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DRAFT

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GUIDANCE ON MUNICIPAL WASTEWATER

Practical Guidance for Implementing the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA) on Sewage

Developed by UNEP/GPA, UNEP/IETC & IHE in collaboration with the World Health Organisation (WHO), the United Nations Centre for Human Settlements (UNCHS–Habitat), and the Water Supply and Sanitation Collaborative Council (WSSCC).

GPA Global Programme of Action for the Protection of the Marine Environment from Land-based Activities

UNEP

Strategic Action Plan on Municipal Wastewater

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This report builds further upon a former version of this document, referred to as "Recommendations for Decision-making on Municipal Wastewater", and on a background document "Strategy options for Sewage Management to Protect the Marine Environment" prepared by IHE, IRC & NEI.
Following expert reviews and future consultative regional meetings on wastewater the present version 2.0 will evolve into a revised version.

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UNEP GPA IHE DELFT IETC International Environmental Technology Center

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Preface

Domestic wastewater discharges are considered one of the most significant threats to human health and to sustainable coastal developments worldwide. The priority for action to address these threats was identified by:

- The Global Programme of Action (GPA) for the Protection of the Marine Environment from Land-based Activities (Washington, DC, 1995);
- Seven regional workshops of government-designated experts held from 1996 to 1998 under the framework of the United Nations Environment Programme (UNEP) Regional Seas Programme, involving more than 60 mostly developing countries.

Aim

The Guidance on Municipal Wastewater document aims to serve as a consensus guide on appropriate and environmentally sound systems for wastewater management. It contains key principles and annotated checklists of recommended practices and procedures, including those needed for investment decisions and public–private partnerships.

Context

The Guidance document is part of the GPA Strategic Action Plan on Municipal Wastewater, developed in co-operation with the World Health Organisation, the United Nations Centre for Human Settlements (UNCHS–Habitat), and the Water Supply and Sanitation Collaborative Council.

Target groups. The Guidance document is aimed at:

- Decision-makers at the national and local level, especially in developing countries (such as staff in Ministries of Health and/or Environment and Majors and Directors of Public Works in [coastal] municipalities);
- Regional organisations, the private sector, development banks, and related organisations that facilitate and participate financially in individual projects;
- Policy-makers at the national level who are responsible for implementing the GPA. They will be invited to endorse the approach followed to develop this Guidance document at the 2001 Global GPA Intergovernmental Review Meeting.

Agents of change

The GPA Guidance document focuses on the following elements, or agents of change:

- Approaches and policies, including demand-driven, opportunity-driven, and integrated management approaches;
- Institutional arrangements, including public participation and new partnerships with the private sector and water users;
- Financing options, including private capital and public–private partnerships;
- Technical options, including a series of steps for choosing the most appropriate technology, and considering waste as a resource

Process

The current version of the guide will form the basis of discussions at regional level with a wide variety of stakeholders, including national and local experts, representatives from non-governmental organisations (NGOs), the private sector, professional organisations, international financial institutions, and potential donors, and other stakeholders in 2001 and 2002. Regional annexes to the Guidance document will be developed as needed to reflect the common views of stakeholders and the mix of approaches and procedures best suited to the realities of the regions.

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Key Principles and Checklists

The Guidance on Municipal Wastewater document comprises key principles and annotated checklists on recommended practices and procedures in addressing the demand for wastewater handling, treatment and management. The key principles and checklists are meant to manage wastewater sustainably by conserving water resources, eliminating pollution at the source, using water efficiently, maintaining acceptable water quality for various uses and functions, and to respond effectively to demands from society.

Key principle 1: Political will and financial affordability are prerequisites for adequate wastewater management

In order to safeguard human and ecosystem health, and to avoid the degradation of water quality and other coastal and marine resources, the two most important prerequisites for adequate wastewater management are: the political will to assign a high priority to wastewater management among other pressing public investment needs, and financial affordability.

Key principle 2: Environment, health and economy are important indicators for action

Human health, economic functions and environmental integrity within the catchments are all essential indicators and driving forces for adequate urban wastewater management. The non-action alternative imposes great costs on current and future generations

Key principle 3: Stepwise implementation of measures is essential to reach long term management goals

Comprehensive stepwise implementation of urban wastewater management is needed to explore alternatives before making decisions on action. This should support adequate, tailor made and cost-effective measures, integrated with other sectors such as water supply and urban and rural planning in catchments, as domestic wastewater management is not an isolated problem.

Key principle 4: Demand driven analyses and prognoses are to be adopted to ensure effective investments

Rather than supply driven investments, demand driven approaches give 'value for money'. Demand driven approaches need proper analyses of the societal demands now and in the near future.

Checklist:

1.1 Step wise approach:

- Are selected policies, programmes, and investments prioritised?
- Are investment plans based on stage-wise implementation within a long-term horizon for planning and operations?

1.2 Priority setting:

- Do studies on socio-economic impacts of environmental pollution in case of inaction and action form the basis for priority setting and
- Are these studies promoted?

1.3 Integration: Is planning and costing for wastewater management integrated with the planning and costing for other sectors, such as water supply, solid waste management, and land use?

1.4 Does the approach optimise a combination of technological options and managerial approaches for different zones in the catchment?

1.5 Is the approach demand-driven, based on appropriate consultation and participation of communities involved?

1.6 Is municipal wastewater management incorporated into integrated approaches for the management of catchments and coastal zones?

Key principle 5: National and local governments are to take their responsibility in creating an enabling environment for sustainable solutions

A country's central government plays a significant role as a facilitator and initiator of appropriate wastewater management in developing systems to ensure good and sustainable governance.

Checklist:

2.1 Does the institutional environment - as set by the central government - encourage local governments, the private sector, regional and river basin agencies, and other partners to initiate and implement programmes? This can include:

- Developing and maintaining national policies and strategies in cooperation with local governments and other stakeholders
- Enacting legal and regulatory instruments
- Encouraging the development of appropriate organisations to complement local government initiatives.

2.2 Does policy development accommodate appropriate temporal and geographic scales to ensure environmentally sustainable implementation?

2.3 Are performance criteria for local governments and environmental agencies in reducing pollution established?

2.4 Are appropriate effluent standards imposed that are feasible for local conditions (including the physical environment, culture, economics and social welfare)?

Key principle 6: Commitment and involvement of all stakeholders are to be assured from the start

Wastewater management is pre-eminently an effort that involves many stakeholders (governmental and non-governmental) who all must be willing to co-operate and contribute to the overall result. Thus, the investment in awareness creation, demonstration of "win-win" situations and development of commitment and 'catchment solidarity' are essential to foster successful wastewater management. In many countries, however, institutional restructuring and strengthening (capacity building) at the local level is required to ensure the good performance of wastewater management systems.

Checklist:

3.1 Devolution:

- Has decision-making been devolved to the lowest appropriate administrative level?
- Do local communities receive financial power to participate in local or regional initiatives to define, operate, manage, and maintain their part of the infrastructure?

3.2 Institutional assessment

- Is there a long-term strategy for institutional reform and capacity building to improve possibly weak or inadequate existing structures, legal and regulatory frameworks, and organisations inside and outside of the government?
- Does it identify weak capacities pertaining both to capacities of individuals (such as wastewater engineers) and to capacities embodied in managerial procedures, regulations, administrative rules, and career and salary incentives?

3.3 Does the system ensure good and sustainable governance and does it

- protect the performance of investments and operations, whether performed by the public or the private sector and
- separate responsibilities of services operator, regulator and owner?

3.4 Accountability

- Can polluting entities be held accountable, irrespective of whether they are owned and operated privately or publicly, by civil society and its representatives (such as consumer associations)?
- Are local governments and environmental agencies accountable to
  - central governments for implementing, operating, and maintaining sustainable wastewater management systems?
  - the local community for operating and maintaining such sustainable wastewater management system?

3.5 Regulation:

- Are tools used to increase effectiveness of restrictive and enabling regulations, including positive incentives such as load-based licensing fees?
- Are market-based instruments used in conjunction with administrative regulation, such as tradable effluent permits, to give polluters more flexibility to invest and operate in the management of wastewater?

3.6 Awareness:

- Has commitment to a clean environment and "catchment solidarity," been developed?
- Has awareness among citizens regarding their dual role as polluters and beneficiaries of wastewater management been generated?
- Have local experiences been generated and synthesised to help identify or articulate the problems to be solved, by
  - creating fora and web-based clearing-houses for exchanging and sharing information and technology at the national, regional and global level, and by
  - making use of or developing operational networks of stakeholders in academia, government, industry, and civil society?

Key principle 7: 'Water User Pays' and 'Polluter Pays' are basic principles to consider

The principles "the water user pays" and "the polluter pays" are basic to achieve sustainable wastewater management systems. These principles can very well be applied in a way to ensure equitable sharing of costs by the rich and the poor.

Key principle 8: Public Private Partnerships and other new financial mechanisms are to be explored

New partnerships between the public sector and the private sector are important options and useful tools to assist local governments in financing and operating the infrastructure for wastewater management. To improve managerial performance, to find synergy and to get access to additional investment capital, often first an adequate re-regulation is required to avoid negative consequences.

Key principle 9: Linking municipal wastewater management systems to other sectors, for example water supply or tourism, ensures better opportunities for adequate cost-recovery. Rates are to be established solidarity-wise and at social equity

Other then e.g. water supply, sustainable wastewater management systems require very high initial investments and, consequently, long term contracts to cover financial risks and sufficient recovery of costs. As profits are likely to be more prominent in other sectors, linking up to these reduces the risks involved and thus enhances the feasibility of new, prospective partnerships.

Checklist:

4.1 Does the financial system balance the quality of the service, the investment costs, and the tariffs that households are willing and able to pay (demand-driven approach)? Specifically, does it

- Reflect people's ability to pay?
- Ensure that citizens receive an adequate wastewater management service with and sensitive to their ability to pay and to their contributions to pollution?
- Reflect true cost?
- Balance the quality of service with costs?
- Categorize service users (industrial, commercial and domestic) and price accordingly?
- Make drinking water services pricing consider costs of collection, treatment and disposal of wastewater?

4.2 Are co-financing schemes and highly cost-effective, appropriate infrastructure encouraged and promoted (e.g. residents in urban areas are primary financers as based on the polluter pays principle)?

4.3 Stakeholders:

- Do the investment and operational mechanisms and instruments enable the equitable distribution of costs and benefits among all stakeholders?
- Are stakeholders who are to gain from the water quality improvement involved and do they contribute financially (including those benefiting from enhanced land values, 'opportunity-driven approach')?

4.4 Revenues:

- Are revenues, such as user charges or pollution fees, used to establish funds for the co-financing of wastewater treatment facilities (instead of being considered as taxes entering the national budget)?
- Are tax revenues allocated to the appropriate service provider (to ensure accountability and transparency)?

4.5 Public-Private Partnerships

- Have regulatory and legal frameworks been reviewed that might impede public–private partnership arrangements (review to be performed by country specific bodies, such as local authorities, national environmental agencies, local associations)?
- Did the review result in an appropriate framework to facilitate local governments and the private sector to investigate partnership opportunities?
- Are recommendations made to discourage monopoly (and which are compatible with the country's economic, social and political situation)?
- Does the contract ensure maximum long-term effectiveness of both parties?
- Does the contract contain a provision for learning by doing by both parties (the contracting authority and the operator)?
- Are performance indicators identified and are they understood by both parties and be used for performance evaluation?
- Do PPP performance indicators meet international standards?

Key principle 10: Sustainable solutions for wastewater management build upon pollution prevention at the source, efficient water use and best available technologies, addressing economic aspects and low-cost alternatives when appropriate

The high costs of wastewater management warrants a very careful search for low-cost and thus more sustainable technologies and approaches that target waste prevention and minimization, pre-treatment, water conservation, and the efficient use of water. More cost-effective technologies comprise e.g. lagoons, natural systems, anaerobic treatment and potential for re-use instead of costly high-tech wastewater treatment plants.

Key principle 11: Innovative alternatives and integrated solutions are to be fully explored before final decisions on action are taken

Checklist:

5.1 Does the treatment technology selection process consider:

- pollution prevention (through water demand management, cleaner production)?
- on-site treatment and reuse options?
- natural self-purification capacity of the receiving environment, in case wastewater is collected without end-of-pipe treatment available?
- wastewater reuse and resource recovery options?
- appropriate and cost effective technologies for off-site, central wastewater treatment systems?
- Stormwater facilities and wastewater treatment sludge disposal options?

5.2 Do land use policies and financial and other regulations promote the segregation of industrial effluents unsuitable for municipal wastewater treatment, for example

- By relocating industries,
- Recycling waste streams, and
- Using the best available (pre-)treatment technologies?

5.3 Is in-house research, exchange of experience and capacity building for the implementation and operation of different technologies promoted?

Glossary

Activated sludge process
A wastewater treatment process by which bacteria that feed on organic wastes are continuously circulated and put in contact with organic waste in the presence of oxygen to increase the rate of decomposition.

Advocacy
Creating awareness and getting the commitment of decision-makers for a social cause

Aerobic treatment
A wastewater treatment process that relies on aerobic bacteria.

Anaerobic treatment
A wastewater treatment process that relies on anaerobic digestion processes.

Biochemical oxygen demand (BOD)
A measure of the organic pollutant strength of wastewater measured in milligrams per litre. This is equal to the mass of oxygen consumed by organic matter during aerobic decomposition under standard conditions during a fixed period (usually five days).

Combined sewer system
A sewer receiving intercepted surface (dry- and wet-weather) runoff, municipal (sanitary and industrial) wastewater, and subsurface waters from infiltration. Normally, its entire flow goes to a waste treatment plant or discharge point, but during a heavy storm, the volume of water may be so great as to cause overflows of untreated mixtures of storm water and wastewater into receiving waters. Storm-water runoff may also carry toxic chemicals from industrial areas or streets into the sewer system

Combined sewer overflow
Discharge of a mixture of storm water and domestic waste when the flow capacity of a sewer system is exceeded during rainstorms.

Digestion (wastewater)
The reduction in volume and the decomposition of highly putrescible organic matter to relatively stable or inert organic and inorganic compounds. Sludge digestion is usually done by aerobic organisms in the absence of free oxygen.

Domestic wastewater
Wastewater principally derived from households, business buildings, institutions, etc., which may or may not contain surface runoff, groundwater or storm water.

Dry latrine
The term is used to describe both:

- Crude systems in which faeces are excreted onto a slab or into an improvised container from which they are manually removed; and
- Latrines from which water and urine are excluded in order to increase the rate at which excreta decomposes.

Dry wastewater sludge
A sludge from a wastewater treatment plant which has been digested and dewatered and does not require liquid handling equipment.

Eutrophication
The process of an aquatic body becoming enriched with nutrients that stimulate aquatic plant growth, such as algae, resulting in depletion of dissolved oxygen.

Groundwater
Subsurface water in a saturation zone or aquifer that can be extracted through a well.

Industrial wastewater
Wastewater that results from industrial processes and manufacturing. It may either be disposed of separately or become part of the sanitary or combined wastewater.

Latrine
An installation used for defecation and urination.

