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Improving Municipal Wastewater Management in Coastal Cities

- Objective oriented planning
- Innovative technologies and financial approaches
- Stakeholder involvement
- Presentation techniques

UNESCO-IHE
Institute for Water Education

UNEP GPA

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Training Manual

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The Governments of Ireland, The Netherlands and Belgium contributed to the funding of both development and delivery of this course in wastewater management.

UNEP/GPA - UNESCO-IHE
Train-Sea-Coast GPA

Improving
Municipal Wastewater Management
in Coastal Cities

A Training Manual for Practitioners

focussing on

- **Objective Oriented Planning**
- **Innovative Technological and Financial Approaches**
- **Stakeholder Involvement**
- **Presentation Techniques**

Foreword

GPA is the only global action programme addressing the interface between the freshwater and coastal environment. One of the problems the GPA addresses is the uncontrolled discharge of wastewater into the freshwater and coastal environment. A priority also identified by UNEP and reconfirmed at the 2002 Millennium Summit and the World Summit on Sustainable Development.

Indeed in many parts of the world sewage is still discharged directly into open water without treatment. Such uncontrolled discharge is one of the most serious threats to the productivity and biodiversity of the world's oceans. At the same time it causes serious environmental and human health problems and threatens sustainable coastal development.

In response to the daunting challenge faced by many governments in addressing wastewater problems, the GPA has developed training for municipal wastewater managers, jointly with UNESCO-IHE Institute for Water Education and the UN/DOALOS Train-Sea-Coast Programme.

The training provides participants with analytical tools, substantive information and skills on how to select, plan and finance appropriate and environmentally sound municipal wastewater management systems. The training is meant for project managers at municipality level, mandated with the task to develop and manage municipal wastewater collection and treatment systems with often very limited resources. The course focuses on four elements: (i) objective oriented planning, (ii) involvement of stakeholders and mobilizing local resources, (iii) conventional and innovative approaches; and (iv) formulation and presentation of proposals.

The content is based on the UNEP/WHO/HABITAT/WSSCC guidelines on municipal wastewater management and stresses the need to link water supply and the provision of household sanitation, wastewater collection, treatment and re-use, cost-recovery, and re-allocation to the natural environment.

UNEP and its partners are pleased to present this first version of the training manual. UNEP very much welcomes comments to ensure that the course addresses the needs of coastal municipalities.

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The Governments of Ireland, The Netherlands and Belgium contributed to the funding of both development and delivery of this course in wastewater management.

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In 2003 a pilot course was developed and delivered in Zanzibar, Tanzania. Based on the experiences and with support from the UN/DOALOS Train-Sea-Coast Programme a team of experts was formed to upgrade the course to Train-Sea-Coast standards. The GPA Coordination Office wishes to thank all those who assisted in the development and production of this training, the participants of consultative meetings, the pedagogic experts who developed the curriculum, Train-Sea-Coast Brazil for their pivotal role in reviewing, editing and packaging the content, and the Western Indian Oceans Marine Science Association (WIOMSA) for conducting the initial regional training needs assessment and their important contributions in arranging the first two course deliveries in East Africa.

This document is handed out to participants of the training. It is supplementary to a fully documented instructor's manual including all presentations, tests and descriptions of the group work that enables cost-effective and instructor independent course delivery.

More information about this capacity building initiative are shared at the GPA Clearing House Mechanism at an inter-agency training web site (http://www.gpa.unep.org/training).

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INTRODUCTION

This chapter serves as an introduction into municipal wastewater-related problems in coastal areas and the role of UNEP/GPA and the Guidelines on Municipal Wastewater Management in addressing these problems. The objectives and outline of the course will be presented and instructors and participants will get the opportunity to introduce themselves and to express their expectations.

The introduction consists of the following parts:

I. Impacts of municipal wastewater in coastal zones
II. Coverage of water supply and sanitation
III. Targets on water and sanitation and guidelines on municipal wastewater management
IV. Objectives and outline of the course

INTRODUCTION

I. IMPACTS OF MUNICIPAL WASTEWATER IN COASTAL ZONES

1. MUNICIPAL WASTEWATER COMPOSITION
2. IMPACTS OF MUNICIPAL WASTEWATER
3. OUT OF SIGHT-OUT OF MIND?

II. COVERAGE OF WATER SUPPLY AND SANITATION

III. TARGETS ON WATER AND SANITATION AND GUIDELINES ON MUNICIPAL WASTEWATER MANAGEMENT

IV. OBJECTIVES AND OUTLINE OF THE COURSE

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INTRODUCTION

I. Impacts of Municipal Wastewater in Coastal Zones

About 75% of the earth is covered with water, of which ca 97% is marine. Oceans play a crucial role in, amongst others, global bio-geochemical cycles, in regulation of the climate and in the provision of food to sustain human populations. In particular people living in coastal areas in developing countries depend on marine food as their major source of proteins (capture fisheries, aquaculture). Moreover, coasts provide numerous opportunities for recreation, making them important areas for the development of tourist facilities; industries and other commercial activities are attracted by the possibilities coastal areas provide for the transport of raw materials and products (development of harbours) and the disposal of wastewater.

