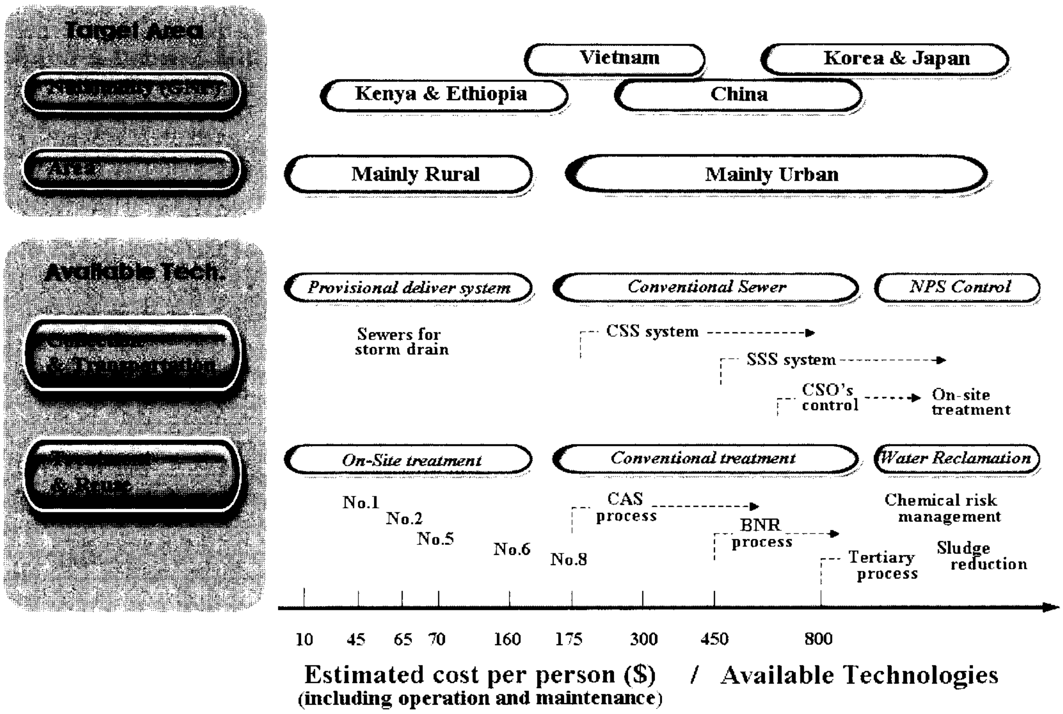


Figure 6.1 Summary of options for selecting the available technology (modified from: [108])

Figure 6.2 shows the 3 key points for the local and national action on the sanitation-related wastewater management. These major points are essential for the successful sanitation management in developing countries, especially focused on the sanitation-related wastewater management.

Traditionally, understanding the concept of sanitation-related wastewater management has been placed at the end of the water resource management chain. In order to strengthen the level of sanitation and environment in developing countries, the concept of integrating relevant institutional, technical, and costing issues of all major affecting parameters for the sanitation management chain should be required. In addition, consideration should also be given to the joint development, the management and/or delivery of drinking water supply, and the sanitation services [89].

Three Key Points for Local and National Action on Wastewater Management in Developing Countries

1. Secure political commitment and domestic financial resources

- Ensure financial stability and sustainability ***(Financing Mechanisms)***

2. Create an environmental policy at national and local levels

- make a long-term perspective, taking action, starting now ***(Policy)***

3. Adapt appropriate technologies

- efficient and cost-effective
- consider eco-technology
- link the sewerage business to other economic business
- make it credible through the case study
(Management approaches technology selection)

Figure 6.2 Three key points to consider for the new strategic framework

It is expected that actions and practices in each phase will have positive social and environmental effects on various communities in developing countries. The main benefits include:

- Public health and environmental improvements
  - Improved individual sanitation
  - Improved surface and underground water quality
- Increased domestic output due to the improved water resources
- Raising the output of agricultural, fish, and livestock production
- Other additional potential benefits include
  - The impact of making realistic charges for the wastewater services should help to encourage the waste minimization at source and reduce the costs for pollution control.