Municipal wastewater
A mixture of domestic wastewater, effluents from commercial and industrial establishments, and urban runoff.

On-site facilities
Sanitation facilities that are located on a householder's plot. May be an on-plot system or the on-plot components of a more extensive system.

On-site sanitation
A sanitation system that is contained within a householder's plot occupied by the dwelling and its immediate surroundings.

Organic material
In wastewater treatment, material that can be biologically consumed in the secondary treatment process. A food source for various micro-organisms.

Pathogen
A disease-causing micro-organism such as bacteria, viruses, and protozoa

Pit latrine
Latrine with a pit for the accumulation and decomposition of excreta and from which liquid infiltrates into the surrounding soil.

Pour flush latrine
A latrine that depends on small quantities of water, poured from a container by hand, to flush faeces away from the point of defecation. The term is normally used for a latrine incorporating a water seal.

Primary treatment
The first stage of contaminant removal in a wastewater treatment plant through screening and settling processes, which can remove 40–50% of contaminants.

Programme communication
The process of identifying, segmenting, and targeting specific groups or audiences with particular strategies, messages, or training programmes.

Sanitation
- Control of physical factors in the human environment that could harm development, health, or survival.
- The study and use of practical measures for the preservation of public health

Secondary treatment
Second stage of wastewater treatment to reduce suspended solids through biological cleansing, to remove between 85–95% of contaminants.

Separate sewer system
Sewer system having distinct pipes for collecting superficial water and wastewater water.

Septic tank
A tank or container, normally with one inlet and one outlet, which retains wastewater and reduces its strength by settlement and anaerobic digestion of excreta.

Sewage
- See Wastewater

Sewer
A channel or conduit that carries wastewater and storm-water runoff from the source to a treatment plant or receiving stream. "sanitary" sewers carry household, industrial and commercial waste. Storm sewers carry runoff from rain. Combined sewers handle both.

Sewerage (system)
System of pipes, usually underground, for carrying wastewater and human waste away from houses and other buildings, to treatment and/or discharge

Sludge
- A semi-fluid, slushy, murky mass of sediment resulting from treatment of water, wastewater, or industrial and mining wastes, and often appearing as local bottom deposits in polluted bodies of water.
- A soft, soupy, or muddy bottom deposit, such as found on tideland or in a streambed.

Sludge or bio-solids
Residue after wastewater treatment. It can be, after proper treatment, used for soil amendment or as fertilizer, unless it contains toxic substances, such as heavy metals or persistent organic pollutants (pops).

Sludge stabilization
Usually anaerobic sludge digestion, a treatment that stabilizes raw sludge. Fully digested sludge has little readily biodegradable organic matter. It is not smelly and about 50% of the solids are inorganic. Sludge can also be digested aerobically.

Sludge treatment
The processing of wastewater sludge to render them innocuous. This may be done by aerobic or anaerobic digestion followed by drying in sand beds, filtering, and incineration, filtering, and drying, or wet air oxidation

Soak away
A soak pit or drainage trench for the subsoil percolation of liquid waste.

Soakpit
A hole dug in the ground serving as a soakaway.

Social mobilization
The process of bringing together all feasible and practical intersectoral social allies to raise people's awareness of and demand for a particular development programme

Solid waste
Litter and other waste in the streets. It can be flushed away with stormwater into the sewer or drainage system and cause blockage in the system.

Stormwater
Stormwater runoff, snow melt runoff, and surface runoff and drainage; rainfall that does not infiltrate the ground or evaporate because of impervious land surfaces but instead flows onto adjacent land or watercourses or is routed into drain/sewer systems

Storm sewer
A conduit that collects and transports rain and snow runoff back to the ground water. In a separate sewerage system, storm sewers are entirely separate from those carrying domestic and commercial wastewater.

Tertiary treatment
Third stage of wastewater treatment including filtration and disinfection, which effectively removes up to 99.999% of pathogens and suspended solids.

Urban sanitation
The renovation or redevelopment of the decaying areas of cities by the demolition or up-grading of existing dwellings and buildings and a general improvement in environmental conditions

Ventilated improved pit (vip) latrine
A pit latrine with a screened vent pipe and a dark interior to the superstructure.

Wastewater
Water carrying wastes from homes, businesses and industries that is a mixture of water and dissolved or suspended solids.

Wastewater charge
Imposed fee, expense, or cost for the management of spent or used water that contains dissolved or suspended matter from a home, community farm, or industry.

Wastewater discharge
The flow of treated effluent from any wastewater treatment process.

Wastewater disposal
Collection and removal of wastewater deriving from industrial and urban settlements by means of a system of pipes and treatment plants.

Wastewater management
All of the institutional, financial, technical, legislative, participatory, and managerial aspects related to the problem of wastewater.

Wastewater pollution
The impairment of the quality of some medium due to the introduction of spent or used water from a community or industry.

Wastewater quality
The state or condition of spent or used water that contains dissolved or suspended matter from a home, community farm or industry.

Wastewater sludge
The removed materials resulting from physical, biological and chemical treatment of wastewater.

Wastewater treatment
Any process to which wastewater is subjected which would remove, or otherwise render harmless to human health and the environment, its constituent wastes.

Wastewater treatment plant
Plant where, through physical-chemical and biological processes, organic matter, bacteria, viruses and solids are removed from residential, commercial and industrial wastewaters before they are discharged in rivers, lakes and seas.

Water closet
A pan, incorporating a water seal, in which excreta are deposited before being flushed away with water.

Water reclamation
Treatment and management of municipal, industrial, or agricultural wastewater to produce water of suitable quality for additional beneficial uses.

Wastewater sludge
The removed materials resulting from physical, biological and chemical treatment of wastewater.

ACRONYMS

BOD	Biochemical oxygen demand
BOO	Build–own–operate contract
BOT	Build–own–transfer contract
CSD	Commission on Sustainable Development
DBO	Design–build–operate contract
EBRD	European Bank for Regional Development
EU	European Union
GESAMP	Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection
GESI	Global Environmental Sanitation Initiative
GNP	Gross national product
GPA	Global Programme of Action for the Protection of the Marine Environment from Land-based Activities
ICZM	Integrated coastal zone management
IETC	International Environmental Technology Centre (UNEP)
IFI	International financial institution
IHE–Delft	International Institute for Infrastructural, Hydraulic, and Environmental Engineering
MPF	Multiproject financing facility
NGO	Non-governmental organisation
OECD	Organisation for Economic Cooperation and Development
POP	Persistent organic pollutant
ROT	Rehabilitate–operate–transfer contract
UNCHS	United Nations Centre for Human Settlements (Habitat)
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNICEF	United Nations Children's Fund
WCC	World Coast Conference
WMO	World Meteorological Organisation
WSSCC	Water Supply and Sanitation Collaborative Council

INTRODUCTION

For a long time, low population densities and the prevailing rural economy kept wastewater pollution localised, preventing it from spilling over into the wider environment. With modest consumption levels and no drains to concentrate wastewater and take it away, rivers and coastal zones remained comparatively free of human-caused pollution. In addition, the absorption capacity of the natural environment was adequate to deal with these modest pollution loads and as a result, the coastal zone did not face severe pollution problems.

However, urbanisation is changing the face of the earth dramatically. Between 1970 and 2000, in just 30 years, the global population doubled from three to six billion people. In this same period, the level of urbanisation in developing countries doubled from less than 25 percent of the population to 50 percent, while the value of their combined economies grew tenfold, from US$ 0.4 trillion to 4 trillion. Moreover, most of the largest urban centres are located in coastal zones. The pollution load discharged into the environment has increased concomitantly, and in many places, nature can no longer cope with these pressures; the very basis of a number of economic activities is threatened. With a continuation of strong, sustained growth of population and the economy, more critical damage can be expected in the next decades.

Municipal wastewater consists of a mixture of domestic wastewater, effluents from commercial and industrial establishments, and urban runoff. Its composition is influenced by specific levels of domestic water consumption, industrial effluent discharges and by ground water infiltration into the sewer system. The impact of wastewater occurs at three distinct levels: the direct living environment or neighbourhood where the wastewater is generated; the level of rivers and lakes used by richer cities for disposal of their mostly untreated wastewater and finally, at the level of the marine environment, which is the ultimate recipient of all such waste.

The coastal zone consists of estuaries and open coastal waters overlying the continental shelf, and is directly linked to open ocean waters. The coastal zones connect inland freshwater systems with the ocean. Land and sea are subtly intertwined, which is associated with important gradients (water depth, salinity, temperature, etc., which in addition fluctuate daily with tides). Such gradients are always characterized by high biological productivity and diversity. Estuaries are shallow and more confined than open sea, and thus are more likely to trap settleable and polluting components. In coastal zones, flow patterns, exchange with the open ocean and the capability to disperse, dilute and metabolize pollutants vary widely.

The Coastal Zone

Occupies 18% of the Earth's surface

Supports 60% of the human population

Contains two-thirds of cities with a population of more than 2.5 million people

Supplies more than 90% of the world's fish catch

Receives nearly all the discharges from the land and rivers

The coastal zones create a unique habitat for much of the marine fish, shellfish and coastal wildlife. Whilst in themselves commercially important for fishing and related activities the coastal zones fulfil critical functions as hatcheries, nurseries and breeding grounds for fish and marine mammals and amphibians alike. They provide ample food supply (algae, sea grasses, plankton and benthic organisms) and protective cover. Many of the commercially attractive species, such as oysters, clams, shrimp and crayfish thrive here. Similarly, these species are an integral component of the food chain and support large populations of marine and land based animals, including top-predators like mammals and birds. In addition, coastal wetlands and vegetation, and coral reefs provide protection against coastal erosion. Besides estuaries, critical coastal habitats include inter-tidal mudflats, salt marshes, lagoons, and mangrove areas. Because of this wide variation one cannot prescribe technologies or management practices that are valid for all conditions.

Various wastewater constituents have serious impacts on the marine environment. For example, high levels of suspended solids may cause excessive turbidity and shading of sea grasses. Fine particles may be associated with toxic organics, metals, and pathogens that adhere to these solids. Biological degradation of organic matter can cause hypoxia and anoxia, resulting in fish death and anaerobic conditions. Nutrients, like nitrogen and phosphorous, can cause nuisance and toxic algal blooms, dieback of coral and sea grasses, and eutrophication that can lead to hypoxia and anoxia, suffocating living resources (fish). Massive die-off of algal matter will result in additional organic matter.

Human exposure to pathogens via contact with contaminated water or consumption of contaminated shellfish can result in infection and disease. Many toxic materials (persistent organic pollutants, or POPs) are suspected carcinogens and mutagens. These materials can concentrate

in shellfish and fish tissue, putting humans at risk through consumption. Bioaccumulation affects fish and wildlife at higher levels of the food chain. Metals can be toxic to various marine organisms and humans; shellfish are especially vulnerable in areas with contaminated sediment, which may impair their reproductive capacity. Fats, oil, and grease float on the surface of seawater and interfere with natural aeration. They are possibly toxic to aquatic life, destroy coastal vegetation, reduce recreational use of water and beaches, and threaten waterfowl.

Coastal and marine pollution has become a worldwide phenomenon and has triggered international action. In 1995, the Global Programme of Action for the Protection of the Marine Environment from Land-Based Activities (GPA) was adopted by 108 countries and the European Commission. In the GPA it is noted that significant wastewater-related problems are common in coastal areas throughout the world and considers urban wastewater discharges one of the most significant threats to sustainable coastal developments worldwide (GPA 1995). The economic impacts on the coastal environment have not been very well quantified but are likely to be large, although the precise value will depend on the value people attribute to a clean and ecologically healthy coastal region.

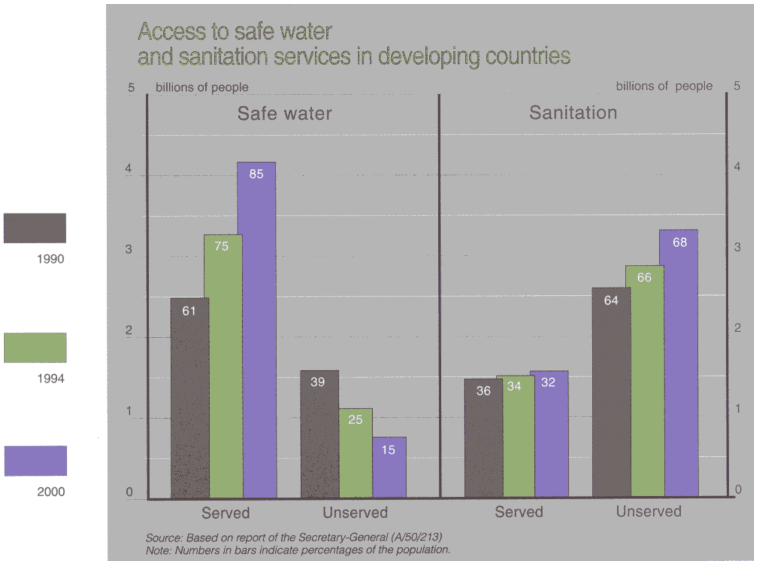

FIGURE I ACCESS TO SAFE WATER AND SANITATION (UNITED NATIONS 1997)

Addressing wastewater pollution requires very substantial investments and intensive, long-term co-operation among many stakeholders. Relative to the task ahead, too little is being done at present; governments, the private sector, and households prefer to spend their money on other goods. In developing countries, for example, drinking water typically enjoys a far higher priority than wastewater management. It is no wonder then that even after the International Drinking Water Supply and Sanitation Decade (1981–1990), nearly 3 billion people, mostly in developing countries, still lack access to adequate sanitation. The UN predicted in 1997 (UN 1997) that in the year 2000 the number of people in developing countries with access to safe water (85%) would exceed the number with access to sanitation (32%) (Figure I).[1]

There is no single recipe, approach, or strategy to address the problems associated with municipal wastewater. Though similar in nature, problems will vary in magnitude and urgency among large cities in the coastal zone and, for example, small island states. This document aims to make practical experience and scientific knowledge available through a series of key principles and checklists to prevent and protect the marine environment from wastewater pollution. These key principles and checklists are supported by chapters on strategies and approaches, sustainability, institutional arrangements, financing mechanisms, and environmentally sound, sustainable technology.

[1] More recent WHO / UNICEF (2000) data suggest that these numbers are 82% and 60%, for global access to 'improved' water supply and sanitation, respectively.

1 STEPWISE AND INTEGRATED APPROACHES

Summary

The main constraints on addressing wastewater pollution are the costs involved and stakeholder awareness and involvement. However, allowing pollution to continue imposes great costs on current and future generations. Urban wastewater management is a necessity to maintain the environmental integrity and economic functions of coastal areas. A comprehensive, integrated and stepwise approach is needed to maintain the environmental integrity and the economic functions of aquatic ecosystems, including ground water, rivers, lakes, and coastal areas.

1.1 Main constraints on addressing water pollution

When wastewater is not handled properly, the consequences may soon be felt locally. The lack of adequate sanitation can cause infectious diseases, or may lead to the contamination of the water supply, to flooding with unsavoury conditions that deteriorate the local aquatic life and threaten the well being of communities that depend on it. Consequently, local communities are usually willing to take collaborative action to improve their neighbourhood conditions, provided that they have certainty of tenure and that the government facilitates their efforts. In developing countries, cleaning up the local habitat is typically a high priority in congested, urbanised areas.

Unfortunately, in many other water pollution situations, people are not typically aware that co-operation is needed. As soon as the residents of a neighbourhood have a drain or sewer installed, their local waste gets flushed away to a downstream neighbourhood or to the river, thus becoming someone else's problem. This imposes costs on the downstream water users instead of on the polluters themselves. This imbalance is called an externality. The polluters are usually reluctant to remedy the situation, in part because they do not "see" the problem. To complicate matters further, the polluting industries and cities may be hundreds of kilometres upstream from the location where the damage from pollution occurs, and the effects of pollution may take years or even decades to become obvious. Because the cause–effect relationship is so complex, many polluters are loath to assume responsibility.

Clearly, the nature of water pollution hampers clear insight into the consequences of waste discharge and poses a key constraint to co-operation and "river solidarity" among water users. Thus, reliable data, communication, and education are needed to overcome these constraints. Similarly, appropriate institutional arrangements and knowledge about causes and effects are necessary to create the organisations and procedures to raise the issues, stimulate dialogue among the different stakeholders, resolve conflicts, and achieve agreement on joint actions.

The second key constraint on addressing water pollution is the cost involved. Even in countries in which labour and materials are inexpensive, the cost of wastewater treatment is high and can be prohibitive. Governments often have not enough resources, while household members may be too poor or unwilling to contribute to new approaches of cost-recovery. Although simple on-site options are less expensive than the more advanced alternatives, their application is often limited by local conditions that demand sewerage and off-site treatment.

Wastewater collection and treatment tend to be two to three times more expensive than the extraction, treatment, and distribution of potable tap water. In addition, the costs of operating and maintaining wastewater collection and treatment systems are often higher than the annual depreciation of the capital investment in the infrastructure. Treatment plants consume a lot of energy, generate large quantities of excess sludge that must be disposed of or used, and require relatively sophisticated equipment that demands well-trained operators and engineers. In the Netherlands, Germany, and other European countries, the local governments currently spend more money on treating wastewater than on all other water-related activities such as flood protection, pumping, and dredging combined—and most of that expenditure is devoted to the operation and management of the treatment plants. Moreover, only a few countries in the world manage to recover all of their costs directly from their customers through user charges.

Many low and middle-income countries in Eastern Europe cannot afford the technologies used in industrialised countries to reach European effluent standards. The estimated length of time needed to meet these European standards, assuming that 1.5 percent of the gross national product can be invested in sewers and treatment facilities, far exceeds the economic lifetime of the treatment plant (20–30 years) and in many cases even that of sewers (50–60 years) (Gijzen 1997). Thus, it is unrealistic to implement conventional wastewater collection and treatment in developing countries to reach European Union standards.

So, does this mean that no progress can be made in developing countries? The picture is less dramatic than the average figures suggest, but calls for a candid strategy and prioritisation:

- First, the wealth in urbanised regions is much higher than in non-urban areas, especially in large cities. Thus, local governments have more resources available to address pollution.
- Second, combined strategies that apply low-cost and on-site sanitation, waste minimisation, and some conventional sewerage can significantly reduce costs compared to conventional, high-investment technologies.
- Third, important efficiencies can be attained and costs reduced by integrating wastewater planning more with that of other sectors, by taking a longer-term planning approach, investing step-by-step, and by ensuring stronger support from citizens.

BOX 1.1 INTEGRATION WITH LAND USE PLANNING.

In a World Bank–financed programme in China for the collection and treatment of wastewater in cities along the Yangtze river, the original proposal to collect and fully treat municipal wastewater had to be altered substantially because of concerns about the technical and financial feasibility. The wastewater contained far too many components originating from industries that would seriously hamper the normal operation of a treatment plant. The agreed-upon, less expensive proposal entailed:

(1) relocating the main factories to new industrial estates;
(2) providing clean technologies where possible, as well as the specialised treatment of industrial wastewater to remove all noxious components; and
(3) collecting primarily household and non-toxic wastewater in the sewers, and, after simple mechanical treatment, releasing it into the river. Full treatment of domestic wastewater was considered a second priority because of the large dilution capacity of the Yangtze.

Prioritise actions and invest stage-wise

Thus, ample scope exists for targeted and effective wastewater management programmes, spread out over longer periods of one or more decades. There is no single technology that is equally well suited for all regions, climates, and geographical and socio-economic conditions across the world. Moreover, the high costs involved in achieving comprehensive wastewater management necessitate that such a longer-term and broader strategy is defined. Authorities are therefore recommended to prioritise their actions to minimise current and future environmental damage with carefully selected policies, programmes, and investments and to invest step-wise in infrastructure for wastewater management while maintaining a long-term horizon for planning and operations. Stepwise means here that the ultimate goal of a clean environment is reached through a series of smaller, locally implemented and environmentally beneficial steps, instead of trying to achieve this in one single, large and costly, nation-wide investment effort (figure 1.1). For example, with rapidly expanding cities, it is worthwhile to plan ahead, before an area becomes a busy city area with many industrial and commercial interests but lacks proper wastewater treatment. Box 1.1 gives an example of long-term planning and integration with land use planning.

Promote economic studies

Priority setting can be based on cost / benefit analyses of wastewater management schemes, like the Izmir Bay case study (UNEP 1993). This study calculated favourable ratios for a number of wastewater investment scenarios. It is therefore recommended to authorities and other stakeholders to promote studies to quantify the socio-economic impact of environmental pollution in cases of inaction and action, and use such information to determine the priorities for investment and clean-up programmes.

Use a combination of options

A strategic approach is required in the consultation of a menu of technological options and managerial approaches to find the appropriate solutions. For example, for each different zone urbanised areas will have to rely on a carefully composed multi-pronged strategy: cost-effective on-site sanitation and proper drainage of poorer neighbourhoods; low-cost sewerage in middle-income neighbourhoods; gravity sewers and treatment in more affluent quarters.

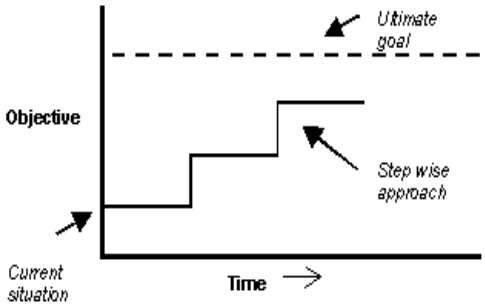

FIGURE 1.1 STEPWISE APPROACH

1.2 The cost of inaction

The cost of halting the pollution of water may seem prohibitive, and the constraints on initiating action may be numerous, but allowing pollution to continue causes damage and costs money. The damage may sometimes be difficult to measure, but a growing body of evidence demonstrates that pollution is associated with large, quantifiable direct costs to the existing economy and with even higher (missed) opportunity costs. Early preventive action can often generate substantial benefits by reducing future expenditures to

mitigate the effects of pollution. Few people, including decision-makers are aware that these damages are indeed more costly than one would intuitively expect.

Damage can generally be expressed in monetary terms, which allows a comparison with the cost of preventing or repairing the damage as well as a cost-benefit analysis. Several values cannot yet be properly monetised, such as the loss of biodiversity, or other environmental assets, or the social functions of water (Table 1.1). The 1992 cholera epidemic in Peru is a clear case of wastewater pollution damages (Box 1.2).

Box 1.2 COST OF INACTION: PERU
In 1992, Cholera spread in Peru because of poor sanitation and the inadequate disinfection of drinking water. This caused the tumble of Peru's income from fish exports and tourism, which had accounted for 34 percent of the gross national product before the epidemic. The income lost and additional health costs were estimated at US$1 billion, which equalled 10 times the annual amount spent on water supply and sanitation in the national budget.

The increasing urban pressures on coastal zones will multiply the incidence of pathogen contamination, oxygen stress, and the emergence of red tides and toxic micro-organisms. Moreover, these events may confront us with yet unknown problems. Therefore, urban wastewater management is necessary to maintain the environmental integrity and economic functions of coastal areas. The inaction alternative imposes great costs on current and future generations.

TABLE 1.1 DAMAGE FROM WASTEWATER POLLUTION

Direct health damage. Increased illness or mortality due to the ingestion or skin contact with contaminated water, raising direct health care costs (treatment expenses, lost income) and indirect –opportunity- costs. GESAMP (1999) estimated the impacts of bathing in and eating shellfish from polluted seas at a cost of approx. US$12–24 billion per year.
Loss of tourism income. International tourism and residential amenities have drastically raised the economic value of freshwater and coastal assets, as pollution and unsanitary conditions deter tourists. Spain's tourism industry depends on its coasts, employing 10 percent of the country's work force. The Caribbean island Bonaire depends almost entirely on tourism related to its coral reef —that is threatened by the island's wastewater.
Lost income. Notably for fishermen and aquaculture farmers, but also including the loss of productive days when industrial processing and cooling water supply must be suspended. The fisheries are usually of commercial nature but subsistence fishery should also be counted, as many poor people depend on fishing to supplement their protein intake.
Loss of amenity value. Real estate loses value when the quality of the surroundings deteriorates; investments in cleaning up the environment increase their amenity value.
Additional treatment costs in drinking and industrial water production.

1.3 Finding an appropriate approach

A comprehensive and integrated (stepwise) approach to urban wastewater management is needed to maintain the environmental integrity and the economic functions of aquatic ecosystems, including ground water, rivers, lakes, and coastal areas.

The traditional, supply-driven approach, in which planners and engineers assess the needs and decide what type of service will be provided, was not always successful, particularly not in developing countries. Understanding the defects of the supply-driven approach led to the development of a demand-driven approach. This approach encourages the use of technologies that are more appropriate to local conditions, and, most importantly, recognises that technology alone is not sufficient to sustain wastewater management systems. The demand-driven approach pays more attention to users' preferences, and ability and willingness to pay. Box 1.3 lists the key concepts in the demand-driven strategic sanitation approach developed by the World Bank.

Follow demand driven approach

The objective of the demand-driven approach is to make service delivery sustainable by basing future improvements on:

- Demand for services, identified through appropriate consultation with potential users
- Community participation in the selection, planning, implementation, and operation
- Selection of environmentally sound technology appropriate for local physical and socio-economic conditions
- Transforming the role of central government agencies from service provider to enabler

- Co-ordinating the agencies responsible for different subsectors (such as water supply, sanitation, and solid waste) and comprehensive planning (physical/land use planning, integrated water management, planning of industrial developments). (Watson and Jagannathan 1995; Peterson *et al.* 1994)

Integrate planning

The need for integrated approaches and processes, such as integrated water management, river basin management, and integrated coastal zone management, is now widely recognised. The recent increase in attention to integrated management approaches, such as river basin and integrated coastal area management (ICAM) provides another opportunity to address municipal wastewater, because it can be an integral part of these comprehensive approaches. The lessons from ICZM can benefit the development of appropriate wastewater policies (Box 1.4).

Incorporate wastewater management in coastal zone management

The use of an integrated approach can be triggered by the need for sanitation. Adequate handling of wastewater is a prerequisite for enabling socio-economic development and provides opportunities to address the wastewater problem. However, planned developments of certain economic sectors may also create an opportunity to address sanitation, such as:

- an expansion of tourist sector/hotel development,
- the development of coastal aquaculture,
- urban expansion through project developers due to potential enhanced property values,
- industrial development requiring clean, fresh water such as the food processing industry and breweries.

Stakeholders should be involved in the policy-making, and the (planned) socio-economic developments should be linked with planning and investments for municipal wastewater management. Stakeholders can also be approached to pay their share of the investment and operational costs. It is clear that an opportunity-driven approach, which also may include voluntary initiatives, has a wider dimension than the demand-driven approach.

The World Water Vision (2000) presented at the Second World Water Forum in the Hague, emphasised the need for new mechanisms for managing water (Cosgrove and Rijsberman 2000), the most vital of which are:

- The pricing of water services at full cost to provide the right incentive to users
- Service-oriented management to respond to users' needs
- Empowering communities, women and men, to stimulate people's initiative and capacity for self-reliance.

Box 1.3 THE STRATEGIC SANITATION APPROACH (WRIGHT, 1997)

The UNDP–World Bank Water and Sanitation Program developed the Strategic Sanitation Approach. This approach sets out a number of key concepts:

- A commitment to sound finances
- A concern with cities as a whole rather than with discrete projects
- A wide view of sanitation, encompassing storm water drainage, sludge disposal, the disposal of human wastes, and solid waste management
- The use of different sanitation options in different areas within a city, depending on local conditions
- The division and devolution of responsibilities for the management of sanitation services - in other words, recognizing that one organisation does not have to be responsible for all aspects of sanitation provision
- The use of a small-step approach, which portrays sanitation provision as a process rather than a series of large projects.

Box 1.4 CHARACTERISTICS OF INTEGRATED COASTAL ZONE MANAGEMENT (WCC 1994).

Integration in coastal zone management is co-operation between all responsible actors. The actors' incentive for cooperation is their common need to achieve the shared objectives, related to coastal zones, resulting in "win-win" situations. In this context, integrated coastal zone management involves the integration of the:

- Responsibilities of agencies at different levels of government (vertical integration)
- Responsibilities of different government sectors (horizontal integration)
- Responsibilities between governments and local groups
- Policies across economic sectors
- Economic, technical, and legal approaches.

Integrated coastal zone management is performed in a dynamic context that often features changes in: (i) demographic and socio-economic conditions, including social preferences and demands; (ii) natural coastal systems; and (iii) long-term conditions.

TABLE 1.2 APPROACHES TO WASTEWATER MANAGEMENT.

Supply-driven approach - Characterised by serious flaws: • The investments are costly, both in absolute terms and relative to the number of people served • The main beneficiaries are the wealthier neighbourhoods that can afford the high connection charges, with the help of subsidies • The environmental and water resources implications are not compared with those of other options • Investments are not recovered (Wright 1997).
Demand-driven approach – Requires**:** • Understanding what potential users and stakeholders want • Learning what resources they have and are willing to use to finance the systems • Learning what resources and capacities they have to manage the operation and maintenance of installed systems • Designing systems, financing mechanisms, and institutional support structures that are best suited to their needs.
Opportunity-driven approach Triggers related to municipal wastewater in coastal zones: • Societal demands for sanitation • Conflicts between users: for example, between users of water resources for water supply and for discharge of wastewater • Effects of non-product outputs on the state of the natural system: such as the discharge of untreated wastewater into sensitive aquatic systems • Opportunities: development and/or planning needs, such as aquaculture development plans, infrastructure for tourism development, or the management of integrated coastal zones (WCC 1993, adapted)

To achieve the World Water Vision goals, investments in water supply and sanitation will have to rise from US$70–80 billion per year to US$180 billion. Private firms - domestic and international - should be the main source of finance, and local communities will have to contribute considerable amounts in cash and in kind. However, in the end, the households, the consumers, will pay most of these costs. Government resources will become a smaller proportion of direct capital investment and maintenance costs.