The measure of success should not only be the coverage of sanitation facilities but also the access, use, and upgrade of the whole environmental infrastructure including facilities, changes in hygienic behaviors, and self-sustained demand for more facilities. There is no doubt that improving the sanitation-related wastewater management including construction and management of environmental infrastructures in developing countries should lead to an improvement in public health, even though it is still difficult to ascertain whether the impact would be direct or indirect in the near future. Nevertheless, efforts to change the way of thinking toward the sanitation management and for the efficient management in developing countries should be continuously made. In this context, results from the investigation of current status and the strategic framework proposed here for the studied developing countries in Asia and Africa are hoped to be helpful to those people in charge of sanitation and environment in respective countries (Establishing the guideline for the sanitation-related wastewater management in these areas is expected to be also applicable to other regions in Asia and Africa).

APPENDIX

The Drainage HaNoi Project, Stage I (1995-2000)

The context of the project:

The drainage and water treatment system in Ha Noi built in French domination is downgrade and deteriorated, decreasing the transmission ability of the pipe, leading to the flood in urban areas. This affects badly to the environment and community heath and to the economic growth of the city. To solve this problem, this OECF - financed project will improve and build the drainage system to be a good one. Main ideas in the Drainage Master Plan (made in 1995 by Japanese International Cooperation Organization):

The size of the project

- The size of study area: 135.4 km^2 including two main basin: Nhue and To Lich Rivers.
- Serviced persons counted to the year 2000 are 1.899 millions, to 2010 are 1.597 millions (in the Capital plan adjustment this figure is 1.446 millions).

The main technology solutions

- The combined drainage for the old city area.
- The separated drainage for the suburban and new urban centers.
- Storm-water drainage is based on 4 main river using regulating lakes (with the total capacity at the Southern key lakes is 5.19 millions m^3) in cooperating with enforcement pumping units (capacity is 90 m^3/s) discharging to Hong and Nhue Rivers.
- Storm-water pumping unit and 4 rivers have been set at a 10 year return period (10 %) and at a 5 year return period for the sewer system.
- Implementing to improve 14 lakes and protect 11 lakes in the city
- Sewer system is distributed into basins, according to the drainage master plan; there are 6 wastewater treatment units in the city, the treated water discharges into the rivers or irrigations.
- Treatment wastewater technology: a process of active sludge treatment technology, oxygen ditch for irrigations, aeration tanks.

The Drainage HaNoi Project, Stage Ⅱ

Aims of the Project

Primary aims of the Drainage Project for Environment Improvement in Hanoi have been repeatedly confirmed between two governments, through the diplomatic procedures and financial arrangements. That is:

- To decrease the flood damage caused by inadequate urban drainage system
- To improve hygienic level in the city
- To up-grade the urban environment

For materialization of these aims, three kinds of approach were scrutinized and formulated by the JICA study team. They were 1) Drainage Plan, 2) Wastewater Disposal Plan and 3) Non-structural Measures of drainage and wastewater disposal plans. The Second Stage project components described herein cover based on the works of 1) Drainage Plan in terms of development framework. Although the construction of the wastewater treatment plant in two places is carried out under the First Stage as a part of wastewater disposal plan, this is an experiment project. Though it is not a part of major steps to the targeted aim, the desire for hygienic level improvement is getting stronger, it is a time to consider improving this issue. Any activity has not been made yet for the above cited item 3) Non-structural Measures, despite that it can be made irrespective of the progress of the construction works.