The United Nations Secretary General recently published a report on the progress made in the 1990s in providing safe water and sanitation for all (CSD 2000). The report concludes that full coverage can only be achieved in the next 25 years if governments, the international community, NGOs, and civil society commit to undertakings of a much larger magnitude than they have done previously. Box 1.5 lists the points recommended for national programs.

There is an important role for all stakeholders, from the household level to the regional and national levels. The private sector has an important role as well, as a partner in building and improving infrastructure and providing services, and as a beneficiary of such measures. Opportunities do exist for the private sector to play both of these roles.

Box 1.5 RECOMMENDATIONS BY THE UNITED NATIONS SECRETARY GENERAL (CSD 2000) FOR INCLUSION IN NATIONAL PROGRAMMES.

1. Making water supply and sanitation integral parts of poverty alleviation programmes
2. Incorporating water supply and sanitation as integral parts of human settlement programmes
3. Improving service delivery, operation, maintenance, service reliability, and water quality
4. Making massive infusions of financial resources coupled with effective cost recovery policies
5. Decentralizing and devolving responsibilities to the lowest appropriate level of management
6. Integrating water supply and sanitation with hygiene education
7. Focusing on the gender dimension of water supply and environmental sanitation
8. Improving information management
9. Integrating water supply and sanitation within a holistic approach to the development, management, and use of water resources.

2 ENABLING ENVIRONMENT AND SUSTAINABILITY

Summary

Governments can play significant roles as facilitators and initiators of appropriate wastewater management. They have the responsibility and authority to set enabling, institutional environments to encourage local governments, the private sector, regional and river basin agencies, and other partners to initiate and implement programmes. They should develop wastewater management policies that accommodate appropriate temporal and geographic scales to ensure environmentally sustainable implementation. To introduce and strengthen an enabling environment, stepwise approaches are recommended here.

2.1 Sustainability

Three principles are fundamental to the creation of socially, economically and environmentally sustainable sanitation systems:

- Equity. All segments of society have access to safe, appropriate sanitation systems adapted to their needs and means.
- Health promotion and protection from disease. Sanitation systems should prevent users and other people from contracting excreta-related diseases and should interrupt the cycle of disease transmission.
- Protection of the environment. Sanitation systems should neither pollute ecosystems nor deplete scarce resources (WHO / UNICEF 2000).

Box 2.1 BARRIERS TO PROGRESS IN SANITATION (WHO / UNICEF 2000):

- Lack of political will.
- Low prestige and recognition.
- Poor policy at all levels.
- Weak institutional framework.
- Inadequate and poorly used resources.
- Inappropriate approaches.
- Failure to recognise defects of current excreta management systems.
- Neglect of consumer preferences.
- Ineffective promotion and low public awareness.

The reasons for failures of wastewater management services are usually complex and consist of a combination of inappropriate technology, weak institutions, lack of political will and user support, and insufficient funding (Box 2.1). Box 2.2 lists a series of factors that determine the sustainability of water supply and sanitation projects (WHO / UNICEF 2000). An essential element in sustainability is the creation of an enabling environment. A coherent inter-agency programme might facilitate this (e.g. SPC, 2001).

Institutional sustainability: an enabling environment

The generally accepted solution to achieve sustainable wastewater management is to place responsibility for managing services as close as possible to where they are to be delivered, with actual services being handled by local agencies, communities and households themselves. Central agencies remain responsible for strategic planning, policy, and regulatory aspects of sector development. The design of institutional arrangements will be discussed in the next chapter.

Set enabling environment

With governments in many parts of the world ceasing to be providers of services and instead acting as facilitators, they need to establish an enabling environment within which the various institutional levels can function effectively. Essential ingredients of such an enabling environment include (UNDP/World Bank, 2000):

- Clearly defined and consistent responsibilities
- A legal structure reflecting these responsibilities
- An effective regulatory body
- Appropriate regulations, codes, and standards
- Reliable and current information

Within this overall framework the public and private institutions that are actually responsible for the provision of services should have as much autonomy as possible. This implies that these institutions should, of course, subject to regulatory controls:

- Participate in overall development planning
- Be permitted to raise funds from whatever source of funds is most suited to their needs
- Have management and operational autonomy, leaving them free to meet agreed targets by whatever means they consider most effective
- Develop their own cost-recovery policies and procedures
- Have as much autonomy as possible in human resource development matters.

Establish performance criteria

To ensure proper implementation and accountability (Chapter 3), criteria need to be established for central governments to assess the performance of local governments and environmental agencies in reducing water pollution arising from wastewater.

Box 2.2 FACTORS DETERMINING SUSTAINABILITY OF WATER SUPPLY AND SANITATION PROJECTS (WHO / UNICEF 2000):

- Community participation in all stages of project planning, design, implementation, management and operation, with consideration of gender issues.
- Political commitment.
- Intersectoral co-ordination and collaboration.
- Adequate institutional frameworks.
- Human resources development in all its forms and at all levels.
- Self-improvement of communities.
- Better hygiene and sanitation.
- Improved information management.
- Improved environmental sanitation in communities.
- Use of appropriate, environmentally sound technologies.
- Involvement of the private sector through sound regulatory and controlling mechanisms.

2.2 Wastewater management policy

Wastewater management is part of a wider set of urban environmental services and it should therefore be planned holistically. At the most elementary level, this means ensuring that water is not brought into a neighbourhood unless there is also appropriate means of handling the resulting wastewater. Holistic planning requires planning to be integrated in three directions:

1. Technical integration (meaning that the full range of possible, environmentally sound technologies is considered and used where appropriate).
2. Institutional integration (meaning that all institutions that could contribute to solving the problem are considered and their appropriate roles selected)
3. Sectoral integration (meaning that inter-relationships between sectors are taken into account and resolved in the most effective way to achieve synergy and balance. Decision-makers and others responsible for planning urban services should consider not just a single service - water supply, wastewater management, solid waste management - in isolation, but a much broader spectrum of activities designed to better people's lives and improve conditions in the city).

Wastewater management should be part of a policy life-cycle, a framework, which comprises a comprehensive set of related tasks. To produce certain desired objectives all tasks must be performed in order. It is a cyclic process that evolves over time and can also be applied in situations in which some sort of wastewater management already exists. An evaluation of the discrepancy between the present and required performance of the system might trigger a renewed cycle of defining or reformulating these tasks.

Each cycle consists of four steps: problem identification, planning, implementation, and finally, enforcement and evaluation. Table 2.1 lists the wastewater management policy steps. Each of the steps can be subdivided in a number of different tasks. The different stakeholders should be involved as early as possible in the process. Since the tasks are executed in a cyclic process, step 1, although seemingly the logical place to begin, is not always the first step taken. Steps to identify opportunities or to evaluate the current situation might come first, followed by the other steps in sequence.
Two recent publications provide detailed guidelines for strategic approaches to the sustainable management of water resources (European Commission 1998) and municipal sanitation (GHK 2000), using the policy life-cycle as an entry point. The remainder of the chapter will describe a number of important considerations in developing a wastewater management policy.

Table 2.1 POLICY STEPS FOR WASTEWATER MANAGEMENT

1. Problem identification a. *Monitoring* b. *Assessment and identification of the need for action*
2. Planning a. *Review of information* b. *Identification of needs and opportunities* c. *Setting of objectives and formulation of the plan* d. *Formal adoption*
3. Implementation a. *Management instruments* ➢ *Regulation* ➢ *instruments* b. *1. Operational management of on-site sanitation initiatives* b. *2. Operational management of infrastructure* c. *Institutional arrangements* ➢ *Institutions* ➢ *Capacity building* ➢ *Awareness / public participation*
4. Enforcement and evaluation a. *Operational management of water quality* b. *Evaluation*

Policy step 1: Problem identification

a. Monitoring. The methodology for monitoring (both performance and environmental monitoring) is well established. In the future, the GPA Clearing-house will be a platform to provide monitoring techniques related to wastewater. An adequate monitoring strategy is focused on:

- The areas where impacts can be expected
- The amount and quality of wastewater from industries and small enterprises that is mixed with domestic wastewater
- The amount and quality of urban runoff and the frequency with which it drains into the wastewater collection system

b. Assessment and identification of the need for action. The early successes in pollution control in industrialised countries in the 1950s and 1960s pertained primarily to oxygen-depleting substances, suspended solids, and some heavy metals, in part because this pollution was recognised first, and in part because the technology to address it was available. However, other pollution, particularly from pathogens and nutrients (nitrogen and phosphorus), has still not been sufficiently mitigated. Lessons that emerged from these early pollution control efforts include the need to:

- Identify the contaminant that is causing serious harm to the region
- Use scarce money to tackle this pollution using cost-effective means
- Establish criteria to prioritise services to communities, based, for example, on health risks or living conditions.

The assessment of the problem, including a review of the existing situation can be conducted on a city-wide basis by local government staff. However, it can also be done at the neighbourhood level with the involvement of stakeholders; the assessment then becomes a powerful tool for raising public awareness.

Policy step 2: Planning

a. Review of information. Relevant existing policies and arrangements must be reviewed to enable linkages with the wastewater sector (Box 2.3).

b. Identification of needs and opportunities. When developing a policy for wastewater management, a number of obstacles may arise to hamper its implementation and performance. Identifying the potential obstacles early in the process can allow them to be addressed within the policy. For example:

- Identifying insufficient institutional capacities suggests that capacity building should be one of the implementation activities
- Recognising the need for financial support for investments should influence the kind of partners that could be involved, such as regional development banks or international water companies.

Box 2.3 POLICIES AND ARRANGEMENTS FOR REVIEW

- Demographic and socio-economic projections, such as the rate of urbanisation, projections of income per capita and distribution, water supply, and water demand
- The existing legal framework including standards, and regulations
- The current institutional framework
- The financial framework
- Related sector policies (such as water supply, waste management, land use planning and zoning, and urban development)
- National economic planning
- Identification of stakeholders and key agencies.

The adequate handling of wastewater can be one of the prerequisites for socio-economic development. Thus, planning and investments for wastewater management should be linked with (planned) socio-economic developments and the integrated management of river basins and coastal zones. These developments provide opportunities to initiate action. National economic planning and sector planning may provide relevant information on how and where to link plans and investments with wastewater management. For the successful implementation of the wastewater management plan, it is essential that all stakeholders are involved at an early stage.

c. Setting of objectives and formulation of the plan. The setting of aims and objectives is a crucial part of a wastewater management plan. It involves consultation and negotiations with all of the stakeholders, as well as the analysis and assessment of the technical, economic, and social feasibility of different options. The objectives of the wastewater management strategy should be measurable and verifiable. The objectives can be a subset of the overall objectives of integrated water management. The latter could have quality objectives and standards for designated water use (that is, for the production of drinking water, for fisheries, for navigation, and so on) and long-

term quality standards for water resources such as rivers, wetlands, and coastal zones. Table 2.2 lists the most important components of a wastewater management strategy.

Impose appropriate standards

Strict environmental standards often do not lead to a cleaner environment. In some cases, initial compliance deteriorates as, for example, pollution control equipment is installed, but is subsequently poorly maintained or is bypassed. In many cases, there is no enforcement culture and the strict standards are ignored altogether. Therefore, goals and objectives set at a national level, should allow local flexibility in implementation. Any attempt to enforce uniform environmental policies throughout large, diverse countries is doomed to failure as they might pose too strict regulations at locations that are unnecessary and can only be achieved at high cost (World Bank 1998).

Consider differen-tiation

Consider temporal and spatial differentiation. Temporal differentiation means to invest stage-wise and keep a long-term horizon of future coverage and extension in mind by taking into account the possible consequences for space, design, and operation. Removing the first 50 percent of the pollutant is moderately expensive, but removing the next 40 percent is more expensive, and removing the last 10 percent is often prohibitively expensive. Spatial differentiation means to differentiate neighbourhoods/suburbs by their physical characteristics (slope, soil type, ground water level, existing infrastructure for water supply and sewerage) and socio-economic characteristics (population density, income, willingness to pay, labour, price of land, energy costs).

d. Formal adoption. A more comprehensive approach for wastewater management requires mechanisms for co-ordinating the responsibilities of agencies at different levels of government, including the responsibilities of the different stakeholders (vertical integration) and those of different government sectors (horizontal integration). The formal adoption of the policy entails the following steps, among others:

- Establishing an interagency co-ordination mechanism between the relevant authorities
- Approving staffing and organisational changes that may be required
- Adopting related policies, goals, and new management arrangements
- Assigning, by legislation, the distribution of responsibilities among the authorities, such as monitoring, revenue collection, operation, and maintenance
- Approving the funding allocation.

TABLE 2.2 COMPONENTS IN WASTEWATER MANAGEMENT STRATEGY

1.	Consider options for pollution prevention (prevent especially toxic pollution at the source; minimise wastewater at its origin)
2.	Apply low-cost and on-site sanitation as much as possible (taking into account environmental impacts)
3.	Consider options for recycling (Municipal wastewater and bio-solids or sludge can be recycled after pre-treatment, for example, into agriculture, aquaculture, or for industrial cooling and processing)
4.	Identify priority constituents and select cost-effective mitigation approaches, taking into account alternative technologies
5.	Make use of the absorption capacities that natural systems offer
6.	Integrate the policy with other sectors, such as water supply and land use planning
7.	Address zoning of polluting and beneficiary functions; industry & coastal tourism
8.	Consider temporal and spatial differentiation:
9.	Strive for an integrated approach to river basin management, raising awareness and solidarity in implementation among the populations living upstream and downstream; river solidarity.

As the policy moves from the planning phase to the implementation phase, the degree of horizontal versus vertical integration may change. At the beginning of the process, it is most important that all of the different levels of government and stakeholders interact. When the policy is being implemented, other related sectors may play a more important role.

Policy step 3: Implementation

a. Management instruments (Box 2.4) Each of the responsible agencies has a set of management instruments, in the form of regulatory and incentive-based instruments at its disposal. These instruments should be supported by legislation and other types of authorisation. The policy must be translated into regulations that, among other things:

- Create measures to prevent pollution at source, for example, the specific collection and treatment of toxic liquid waste such as car oils, laboratory and hospital waste, and industrial waste
- Ensure that sludge is handled according to the adopted quality standards
- Enable the use of economic instruments, such as financial and fiscal stimuli, to promote waste minimisation, pollution prevention, and recycling
- Promote the capacity of authorities to enforce these regulatory and economic instruments.

b. Operational management of infrastructure. A basic distinction can be made between the management of on-site sanitation and of off-site collection and treatment. The management of on-site sanitation demands a distinct approach, as it is also related to hygiene behaviour and regulations for building and land use in the city. The strong involvement of households and neighbourhood communities is essential. Furthermore, small entrepreneurs can fulfil an important role in operational management.