WWTP on operation and planning to build in Nanjing (2004)

WWTP	Capacity (10,000 tons/day)	Construction Status	Area Covered
Jiangxinzhou	40	Under Operation	Waste water along Qinhuai River
North City	30		Xiaguan District
East City	10		Maqun District, and surrounded by circle road, Hucheng River, Zijin mountain
Xianlin	5		Xianhe District; including Xuanwu Software Park and Maqun Science and Technical Park
Suojincun	0.5		
Jiangning	4	Plan to build	Jiangning District
South City	10-20		Tiexin Bridge District
Xianlin (Tiebei)	10-15		Yanziji; Maigao Bridge
2nd Stage of Jiangxinzhou	24		Hexi District
2nd Stage of East City	10		

WWTP and its extensive project in Shenyang

WWTP	Capacity (10,000 tons/day)	Construction Status	Total Amount (10,000 tons/day)	Capacity under Different Phases
North Part	40	Under Operation	92	920,000 tons/day treating capacity now
Xiannv River	20			
Shenshui Estuary	20			
Wuli River	10			
Mantang River	2			
Hunnan	4	Under Construction (should be finished at the end of 2005)	50.5	1,425,000 tons/day at the end of 2005
Liaozhong	5			
2nd Stage of Xiannv River	20			
Zhangshi	15			
Nanxiao River	1			
Huishan River	0.5			
Huishan Trench Eco-WWTP	5			

PRSP

The PRSP underscores the fact that water is a basic need and an important means for both economic and social developments of the country. It states, in part, that "access to water for human consumption, agriculture and livestock use is a major problem in rural area. The water supply situation in rural areas has deteriorated over the years to a point where demand cannot be sustained with current systems. Access to piped water has not increased since 1989 and those accessing other water sources have increased from 14 to 29 % during the same period."

ERSWEC

The ERSWEC underscores the fact that the current institutional arrangements are inappropriate and form obstacles to achieving the set poverty reduction objectives. It recommends the adoption of a program approach to the water sector, with emphasis on service provision to the poor, while ensuring the adequate quality water for the various competing demands. Thus, it proposes a comprehensive institutional reform to facilitate "pro-poverty water and sanitation programs."

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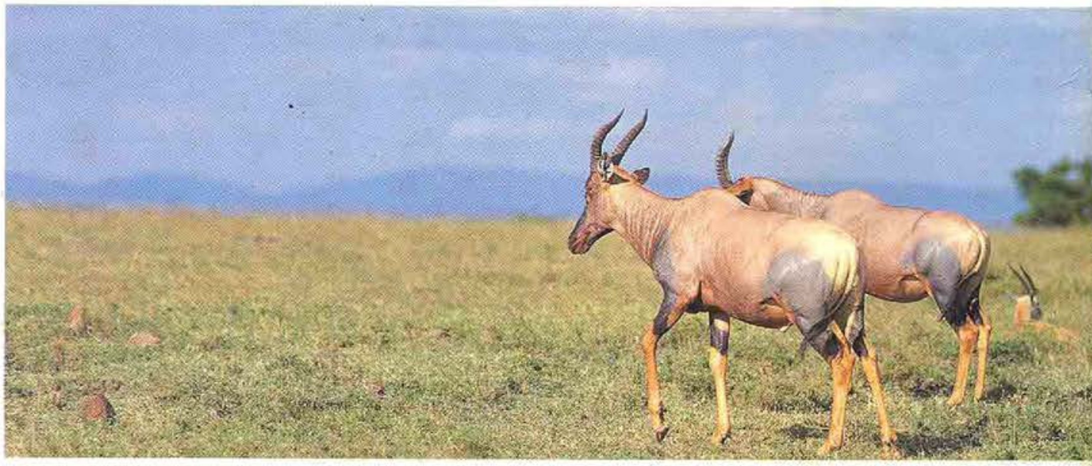

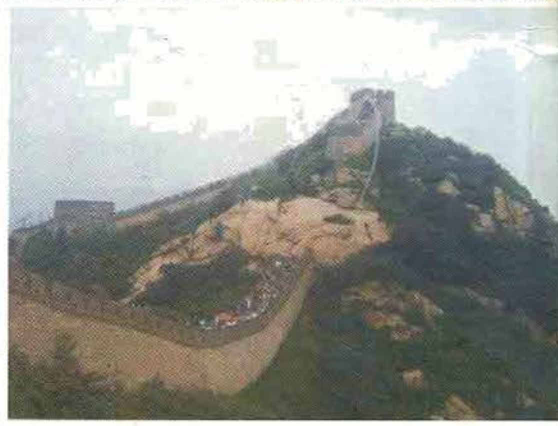

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