Box 2.4 MANAGEMENT INSTRUMENTS

A. Regulatory instruments (command and control)

- Licenses and permits
- Prohibitions on improper disposal of waste and effluents, including sludge
- Rules to discourage the abuse of monopoly privileges
- Standards on water quality of effluent and receiving waters

B. Economic or market-based instruments (incentives and penalties)

- Adherence to ISO14000
- Charges and tariffs
- Covenants between government and industry and/or municipality
- Eco-labelling
- Public disclosure of pollution control records
- Subsidies and co-financing
- Taxes

Several technical agencies are involved in the financing, design, operation, and maintenance of the infrastructure for the collection and off-site, centralised treatment of domestic sewage. For example, public works departments of a municipality are often responsible for operating and maintaining the sewers, while the more complex, main pumping stations and treatment works are often under the purview of regional technical agencies, in order to benefit from economies of scale and synergies.

c. Institutional arrangements. These provide the framework within which management tasks are undertaken and the management instruments are applied. Chapter 3 focuses on these institutional arrangements, as well as on capacity building, raising awareness, and public participation.

Policy step 4: Enforcement and evaluation

a. Operational management of water quality. Enforcing existing rules and regulations is one of the most difficult aspects of governance in developed and developing countries alike. The goal should be to have rules that are generally accepted by society and that can be enforced. Strong and objective enforcement is often required when certain parties clearly benefit economically from breaking the rules (Post and Lundin, 1996). Among other activities, enforcing wastewater policy entails:

- Monitoring the agreed water and effluent quality standards
- Issuing discharge licenses
- Collecting discharge fees or penalties
- Operational management of water quality.

b. Evaluation. The results of the wastewater management plan should be subject to regular monitoring and evaluation as a way of continually improving its performance. Thus, it is especially important that the goals and objectives can be specified as clearly and as quantitatively specific as possible; otherwise, assessments are difficult. Any discrepancies between the required and the actual performance must be communicated to the appropriate authorities, to initiate a new round of policy setting.

Box 2.5 ENVIRONMENTAL STANDARDS

Ambient standards set maximum allowable levels of a pollutant in the receiving water and require explicit agreements on the desired environmental quality objectives.

Emissions standards set maximum amounts of a pollutant that may be emitted by a plant or other source. They have typically been expressed as concentrations, although there is increasing use of load-based standards, which reflect more directly the overall objective of reducing the total load on the environment.

Technique based standards are based on knowledge of what can be achieved with current equipment and practices. A wide range of principles has been used, including "best available techniques" (BAT), "best practicable techniques" (BPT) and "best available techniques not entailing excessive cost" (BATNEEC).

3 INSTITUTIONAL ARRANGEMENTS AND SOCIAL PARTICIPATION

Summary

A long-term strategy for institutional reform and capacity building should be developed where existing structures, legal and regulatory frameworks, and organisations inside and outside of the government are weak or inadequate. Wastewater management is pre-eminently an effort that involves many actors who must be willing to co-operate and contribute to the overall result. To develop commitment to a clean environment and "catchment solidarity" one should invest in creating and maintaining awareness among citizens regarding their dual role as polluters and beneficiaries of wastewater management.

3.1 Type of partners and institutional arrangements

The previous chapter described the tasks in relation to policy setting for wastewater management, each complementary and each requiring distinct expertise and appropriate institutional arrangements. These tasks are performed by and with the involvement of a number of actors: governments (national, regional, and local), regional organisations, (river basin authorities or water boards), households, non-governmental organisations (consumer associations, environmental groups, and civic action groups), professional service providers, water service operators (public and private), and private sector companies (as water polluters and as benefiting entities).

Existing arrangements among these actors depend on a country's cultural, social, economic, and political conditions. However, these conditions change, and thus, the arrangements will also change. For example, England and Wales went through a fundamental shift in their water management organisations in the 1980s because the existing river basin–based Water Authorities could not cope with the large financing requirements to address water pollution. This led to the privatisation of the water utilities in 1989.

This case study illustrates that sustainable wastewater management will require carefully devised institutional arrangements. In particular, the important institutional arrangements include the following (Alaerts, 1997):

The overall institutional structure. Links should be made with other relevant sectors, such as urban development, water management, solid waste, and industrial policy but also to the sectors in which wastewater impacts are felt, such as health, environment, and agriculture. At the national level, it is particularly important that all sectoral functions are adequately addressed through technical organisations and other institutional arrangements; this requires proper role descriptions, responsibility, authority, and other means to carry out the tasks and avoid overlap in competence, loopholes, or "blind spots." Formalised and informal links among all of the stakeholders mentioned above, the vertical integration, is required to optimise communication and co-operation.

Implementing agencies. These comprise typical, "formal" agencies such as national ministerial departments, state or municipal technical departments (for example, departments of environmental management, public works, or public health engineering), water utilities, and river basin agencies. At very local levels, they can include community-based organisations for sanitation in slum areas. The performance of implementing agencies depends on their mandate and means, the right balance between decision-making and financial autonomy and accountability, the quality of their leadership, and the professional skills mix of their staff.

Legislation is required to determine the division of responsibilities and authority, performance standards, systems for regulation and incentives, financial flows, and so on. The legislative obligation can also come from international law. For example, conventions (binding arrangements between governments) are in place in a number of regions of UNEP's Regional Seas Programme. In one region, the Wider Caribbean, a protocol was adopted in 1999 focusing specifically on municipal wastewater, obligating member countries to address the problem in a phased manner and on an agreed schedule.

Apply both restrictive and enabling regulations

Regulatory tools and incentives systems. These institutional arrangements consist of agreed procedures. Typically, a mix of regulatory and incentive systems ("sticks and carrots") is most effective. The incentive systems are especially relevant because they often have the largest influence on the behaviour of people or an industry. Positive incentives include subsidies, co-financing arrangements, and tax reductions to promote the construction of wastewater facilities. Negative financial incentives include tariffs, charges, and penalties to discourage the production of potentially polluting substances, reduce water use, or generally to make polluting alternatives more

expensive than clean alternatives. Regulation in the United States, for example, first tried an administrative approach, but it is now supplemented with more flexible approaches (Mariño and Bohland, 1999).

Financial flows. The appropriate structure of financial flows is particularly critical in attaining pollution control goals. The overall effectiveness of a wastewater management plan depends on the successful completion of complementary activities by separate agencies, such as for wastewater collection, its treatment, and discharge regulation. For each activity, financing arrangements must be sustainable and the costs commensurate with willingness to pay. Thus, each main activity depends on different contributors, including households, industries, municipal governments, and national funds. Consequently, money flows originate in different sectors, are often managed by more than one agency, and must be directed to different cost sites that are frequently located in different sectors.

3.2 Design of institutional arrangements

Before modifying institutional arrangements, existing institutional frameworks must be identified and their strengths and weaknesses assessed. The assessment should examine the following: the agencies already in place, their organisational structure, roles, responsibilities, gaps, and/or overlapping authority. Most countries have extensive central government agencies, but regional, and especially local levels, will have minimal experience and capabilities. Thus, institutional strengthening must begin with the existing structure and recognise that any structure requires continuous effort before it is functional. The national institutional framework must be integrated to ensure that central, regional, and local agencies are aware that co-ordination and co-operation are essential when addressing wastewater sector issues.

A number of design criteria can be devised for institutional arrangement in wastewater management:

Develop commitment

"**Catchment solidarity**" This requires creating appropriate organisations and other institutions dedicated to:

a. Strengthening the sense of solidarity and co-operation among people within the river basins
b. Ensuring that all stakeholders in water use, including the in-river ecological interests, are recognised and have a voice
c. Setting long-term goals and priorities
d. Collecting feasible financial contributions from all inhabitants (water users and polluters) that can then be allocated to a step-wise investment program.

Flexible regulation. Regulations, if enforced adequately, can serve a number of purposes, but often come with hidden opportunity costs if they do not take local circumstances and opportunities for synergy into account. Many regulations for pollution control could be better formulated so that local regulators and polluters can devise cost-effective solutions. In this way, the government positions itself as the facilitator, and as guarantor that the goals will be achieved, rather than the implementer of the policy. More flexible regulations typically include:

Introduce market-based instruments

a. Market-based and financial instruments
b. Self-regulation: Covenants and other voluntary initiatives, negotiated between the governments and polluters (such as industries and municipalities), which set mid and long-term goals but leave the detailed implementation to the polluters themselves
c. Informal regulation: Public interest in environmental quality raises the pressure on polluters to comply with regulations.

Introduce task distinctions

Task distinctions between "operator," "regulator," and "owner." It is advisable to strictly separate the functions of regulation and monitoring of wastewater discharges (typically a role for an environmental agency), and the function of attaining the standards (typically the role of the municipality, a related technical agency, or a utility). Similarly, a distinction must be made between "owner" and "operator." Although municipalities may be vested with the responsibility and authority to collect and treat wastewater, and thus "own" the wastewater, they may choose to delegate parts of the operational tasks to private firms or other public agencies.

Synergies. The optimal arrangement of institutions entrusted with the different pollution control functions is partly determined by the existence of synergies with existing or new institutions, which in turn depends on a country's hydrological and other characteristics (Box 3.1).

BOX 3.1 EXAMPLES OF SYNERGY

United States. The greatest synergy was found by combining all regulatory and several management functions into one environmental agency, the Environmental Protection Agency, while the operations remain at the municipal level.

France. Synergy between the management of water quantity and water quality is found in river basin agencies, while the wastewater operations remain in municipal hands.

Netherlands. Synergy is achieved by assigning the task of wastewater treatment to water boards. In some situations, the management of wastewater infrastructure is merged with other services, such as water supply, power, or public transport, into a city enterprise (like, for example, in Germany and Colombia).

Make polluting entities accountable

Enforcement, accountability, and transparency. The design of tasks like monitoring water quality, issuing discharge licenses, collecting discharge fees or penalties, and the operational management of water quality should take the potential for enforcement into consideration. It is important to maintain public scrutiny on organisations that serve such public purposes as wastewater management to keep them efficient and effective.

Make local governments accountable

Accountability to (the different interests in) the public and other stakeholders can be institutionalised in organisations by adjusting their working procedures to this purpose or requiring them by law to submit to public audits or divulge critical information. Transparency regarding the organisational objectives, targets, performance as measured against benchmarks, and finance is essential to allow the public to assess the effectiveness of the organisations and, if necessary, to call for remedial action. Transparency and access to information are essential to accountability; the effectiveness of this transparency depends upon agreement on detailed internal procedures.

Competition. Networked systems for wastewater management present very strong natural monopoly characteristics, much stronger even than in water distribution. There is virtually no scope for introducing direct competition within such systems. Experience shows that direct government providers of wastewater services typically lack either the competitive or regulatory pressure needed to stimulate efficient performance. The introduction of the beneficial effects of competition can be achieved through the adoption or threat of public–private partnership contracts. This will not lead to "perfect" competition, but can promote many of the beneficial effects of competition. Competition is increasingly seen between private sector operators, and between the public and the private sectors.

Long-term economic equilibrium. The investment, maintenance, and operating costs of virtually all wastewater management systems are very high. Moreover, because much of the infrastructure is invisible, there is a strong tendency toward neglect, leading to rapid deterioration. It is therefore particularly important to ensure that the long-term economic equilibrium of the system is designed into the institutional arrangements. This applies in both public operation and public–private partnership contracts. It is particularly important in public–private partnership contracts in which the private sector has been asked to make very substantial capital injections and incur short-term operating losses at the beginning of the contract to correct a backlog situation. These investments and operating losses must be compensated prior to the expiration of the contract.

Devolve decision-making to lowest level

Devolution and subsidiarity. The experience with water management calls for "decentralising water management to the lowest appropriate administrative level" (WMO 1992). As a rule, national governments should not implement tasks that can be done more efficiently or effectively at lower government levels, although they should ensure that these tasks are executed (subsidiarity principle).

Similarly, governments should not implement tasks that can be done more efficiently by private firms or by local communities. National governments are to keep control by facilitating agreement on broad national priorities and strategies, and by issuing and enforcing general regulations. Local government has clear responsibilities in meeting sanitary goals, but must seek cost-efficient ways for implementing these duties.

3.3 Building institutional capacity

Weaknesses in institutions or institutional arrangements are a major cause of underperformance in the wastewater management sector. The 1996 United Nations Development Programme (UNDP) Symposium on Capacity Building in the Water Sector (Alaerts et al. 1999) concluded that it is

insufficient to train staff and students better, when the aim is to remedy these weaknesses. Rather, it is necessary to work simultaneously on three basic elements:

- The creation of an enabling environment with targeted policy and legal frameworks
- Institutional development, including community participation
- Human resources development and strengthening of managerial systems.

Develop strategy for institutional reform and capacity building

In a number of cases, it may suffice to strengthen the existing situation, for example, by introducing new or additional procedures and skills, such as technological expertise, accounting, communication with local communities, or cost recovery mechanisms. In other cases, however, it is necessary to reform the existing arrangements, which can entail wide-reaching interventions in the administrative, organisational, legal, and regulatory frameworks. Table 3.1 lists a number of tools that can be used for capacity building. Of course, capacity-building programmes must be carefully tailored and prioritised to suit local problems and financial capabilities and personnel capabilities.

3.4 Advocacy and public awareness

The success of wastewater management programmes depends on effective advocacy and public awareness through information, education, and communication. A communication process includes advocacy, social mobilization and programme communication (McKee 1992). Figure 3.1 illustrates how the government of Bangladesh has used McKee's communication planning model for the Sanitation for All programme, implemented from 1993 to 1998. The Commonwealth of Australia (2000) gives an example of how an implementation plan may look like, here integrating both human health and environmental issues.

Communication for behavioural change is a complicated process of human action, reaction, and interaction. It involves looking at situations from the viewpoint of other people, and understanding what they are seeking. It requires understanding the potential obstacles to change, presenting relevant and practical options, and telling people about the results of the choices they make. Communication can help to get policy-makers, the private sector, and people / communities committed to programmes and can help to prevent expensive mistakes. People must be informed and convinced, or they do not feel part of the process and may not be motivated to change their behaviour. In addition to leaders, who initiate, promote, and coordinate activities, "champions", such as a neighbourhood or group of families, are another critical component for success. The activities of advocacy, social mobilisation, and programme communication do not necessarily happen consecutively.

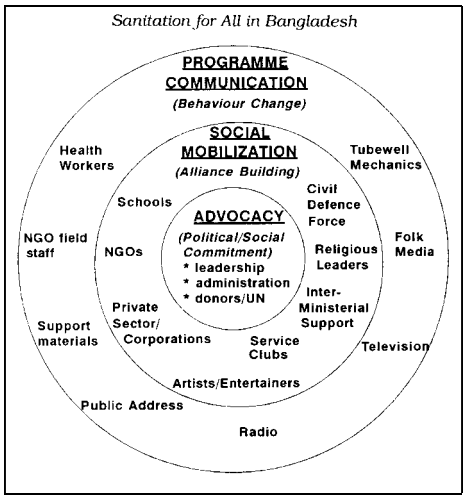

Figure 3.1 Communication planning model (McKee 1992)

Understanding attitudes and behaviour change

It is most important to recognise that public understanding and attitudes regarding wastewater management systems differ significantly from every other form of infrastructure service. The very question is often subject to an effective taboo, since people do not want to recognise their individual contributions to waste generation. In addition, the system is one of collection; there is no tangible "product" with which "value" can be associated. The infrastructure is almost entirely invisible and therefore suffers from a problem of "out of sight, out of mind." People quickly forget the problems and discomforts they suffered before an adequate system was established. Moreover, it is very difficult to sanction non-payment or non-compliant use of the system. All of these factors combine to present a formidable challenge to political decision-makers, planners, and operators. This challenge has to be met at both the inception of the system and throughout the life of the service.

Create awareness among citizens

Strategies, approaches, and steps
Table 3.1 shows a strategy for advocacy and awareness raising, needed to mobilise different segments of society to support sustainable wastewater management.

TABLE 3.1 STEPWISE SYSTEMATIC APPROACH TO ADVOCACY AND AWARENESS RAISING

1. Identify the issues. May be changed or adapted during strategy implementation. In wastewater management, an example is the call for a clean river or lake.
2. Assess the current situation Focus on the systems in place for wastewater collection, disposal and treatment. The assessment can be conducted by local government staff - citywide or at neighbourhood level - and can involve the major stakeholders, such as the private sector, community level authorities, and communities. The assessment in itself can be a powerful tool for raising public awareness.
3. Assess current knowledge, attitudes, and practices. Segment the audience to develop and deliver specific target group oriented messages. These messages must be based on the present knowledge, attitudes, and practices in order to be relevant.
4. Conduct audience research and segmentation. Segmentation of audiences and their communication needs is essential for effective communication. Priority targets in the short-term are those who make and influence decisions (such as policy-makers, sector professionals, local government staff, and communities/users). Usually the local government has to take responsibility for action and play a leading role.
5. Find the right incentives It is necessary to find the right incentives for each target group to better mobilise people to become vested in the management of wastewater.
6. Set verifiable goals. Reach agreements on specific operational goals that are realistic and achievable in a specified period. It is best to involve the main stakeholders in setting goals and in developing and agreeing upon verifiable indicators.
7. Build alliances. Identify and mobilise potential partners for political and financial support. Approach every stakeholder connected with waste management, including legislative bodies, NGOs, industries, religious leaders, the media, community and professional groups.

4 APPROPRIATE FINANCIAL MECHANISMS

Summary

The key problem in financing wastewater programmes is that low and middle-income countries cannot afford capital-intensive conventional, engineered solutions. The financial system to recover cost should balance the three critical and interrelated aspects of sustainable wastewater management: quality of the service, the investment costs, and the tariffs that households are willing and able to pay. It should ensure that citizens receive an adequate wastewater management service sensitive to their ability to pay and to their contributions to pollution. The "water user pays" and "the polluter pays" principles are prerequisites for achieving sustainable wastewater management. Partnerships between the public sector and the private sector are discussed as potentially useful tools to assist local governments in financing and operating the infrastructure for wastewater management[2].

4.1 Cost recovery mechanisms

Balance service quality, investment and tariffs

The target levels for water quality and wastewater management determine the required investment. The investment level, with its operational and maintenance costs, determines the costs that need to be recovered through - a combination of - tariffs or taxes. Cost recovery again determines the service level that can be provided and the associated water quality objectives that can be realised. Recognising the different needs of the different users and selecting the technical and institutional solution for which those users are willing and able to pay are prerequisites for optimising revenue.

Various cost recovery mechanisms or economic instruments can be applied to cover (at least) the operational costs of urban sanitation and wastewater treatment. These include charges to direct users, effluent charges, and indirect local taxes (Table 4.1). High user charges may encourage industries to treat their wastewater flows to ensure that they are suitable for discharge to surface waters. However, high tariffs may induce (illegal) discharges outside of the wastewater system. In some countries, the costs of overall water management in a river basin are shared among the users and polluters.

Encourage co-financing

Enforcing these mechanisms requires an efficient revenue collection system; raising awareness that people pay for a service delivered to them rather than imposing a penalty for disposing waste may assist in the efficient collection of revenue. Use charges or pollution fees to establish funds for the co-financing of wastewater treatment facilities, instead of considering these revenues as taxes that enter the national budget. To ensure accountability and transparency, establish systems to ensure that tax revenues are allocated to the appropriate service provider.

4.2 Willingness to pay and cost sharing

Ensure equity

Any sustainable wastewater management programme must address the key issues of financing and cost recovery on the one hand and ensuring equity on the other. This concerns local community-based sanitation initiatives as well as large-scale programmes funded by international donor organisations. In most developing countries, a conflict will arise if sound financing is to mean full cost recovery and equity. In such cases, targeted subsidies are necessary from the rich for the poor, who cannot afford the service costs.

Many well-known case studies, such as those on PROSANEAR in Brazil, the Orangi Pilot Project in Pakistan, and Kumasi sanitation project in Ghana, have shown that people's willingness to pay for sanitation improvements is much higher than expected if they can select the type of sanitation system that they prefer. Table 4.2 lists the key features for success in this willingness to pay.

Households may be willing to pay for in-house sanitation facilities and for facilities that remove the wastewater flow from their property. However, individual households often do not directly perceive the more aggregate level benefits from wastewater services. Nevertheless, at the level of the block, neighbourhood, or city, households may collectively place high value on services that remove excreta from their area as a whole. The waste discharged from one city may pollute the water supply of a neighbouring city. Accordingly, groups of cities in a river basin, as well as farmers and industry, perceive a collective benefit from environmental improvement.

[2] UNEP/GPA organised a workshop on innovative financial arrangements in June 2001

TABLE 4.1 COST RECOVERY MECHANISMS

	Consumption-based user charges. User charges are levied upon the discharge of wastewater into the sewerage based on volume and/or characteristics of the effluent. The volume of discharged wastewater is directly related to the consumption of potable water. Consequently, the tariff is usually collected as a surcharge on the water consumption bill.
Use charges for co-financing wastewater treatment	**Effluent charges.** Can be based on the actual quality and quantity of wastewater, on a fixed amount per household, or, with regard to an industry, on a proxy based on verifiable information from an organisation (production or the number of employees). Effluent charges are applied in Western Europe, in some developing countries (Indonesia and Mexico), and in a few Eastern European countries. It is rather complex in design and implementation; it requires monitoring of effluents, the ability of authorities to assess appropriate tariffs, the capacity to implement appropriate billing systems and polluters' ability to change their behaviour.
Allocate tax revenues to appropriate provider	**Indirect local taxes.** Local governments may impose indirect taxes to generate revenue directly for the financing of wastewater systems (through surcharges on property taxes, in general, these are levied only on properties with access to the sewer system). The limitations are that revenues depend on the performance of the property tax system, which might not be (well) developed in low-income countries, while furthermore, the money collected from wastewater discharge is not always earmarked for water infrastructure (as it goes into the national treasury).
	Discharge permits. A responsible authority sets maximum limits on the total allowable emissions of a pollutant to a sewer or to the surface water. In the discharge permit, the charges or levies can be incorporated for cost recovery purposes. It requires monitoring of flow and quality effluents.

Ensure service sensitive to ability and willingness to pay

Costs assigned to each level in this hierarchy should be in accordance with the benefits accruing at each level (Wright 1997):

- Households should pay for most of the costs for on-site facilities, such as bathrooms, on-site sewer connections, and septic tanks.
- Residents of a block or neighbourhood collectively pay the costs of transferring collected waste to the boundaries of this block or neighbourhood (or in treating the neighbourhood's waste).
- Residents of a city collectively pay the additional costs of collecting waste from neighbourhoods and transporting these to the boundary of the city (or treating the cities' wastewater).

In addition, negotiations could lead to opportunities whereby the stakeholders in a river basin - cities, farmers, industries, and so on - collectively assess the value of different levels of water quality for which they wish to pay and agree on financial responsibility for the costs of treatment and water quality management. In coastal areas, stakeholders may include hotels and fisheries for which water quality has a high (commercial) priority.

Involve stakeholders

The participation of beneficiaries in the planning and decision-making process is essential. This method increases the sense of responsibility among the beneficiaries to pay the wastewater bills once the service is operating. In addition, the chosen solutions tend to be lower cost technologies (Box 4.1).

TABLE 4.2 KEY SUCCESS FACTORS IN WILLINGNESS TO PAY

1. Community members make informed choices, based on:
   - Their participation in the project
   - Technology and service level options, recognizing that more expensive systems cost more per member
   - When and how the services are delivered to them
   - How funds are managed and accounted for
   - How their services are operated and maintained.
2. An adequate flow of information is provided to the community and procedures are adopted to facilitate collective decisions within the community and between the community and other actors.
3. Governments play a facilitative role, set clear national policies and strategies, encourage broad stakeholder consultation, and facilitate capacity building and learning.
4. An enabling environment is created for the participation of a wide range of providers of goods, services, and technical assistance to communities, including the private sector and NGOs.

The "polluter pays" principle is a fair and straightforward concept, but, in practice, it has been extremely difficult to implement. There are categories of users unable or unwilling to pay for their contribution to pollution loads. For example, agriculture may well be the primary polluter in any large river basin, yet typically, the government will not attempt to charge or restrict agricultural operations. Furthermore, pollution from urban storm sewers (in either separate or combined systems) is usually ignored, and industries claim that they are unable to pay. An additional problem is formed by the lack of incentives that polluters face, due to inconsistently applied policies. These practices tend to distort the polluter pays concept. Unfortunately, the problem of major polluters not paying their share is typical worldwide.

Thus, in light of the increasing degradation of water quality and the coastal environment that threatens human health, concrete action with true partnership with the private sector should be encouraged, and changes in "business as usual" practices should be promoted. Furthermore, regulatory instruments should be developed to enforce the polluter pays principle and foster a willingness to pay among all polluters, including industry and government institutes.

Box 4.1 Cost sharing in the Orangi Pilot Project in Karachi, Pakistan (Serageldin, 1994).

In the 1980s, the 600,000 residents of the Orangi slum area had no access to the city's sewer system. A renowned community organiser began with a small amount of core external funding to explore alternatives. The residents were asked about their needs and wishes and some community members participated in the construction of facilities, which included in-house sanitary latrines and house sewers on each plot and underground sewers in the lanes and streets. Simple techniques and free labour reduced infrastructural costs to less than US$100 per household. Elected lane and neighbourhood managers manage the sewers, and households pay for the costs, partly in kind.

4.3 Investment options for infrastructure

Traditionally, investments for wastewater management infrastructure have been met solely from public finance mechanisms, foreign aid, or multilateral lending. However, these funding sources are not sufficient to meet the current challenges. Subsidies have often been used as a mechanism for financing this kind of infrastructure. Subsidies can help in certain areas, but they must be implemented with great care; subsidies often introduce undesirable side effects, such as creating dependencies and reaching the wrong target group, which may even be worse than the problem they were intended to solve.

Unlocking additional funding sources is now an important area of initiative if progress is to be made in managing wastewater sustainable. In this regard, the use of public–private partnerships offers new solutions. Appropriate partnership contracts between the public and private sectors can help in three ways. First, they can improve the self-sustainability of the system, second, they can open up routes to alternative and additional forms of financing, third, they also offer potential for innovative solutions and sharing of risk. Table 4.3 shows an overview of some of these options.

TABLE 4.3 INVESTMENT OPTIONS FOR INFRASTRUCTURE: FROM TRADITIONAL TO MORE COMPLEX INNOVATIVE

Type of financing	Characteristics	Constraints
Grant Finance Most of the existing wastewater infrastructure has been financed through allocations from national or local government budgets.	Helps to overcome the lack of household or community willingness to pay for pollution abatement that only benefits downstream communities. Permits systems to fully cover costs at lower tariff rates than would otherwise be feasible.	Lower tariffs reduce the incentive for households or industries to abate pollution. Reduces the pressure on municipalities to identify the most efficient solution to their problems, since they typically support only facility construction.
Through government or multilateral institutions Focuses on capital costs of wastewater collection and treatment facilities. Typically contains a subsidy component (below-market interest rates; or credit risk guarantees)	Long grace and repayment periods (compared to commercial loans). Matches the expected facility life to the loan period. Fewer incentive risks than grants, since they must be repaid (ultimate incentive effects depend on tariff structure)	

Type of financing	Characteristics	Constraints
a. International Financial Institution (IFI) Loans may provide low-cost project financing. Includes loan conditions (tariff structures, financial performance measures) designed to maximise incentives for efficient service.	Favourable terms (low interest margins or long repayment periods) In many cases, accepts the country credit risks (Lauren *et al.* 1995).	IFI loans require in many cases a sovereign guarantee. The denomination of IFI loans in a foreign currency exposes projects to a foreign exchange risk
Market financing ***a. Commercial banks*** Bank loans are secured by contracts and documentation to assure that funds will be used to support the project in the way intended, a mortgage (land, fixed assets)		Commercial banks typically require a public sector guarantee, which may not be available.
b. Bonds (municipal, int'l)	Traditionally, in the US, these bonds have a tax-exempt status that makes them attractive to creditors (and are, in fact, a form of subsidised finance).	Require a good name with respect to governance, a sound municipal fiscal policy, and adequate collateral or securitisation of risk to cover the foreign exchange risk and other risks involved (Allred, 1998).
Private capital A project pool structure that spreads risks over a number of projects; the primary source of repayment is not the cash flow from a single project, but rather, the performance of a number of projects. ***a. Revolving funds*** Financed from various sources to finance project costs. Subsequent repayments from the projects are then used to replenish the fund, permitting the funding of other investments. ***b. Equity funds***	***a. Revolving funds*** The large, diversified pool of borrowers spreads debt payment risks. Households, communities, and property investors may also apply revolving funds to finance on-site and local sewerage systems. In the sanitation sector, revolving funds are usually created with extensive government or donor involvement. ***b. Equity funds*** Mitigate project and country risk by creating a portfolio of projects under a company (Haarmeyer and Mody, 1998)	

International financial markets can be involved in financing various combinations of debt and equity. A potentially promising trend consists of transferring part of the responsibilities for infrastructure management to private partners to bring in capital as well as to gain from typical private sector virtues like managerial capacity, operational efficiency, and access to capital markets. Since 1990, the participation of private sector companies in water and sewerage projects in developing countries has accelerated. By cooperating with private companies, water and sanitation projects may benefit from the following advantages:

- Private companies are usually technically better qualified to manage the facilities efficiently, resulting in lower operating costs and more secure revenues
- Private companies have access to cheap, long-term financing.

Public–private partnerships in the water supply sector are more common than in wastewater management. Only about 14 percent of total private investment in water and sewerage is directed exclusively to the wastewater sector. About half of the total private funds have been allocated to investments in combined water and wastewater projects; however, in these projects, water supply usually has priority (Silva *et al*. 1998; World Bank 1997).

According to the WHO/UNICEF Global Water Supply and Sanitation Assessment (2000) the majority of urban water supply utilities are still publicly operated (Table 4.4). The options most commonly cited in the assessment where concessions and management contracts. Figure 4.1 illustrates the relative small annual investment in sanitation as compared to investment in water supply. In spite of these findings, there are strong economic, environmental, and health reasons for combining municipal wastewater and water system within a single contract.

TABLE 4.4 PUBLIC PROVISIONS OF URBAN WATER SUPPLY (WHO/UNICEF 2000)

Region	Median (%)
Africa	100
Asia	93
Latin America & Caribbean	92
Northern America	55
Oceania	90
Europe	90

Review frameworks that might impede PPP

As the role of the private company increases, stakeholder support and commitment, cost-recovering tariffs, information about the system (the utility's assets), and a developed regulatory framework become more important. In addition, political and economic stability are necessary for creating access to inexpensive, long-term (private) financing.

Ensure long-term effectiveness

On the basis of a review of twelve projects in the water sector, Leclerc *et al.* (2001) identified a series of criteria for solid implementation of public-private partnerships on the basis of case studies (Box 4.2). These criteria relate to the necessary prerequisites, implications of long-term commitments and incorporation of the local constraints, needs, demands and technical specifications.

Box 4.2 KEY LESSONS IN SETTING THE BASIS FOR A SUSTAINABLE PUBLIC-PRIVATE PARTNERSHIP (LECLERC *ET AL. 2001)*

Basic elements in creating sustainable partnership?

1. Make sure that ownership rights to contributed assets are clearly defined.
2. Strongly commit to the partnership by appropriate public legislation
3. Be aware that technical expertise is required to design the initial contract
4. Allocate risks realistically to reach a fair balance of risks and benefits among parties. Try to obtain commitments from multilateral institutions to secure funding
5. Propose clear investment procedures

How to engage in long-term partnership?

6. compliance with commitments in the long run, facilitated by local and national political stability
7. Implementation of appropriate legislation and setting up of regulatory agencies
8. Maintaining a transparent and ongoing dialogue

How to take local context into account?

9. Acknowledge the need for tariff flexibility, related to exchange, interest and inflation rates change but in range of variation compatible with population's affordability
10. Use local funding to respond to this type of financial issues
11. Adapt the project's investments to population needs and resources, to obtain water tariff which is acceptable for the local population
12. Plan a step-by-step involvement of the private sector in order to mitigate risk and adapt the contract to changes in the local situation

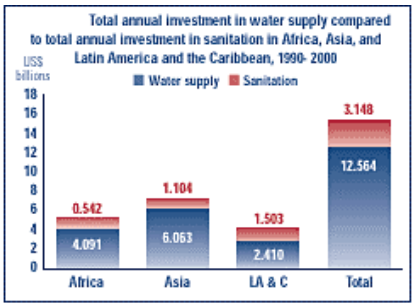

FIGURE 4.1 TOTAL INVESTMENT IN WATER SUPPLY COMPARED TO SANITATION (WHO / UNICEF 2000)

Tables 4.5 and 4.6 show the allocation of key responsibilities, and a concise overview of public-private partnership options, respectively. Service and management contracts and simple lease structures have proved to be rather successful tools in improving operational efficiency. However, they do not provide a means for service expansion or upgrading, for which substantial amounts of capital are required. Concessions, BOTs, and (partial) divestitures are means to raise funding for such investments.

A recent report by the OECD describes the multiple tasks required for municipalities, national governments, and international donors to increase the private investment options for urban water and wastewater services (Gentry and Abuyuan, 2000). Setting the water tariffs and performance standards, providing strong regulatory oversight, using market access controls, increasing public awareness, and addressing transitions are but a few of the important steps involved; thus, such partnerships require extensive preparation and should involve long-term co-operation.

TABLE 4.5 PRIVATE SECTOR PARTICIPATION: ALLOCATION OF KEY RESPONSIBILITIES UNDER THE MAIN OPTIONS (WORLD BANK 1997)

Option	Asset ownership	Operations & maintenance	Capital investment	Commercial risk	Typical duration
Service contract	Public	Public and private	Public	Public	1-2 years
Management contract	Public	Private	Public	Public	3-5 years
Lease	Public	Private	Public	Shared	8-15 years
Concession	Public	Private	Private	Private	25-30 years
BOT/BOO	Private and public	Private	Private	Private	20-30 years
Divestiture	Private or private & public	Private	Private	Private	Indefinite (may be limited by license)

Box 4.3 Concession in Buenos Aires, Argentina (Aguas Argentinas, 2000; Bennett, 1998; Haarmeyer and Mody, 1997; Panayotou, 1997).

The government of Argentina delegated Buenos Aires's water and sewage services through a 30-year full concession. It kept the assets under public ownership and transferred operation, maintenance, and wastewater treatment to a private concessionaire. The government established a regulatory agency to regulate and control the concession. Performance targets included, among others, 90% coverage in the sanitation sector by year 30, a reduction of unaccounted-for water from 45% to 25%, and an increase in sewage treatment to 93%. During the first 6 years of operation, sewage treatment plants were extended and newly built allowing a 40% increase in treatment capacity of effluent. The sewerage treatment services increased with 23%, while the number of people served with drinking water increased by 33%. Investments financing: 40% equity funds and 60 percent loans (debt).

TABLE 4.6 TYPES OF CO-OPERATION IN PUBLIC-PRIVATE PARTNERSHIPS: FROM SERVICE CONTRACTS TO DIVESTITURE (**WORLD BANK** 1997)

Type of partnership	Characteristics	Constraints
Service contracts Specific components are out-contracted to the private sector, but government retains responsibility for operation and maintenance of the system.	Examples of service contracts are the operation of a treatment plant, billing, and collection operations (Bennett 1998)	
Management contracts Responsibility for the entire operation and maintenance is transferred to contractor.	Payments can be a fixed fee, but are usually related to the achievement of performance targets. This creates an incentive for increasing productivity (Idelovitch & Ringskog 1995).	Setting, monitoring, and evaluating of targets is difficult. The achievement of targets may be related to capital investments, which are not the responsibility of the private contractor.
Lease contracts A private operator is responsible for operating, maintaining, and managing the system, including revenue collection for rented assets.	The government remains the sole owner of the assets and is responsible for expansion and upgrading investments, debt service, and tariff setting and cost recovery policies.	Lease contracts are particularly beneficial if no substantial capital investments are required; thus, they are not popular in the wastewater management sector.
Concessions The concessionaire has full responsibility for the delivery of infrastructure services: operation, maintenance, system expansion, collection of revenues and fundraising for	The concessionaire has strong incentives to make efficient investment decisions and to develop innovative technological solutions, since any efficiency gains will directly increase its profits. Full utility concessions	A critical factor is the quality of regulation, as it concerns a long-term monopolistic position of the concessionaire.

Type of partnership	Characteristics	Constraints
investments. The government is responsible for establishing and enforcing performance targets	are attractive where large investments are needed to expand coverage of the service or to improve quality.	
Build–Own–Transfer (BOT) contracts[3] The private sector finances, builds, and operates a new facility according to the governmental performance standards. Government retains ownership of the facility. In the construction period, the private sector provides the investment capital required. In return, the government guarantees the purchase of a specified output.	The operation period should be long enough for the contractor to recover its construction costs and to realise a profit. The agreements mitigate commercial risks for the private sector, because the government is its only customer. Thus, BOTs are financed with a relatively high debt component.	Contracts do not apply to existing infrastructure, and therefore do not tackle the deficiencies and turn financially weak utilities into strong ones. Length and complexity of the agreements: most BOTs have to be renegotiated once they are underway. The size and time frames of the contracts often require sophisticated and complicated financing packages (Bennett 1998; Haarmeyer and Mody 1997)
Divestiture Full divestiture pertains to a situation where the utility has been fully privatised. Ownership of the utility rests with the private operator. The private operator is responsible for operation and maintenance, investments and tariff collection. Regulation is completely separated from the ownership and operation.	Improved incentives for efficient investment decisions and the development of innovative technologies; Low transaction costs compared to the costs of tendering and contract negotiations associated with the models discussed above.	Possible conflict of interest as public sector is responsible for regulation (safeguarding public interests) and as company shareholder responsible for maximising returns, could lead to political interference and counteract private sector management advantages. Absence of competition (no tendering) can raise transparency and corruption concerns.

[3] Variations on the BOT model include: BOO (Build–Own–Operate: assets are not transferred); ROT (Rehabilitate–Operate–Transfer: investment in rehabilitation); Reversed BOOT: government responsible for asset construction, private company for operation; DBO (Design–Build–Operate: private company also conducts investment design).

5 SUSTAINABLE COST-EFFECTIVE TECHNOLOGIES

Summary

The high cost of wastewater treatment warrants a very careful search for low-cost and more sustainable technologies that target pollution prevention, water conservation, and the efficient use of water. Because of the wide variations encountered in coastal systems it is not possible to prescribe a particular technology or approach on an international level that will address all water quality issues at all locations satisfactory. Any such approach would necessarily fail to protect resources in some coastal areas and would place excessive and unnecessary requirements on others. A stepwise approach to technology selection is outlined, addressing pollution prevention, on-site treatment, off-site transportation and treatment, with natural treatment, reuse and finally, conventional treatment

5.1 Wastewater Treatment Technology

The selection of treatment technology is an essential step in any wastewater management strategy. The technology should be environmentally sound, appropriate to local conditions, and affordable to those that must pay for the services. The selection process should be combined with awareness and behaviour changes, regulations, and enforcement, and should be applicable and efficient within the context of the whole river basin. The average performance of a technology, its reliability (under variable wastewater flows and compositions and operational problems), its institutional manageability (planning, designing, construction, operation and maintaining capacity, including the local availability of skilled human resources), and required investment, operation, and maintenance costs are other aspects to be considered.

Various overviews on the selection, design, construction, operation, and maintenance of on-site and off-site wastewater collection and treatment systems are available (eg. Metcalf and Eddy 1991; Viessman and Hammer 1993; GHK 2000). UNEP's International Environmental Technology Centre (UNEP/IETC) offers an Internet-accessible database for environmentally sound technologies to address urban environmental problems and the management of freshwater basins[4].

Introduce appropriate strategy

As the water consumption per capita increases, sanitation becomes increasingly water-based. Septic tanks can be introduced as a decentralised, on-site treatment system. Septic tanks do not provide a sufficient degree of treatment for improvement to receiving water quality. Therefore, discharge of septic tank effluent directly to a watercourse is not acceptable. In urban areas with higher water consumption rates and population densities, wastewater collection is often required and the collected wastewater must be treated off-site in centralised systems. The most appropriate technology for a given wastewater depends on the receiving water quality requirements. Conventional mechanised treatment technologies do therefore not necessarily provide better treatment efficiency than natural treatment systems. Low-cost, natural systems are easy to operate and virtually maintenance-free and therefore always recommended over mechanical systems where they would be effective and space would be available.

5.2 Sanitation Technology Approach

The approach to sanitation technology selection considers the following options sequentially: pollution prevention, on-site treatment, off-site transportation coupled with natural treatment and/or reuse and finally, if all other options are exhausted, conventional treatment (Table 5.1)

Step 1: Pollution prevention

Segregate industrial effluents

Pollution prevention[5] aims at reducing and preventing pollution at its source. It minimises the use of resources and thereby reduces the amount of waste discharged into the environment. Industries have implemented a wide variety of pollution prevention measures, and a large number of successes have been documented in recent years (see, for example, the website of the UNEP Cleaner Production Program)[6]. Industrial adoption of cleaner production technologies can reduce or even eliminate the need for investment in end-of-pipe treatment technology. As a rough guide, 20 to 30 percent reductions in pollution can often be achieved without requiring any capital

[4] Internet: http://www.unep.org.jp/
[5] Other regularly used terms are cleaner production, waste prevention or minimisation, and source reduction
[6] Internet http://www.unepie.org/

investment, and additional reductions of 20 percent or more can be achieved with investments that have a payback period of only a few months (World Bank 1998). Water demand management through reducing domestic water consumption rates is a very effective way of reducing wastewater treatment costs (Box 5.1).

BOX 5.1 BENEFITS OF POLLUTION PREVENTION IN MUNICIPAL WASTEWATER

1. Reduction of domestic water consumption and generation of higher strength, better treatable wastewater
2. Smaller, lower cost water supply and wastewater systems required
3. Possible recovery and use of waste components (through separate collection systems)
4. Stimulates development of dry sanitation systems
5. Effective reuse of wastewater of different quality for different purposes

The original expansion proposal of the wastewater treatment capacity for Seoul and Pusan (South Korea) was based on the projected growth of tap water consumption from 120 to 250 litres per capita per day. When the costs of such expansion appeared too high, investments were made to promote water savings in households. This eventually allowed the design of sewers and wastewater treatment plants to be scaled back by half (VEENSTRA *ET AL.* 1997)

Step 2: On-site treatment

After having ensured that pollution is prevented to the largest possible extent, on-site treatment should be considered as the second step. On-site sanitation is effective when little or no piped water is available. It consists of on-site systems for wastewater collection and treatment at the level of a household, a community, or an apartment block. Package plants are used mostly for resorts, hotels, and other public buildings.

On-site systems use either a septic tank or a pit for collection (Table 5.2). The congested nature of many peri-urban settlements restricts the space available for pit latrines and septic tanks. Furthermore, in densely populated areas, the volume of generated wastewater may exceed the capacity for ground infiltration. The additional risks of ground water pollution and soil destabilisation (affected by factors such as ground porosity, slope, and high water tables) often necessitate wastewater collection and centralised treatment. Depending on the local physical and socio-economic conditions where central wastewater collection systems are not economically feasible, on-site sanitation may therefore be feasible only for lower density towns, city districts, and rural areas.

Step 3: Wastewater collection and stormwater drainage

Off-site options should be considered when on-site treatment could entail direct risks to health or to ground water, or risk the faecal contamination or eutrophication of coastal waters, as in more densely populated areas. Centralised treatment systems require wastewater collection and transportation through a sewer system. Combined sewer systems carry wastewater and stormwater in the same conduit. Separate systems transport stormwater and wastewater through separate stormwater drains and sanitary sewers respectively.

TABLE 5.1 SANITATION TECHNOLOGY APPROACH (ADAPTED FROM VARIS AND SOMLYODY 1997)

1. Start with pollution prevention.
2. Use on-site treatment and reuse
3. Use off-site transportation: wastewater collection and stormwater drainage.

4.a Apply Natural treatment systems: The use and/or stimulation of the natural self-purification capacity of receiving water bodies.

4.b Consider reuse options and waste valorisation: using simple technology and ecological engineering for the conversion of wastewater into resources.

5. Install conventional off-site wastewater collection and centralised, high technology, end-of-pipe treatment

For both collection systems, the construction costs are relatively high, depending on slopes, soil, and ground water level. The unit costs for wastewater collection decrease with higher population densities. Gravity sewers are preferred because of their lower operation and maintenance costs compared to pumped systems. Veenstra et al. (1997) note that gravity wastewater collection become economically feasible at population densities of 200 to 300 persons per hectare in developing countries, and at 50 people per hectare in industrialised countries

Intermediate wastewater collection technologies can be applied where conventional wastewater collection systems may be difficult and expensive to construct in densely populated, low-income areas. Small PVC pipes connected to septic tank overflows allow easy construction in rocky surfaces and prevent damage due to soil instability, while virtually eliminating infiltration. The

operation and maintenance of these small bore systems is labour-intensive and requires community involvement. One possible problem arises if septic tanks are not desludged regularly, or if only the liquid is removed; this leaves the solids in the tank until they overflow, possibly causing the blockage of small sewers. This poses additional public health risks if the overflowing septic tanks are illegally connected to public, open drains or sewers. A number of successful examples of small bore wastewater collection projects in Brazil, Colombia, Egypt, Pakistan, and Australia is available (Veenstra *et al.* 1997). UNEP (1998) presents a decision trees for on-site sanitation.

TABLE 5.2 ON-SITE WASTEWATER TREATMENT SYSTEMS

Collection characteristics. Septic tanks and pit latrines are low-cost technologies that allow construction, repair, and operation by local communities or homeowners and effectively reduce public health problems related to wastewater are. A septic tank is a watertight tank that collects wastewater from toilets, showers, sinks, and other household utilities through a pipe, solids settle on the bottom. In a pit latrine, the solids settle but the liquid seeps directly into the soil.
Treatment Characteristics The liquid flows out of the septic tank into a drainage field or overflows into a drainage system. The required effluent disposal area depends on flow rate and local soil infiltration. The effects of these flows on the quality of the ground water must be considered. Accumulating solids have to be periodically removed from the tank. In properly designed septic tanks with soil absorption of the liquid flows, the soil will remove the remaining BOD, suspended solids, bacteria, and viruses from the effluent.
Selection criteria Population density (number of people per hectare); Produced wastewater volume (in cubic meters per hectare per day); The presence of shallow water wells susceptible to wastewater pollution; Soil permeability; Unit cost of wastewater collection; socio-economic and cultural considerations.

Stormwater
Although the pollution load of stormwater is generally lower than that of municipal wastewater, it may contain as much solids as domestic wastewater, depending on the debris and pollutants in the path of stormwater run-off (data in Table 5.3). Stormwater pollution sources are chemical spills, particulates from motor vehicle exhaust and deposition of atmospheric pollutants. During heavy storms, combined sewer overflows containing a mixture of stormwater and municipal wastewater can seriously contaminate the surroundings and the receiving – coastal – environment. Heavy storms can result in flooding, causing the stormwater to spread litter and solid wastes. Stormwater drains often function as solid waste disposal areas. The lack of solid waste removal from these drains affects their functioning and leads to flooding.

TABLE 5.3 COMPOSITION OF DOMESTIC WASTEWATER AND STORMWATER (VEENSTRA *ET AL.* 1997, IETC 2000)

Parameter		Domestic wastewater[1] (Veenstra *et al* 1997)	Urban stormwater (Novotny and Olem, quoted in IETC 2000)
TDS	mg/l	400 – 2,500	
TSS	mg/l	160 – 1,350	3 – 11,000
BOD	mg/l	120 – 1,000	10 – 250
COD	mg/l	280 – 2,500	
Kj-N	mg/l	30 – 200	3 – 10
Total-P	mg/l	4 – 50	0.2 – 1.
Coliforms	/100 ml	10^4 - 10^6 (faecal)	10^3 – 10^8 (total)

[1] based on domestic water composition rates between 60 and 250 L/c.d

The stormwater flow during rain storms can be attenuated through the use of basins and ponds, allowing control of flows downstream of these basins or ponds. Basins and ponds also act as infiltration devices. Detention time is of the order of two to three weeks. Run-off water quality is improved upon storage in basins or ponds because of sedimentation of solids, bacterial action and nutrient uptake by vegetation. Water stored in ponds can also be used for irrigation of parks and gardens or for fire-fighting and other purposes.

Step 4a: Natural treatment systems
The use of the cleaning capacity of natural systems should be considered as the next step for the treatment of the collected wastewater. In areas with higher population densities, it is feasible to develop a local collection system and use a single facility to treat the community's waste. Lagoons and stabilisation ponds are inexpensive, common biological treatment options with low operational

costs. They are being used, for example, in mid-sized communities in the wider Caribbean region (UNEP 1998). The treatment is stimulated by self-purification of the natural ecosystems and water bodies or by stimulating these natural, biological processes in effective, low-cost, engineered systems.

The capacity for nutrient removal may not be adequate for densely populated areas near eutrophication-sensitive estuaries or near coral reefs. In these cases, more conventional natural treatment options may be required. Such systems are operating in both developing and industrialised countries for the conversion of wastewater into useable resources. Marine wastewater outfalls are an example of natural self-purification based technology. Raw and pre-treated wastewaters are discharged in coastal waters, deep and dynamic enough to achieve a proper dilution.

Box 5.3 ECOLOGICAL ENGINEERING

WASTEWATER–FED AQUACULTURE.

The world's largest example of wastewater-fed aquaculture is the Calcutta wetland system, located immediately east of the city (Edwards and Pullin, 1990). The wetlands receive about 550,000 cubic meters of untreated wastewater per day, which flows through about 3,000 hectares of constructed fishponds within the wetlands area. The annual fish production amounts to 13,000 tons (mainly Indian Major Carp and Tilapia), which is supplied to fish markets in central Calcutta and consumed in the wider region.

DUCKWEED-BASED WASTE WATER TREATMENT

A small-scale, duckweed-based pond to treat domestic wastewater has been operated for more than 10 years (Gijzen and Ikramullah, 1999). The protein-rich duckweed biomass is harvested daily and fed to adjacent fishponds, which yield an annual fish production of 12 to 16 tons per hectare. A detailed financial evaluation of the wastewater treatment and aquaculture facility suggests that this is probably the first system that is able to generate a net profit from the treatment of domestic wastewater. This is possible because the low-cost treatment is combined with revenue generating aquaculture.

Step 4b: Reuse options and waste valorisation

While considering the use of the cleaning capacity of natural systems, the reuse of wastewater and wastewater products should also be considered. A main problem with wastewater treatment is that the result obtained after treatment is not widely recognised as a valuable product. This may explain in particular why many 'low-cost' wastewater treatment systems are poorly maintained and eventually become inactive. If the treatment process itself, in addition to the purified effluent, generates valuable products, it would create an important incentive to optimise the operation and maintenance of the treatment plant. There are numerous examples of effective reuse or resource recovery from wastewater achieved in so-called integrated systems.

Integrated systems combine processes and practices to optimise the use of resources by recycling waste, to recover and reuse energy, nutrients, and possibly other components. The conversion processes for different sources of waste are arranged so that minimum inputs of external energy and raw materials are required and maximum self-sufficiency is achieved.

In rural Asia, integrated systems are an old concept that has been applied for hundreds or probably even thousands of years. In China, for example, there are huge farms that are almost completely self-sufficient in terms of energy and nutrients because of the effective recycling of their waste streams. Box 5.3 presents examples of effective reuse and waste valorisation, and low-cost and land intensive systems that could be attractive, especially in low- and middle-income countries. The application of integrated concepts provides a good balance between resource use and reuse and environmental protection.

Box 5.2 CRITERIA FOR NATURAL TREATMENT SYSTEMS

- The potential to generate useable resources
- The price and availability of land, as they require greater land area than conventional processes
- The possibility of reducing retention time by stimulating natural conversion processes and / or by anaerobic pre-treatment

To prevent toxic components from polluting the bio-solids or sludge, the components should be retained at the source as much as possible. The then–clean bio-solids can be used in agriculture to improve of the structure of the soil and as fertilizer.

The long-term approach to sustainable sanitation requires a thorough re-thinking of the current concept of high quality water supply and centralised high-tech wastewater treatment (Vision 21 2000). Measures could aim at the effective recovery of nutrients and energy from wastewater by re-organising the current concept of water supply and sanitation. Innovative options in environmental sanitation such as the development of (high-tech) dry or semi-dry sanitation services could provide completely new perspectives for energy and nutrient recovery (Box 5.4).

Step 5: Conventional treatment
Only after all of the options described above have been considered and rejected, the use of conventional systems should be considered. The development of the 'Western' conventional wastewater management concept originated in the 19th century with the prime objective of preventing waterborne diseases. This has been achieved by selecting clean water resources and by developing effective systems for water treatment and the distribution of potable water. Consequently, large volumes of clean drinking water are used to transport human waste out of the city. Since the large-scale introduction of centralised water supply and wastewater collection infrastructure, cities in countries with a high gross national product have been essentially free of waterborne diseases.

Conventional wastewater collection and disposal systems:

- Aim to control the transmission of waterborne diseases and to prevent degradation of the environment
- Require large volumes of diluted wastewater, collected by an extensive sewer system and treated in modern, centralised treatment works
- Require large investments, highly skilled labour, and stable socio-economic conditions
- May increase the risk of waterborne diseases if collection of wastewater is not combined with effective end-of-pipe treatment.

The main aim of off-site wastewater treatment is to reduce biochemical oxygen demand (BOD) and suspended solids (SS) to acceptable levels. The different treatment systems achieve the removal of solids and in providing oxygen in different ways. Heavy metals and other pollutants are not generally a problem in domestic wastewater, unless the sewerage system receives industrial discharges. Conventional treatment systems can be classified as primary, secondary and tertiary processes. Primary or mechanical treatment consists of screening and grit removal to eliminate sand, gravel and other coarse solids from the influent wastewater stream, followed by a gravity separation process to remove settleable suspended solids.

Conventional secondary, biological treatment is directed at the removal of soluble biodegradable organic matter by biological degradation. Secondary treatment processes can be aerobic or anaerobic or a combination of the two. Activated sludge, the rotating biological contactor and the trickling filter are the most common examples. The activated sludge system is a versatile system offering operational flexibility and high reliability. It allows integration of nutrient removal processes, such as nitrification, denitrification and biological phosphorous removal. Although trickling filters are more easily operated and consume less energy than activated sludge processes, they have lower removal efficiency for solids and organic matter, they are more sensitive to low air temperatures, and can become infested with flies and mosquitoes. Trickling filters have no capacity for nutrient removal. Rotating biological contactors are frequently used for small wastewater flows, such as from hotels and small compounds.

Compared to aerobic treatment, anaerobic treatment has high loading capacity, requires little energy input and produces low volumes of - well-stabilised - sludge. It is applicable at small and large scale and offers a possibility for on-site sanitation systems. Post treatment is however required to meet discharge standards. Anaerobic treatment is basically a pre-treatment method that has been extensively used in the treatment of industrial wastewaters of high organic strength. The application of anaerobic wastewater treatment for domestic wastewater in tropical regions is tested (Mara *et al.* 1993).

Tertiary treatment is directed at the removal of nutrients (nitrogen and phosphorous). Phosphorous removal processes involve either the addition of chemicals to precipitate

Box 5.4 ECOLOGICAL (DRY) SANITATION

The possibilities for re-use of specific components present in sewage can be positively influenced by re-organising the collection of domestic sewage. Larsen and Guyer (1996) proposed the collection of urine, referred to as anthropogenic nutrient solution (ANS), at the source and to release it into the existing sewer sequentially. In this way, a substantially enriched nutrient fraction is produced, which can be processed into high quality fertiliser in a central handling facility. A general trend has been that technology developed in industrialised countries will be copied in developing nations under conditions of growing economies. Interest in ANS management in 'western' countries would therefore possible further stimulate the development of existing ANS strategies in China and other developing countries

Web sites related to ecological sanitation:
http://www.undp.org/seed/water
http://www.wkab.se
http://www.laneta.apc.org/esac/drytoilet.htm

phosphorous or controlled biological reactions to grow bacteria with high phosphorous levels and settle them out. Nitrogen removal is based on biological reactions to convert ammonium and organic nitrogen into nitrate (nitrification) and then into gaseous nitrogen (denitrification).

Economies of scale can play a role in designing conventional wastewater management and infrastructure. This is because of the physical and technical characteristics of treatment technology and water pollution. The consequent incentive to centralise the capacity of treatment plants is balanced by the increasing cost of transporting wastewater over longer distances. Planning wastewater treatment based on the administrative boundaries of small municipalities rarely makes sense. On the other hand, regional co-operation among municipalities or other local government creates major financial gains and offers stronger "win-win" options than it does in any other sector. Large plants serving more than 300,000 people are also able to invest in technologies that substantially lower the operational costs for maintenance, energy, and sludge disposal. For example, only large plants can invest in sludge digestion reactors with methane gas recovery and gas-powered generators. Enough electrical power can then be generated to supply all of the power required by the plant, which is often the largest recurrent operational expenditure. Similarly, it usually makes technical and, thus, financial sense to combine domestic and most industrial (pre-treated, not heavily polluted) wastewater streams.

Box 5.5 SAMPLE CHECKLIST FOR COST-EFFECTIVE MUNICIPAL WASTEWATER INVESTMENTS (WORLD BANK 1998)

1. Have measures been taken to reduce domestic and industrial water consumption?
2. has industrial wastewater been pretreated?
3. is it possible to reuse or recycle water?
4. can the proposed investment be analysed in a river basin context? If so, have the merits of this investment been compared with the benefits in other parts of the river basin? Note that a least-cost strategy for achieving ambient water quality may involve different (or no) technologies at different locations
5. Has the most cost-effective technology been used to achieve the desired improvement in ambient water quality?
6. Has an economic analysis been done to asses the benefits (in terms of ambient quality) that could be achieved by phasing in investments over, say, 10 or more years?

Sludge Management

Removing pollutants from wastewater results in the production of sludge, which requires treatment – stabilisation - before its disposal. Sludge stabilisation by digestion is the process of BOD reduction that can be carried out under aerobic or anaerobic conditions. Aerobic stabilisation requires less energy when carried out as part of a composting process. Anaerobic digestion produces biogas, a mixture of methane and carbon dioxide. Anaerobic digestion is the most commonly used process for sludge treatment. Digested sludge requires de-watering before its final disposal. If concentrations of the heavy metal and toxic organics are below the admissible standards, the de-watered sludge can be applied as soil amendment; if concentrations exceed these standards, the sludge is placed in landfills or is incinerated. The assessment of the sludge quality requires an adequate monitoring system.

Industrial wastewater frequently contains non-biodegradable pollutants and requires physico-chemical treatment (chemical coagulation and flocculation). Therefore, industrial sludge is often heavily contaminated and not fit for reuse. Treatment of municipal wastewater sludge contaminated with heavy metals or toxic chemicals will be more difficult and the potential for re-use of the sludge will be limited. It is therefore essential to separate industrial from domestic wastewater or (pre-)treat industrial wastewater on-site, prior before discharge into the sewer.

Urban wastewater management

In many urban situations, both the municipal sewage system and industrial wastewater treatment are inadequate. A municipal sewage network may be in place, but coverage is usually incomplete and the level of treatment provided is inadequate. Even where reasonable treatment facilities exist, poor maintenance and operation often result in failure to meet design effluent levels. From an environmental (as distinguished from the sanitation) point of view the focus must be on the receiving water bodies. Upgrading or extension of the wastewater collection system may reduce diffuse pollution but may produce major point discharges that must receive adequate treatment to avoid discharges into the, coastal marine, environment. Box 5.5 presents a World Bank (1998) checklist for cost-effective urban wastewater investments that follows the pollution prevention approach.

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