Therefore it is not surprising that coastal zones are heavily populated. It is estimated that nearly half of the world population lives within 100 km of a coastline, many of the world’s mega cities are situated in coastal areas and there is a trend towards increasing migration of people to coasts (Hinrichsen 1998, GESAMP 2001). This has put enormous pressure on fragile coastal ecosystems and continues to threaten the sustainable use of its precious resources. Coastal and marine habitats are altered or destroyed, natural resources are overexploited and pollution and eutrophication are now widespread phenomena. Another threat comes from human activities farther inland. The prevailing ‘out of sight-out of mind’ attitude with respect to the disposal of waste in particular affects coastal zones, being the ultimate recipients of pollutants and sediments originating from land-based human activities (Figure 1).

In a series of regional consultative meetings with government designated experts, *UNEP’s Global Programme of Action for the Protection of the Marine Environment from Land-based Activities* (UNEP/GPA), has identified wastewater-related problems as one of the major problems in coastal zones throughout the world. In particular municipal wastewater discharges are considered as one of the most significant threats to sustainable coastal development (UNEP/WHO/HABITAT/WSSCC 2004), affecting human health as well as environmental quality aspects, both resulting in economic losses.

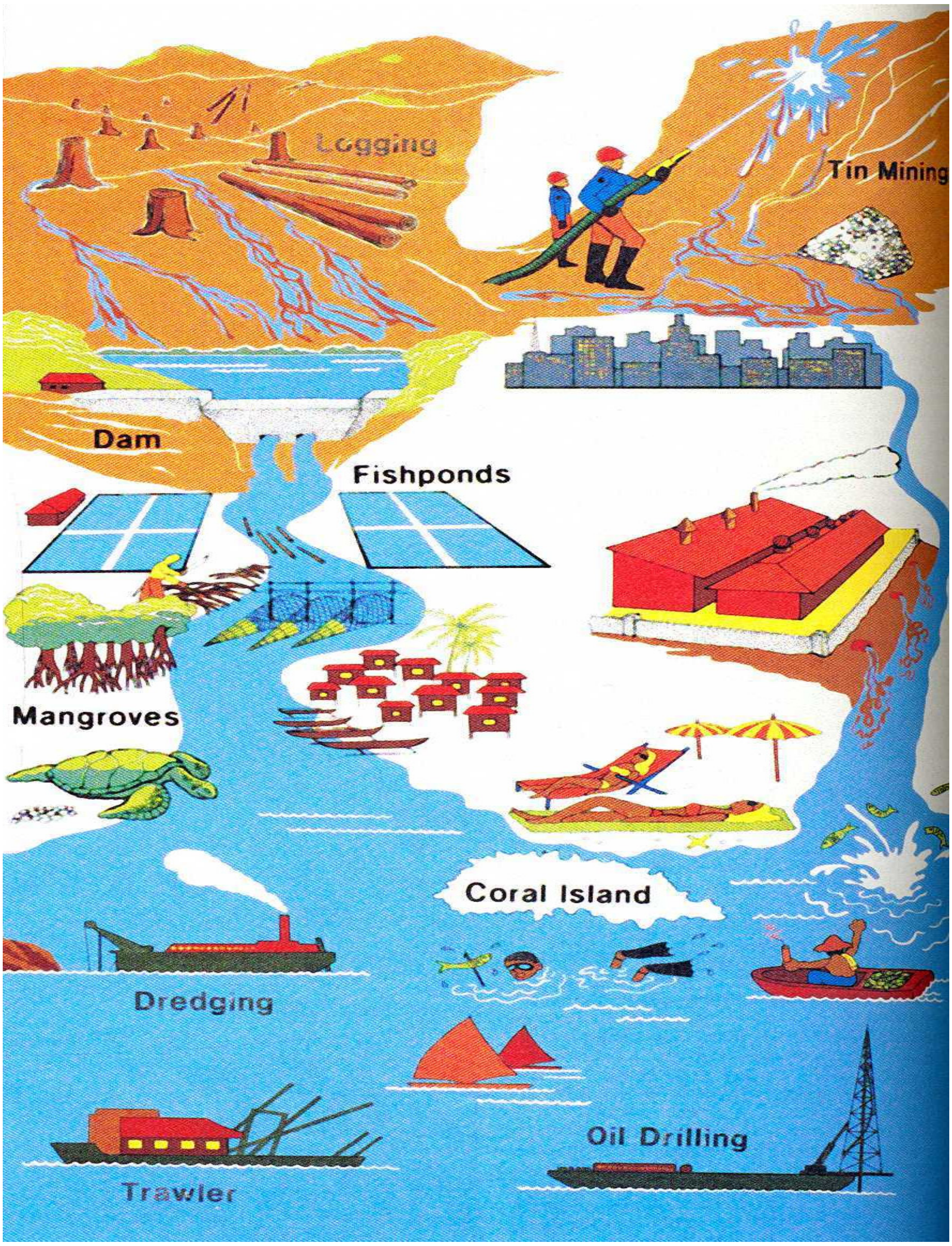

Figure 1- Human activities in a tropical river catchments and coastal zone (from Pauly and Thia-Eng, 1989).

1. Municipal wastewater composition

Municipal wastewater consists of a mixture of domestic wastewater, effluents from commercial and industrial establishments and urban run-off (Figure 2).

Domestic wastewater

The composition of domestic wastewater depends strongly on the level of water consumption. This varies between 40 to more then 300 $Lc^{-1}d^{-1}$ and explains the wide concentration range of wastewater components (Table 1). Domestic wastewater is produced in areas with in-house tap connections and connections to sewer infrastructure. In areas with hand pumps or public stand posts, water consumption is in general low, and sewer infrastructure is unavailable.

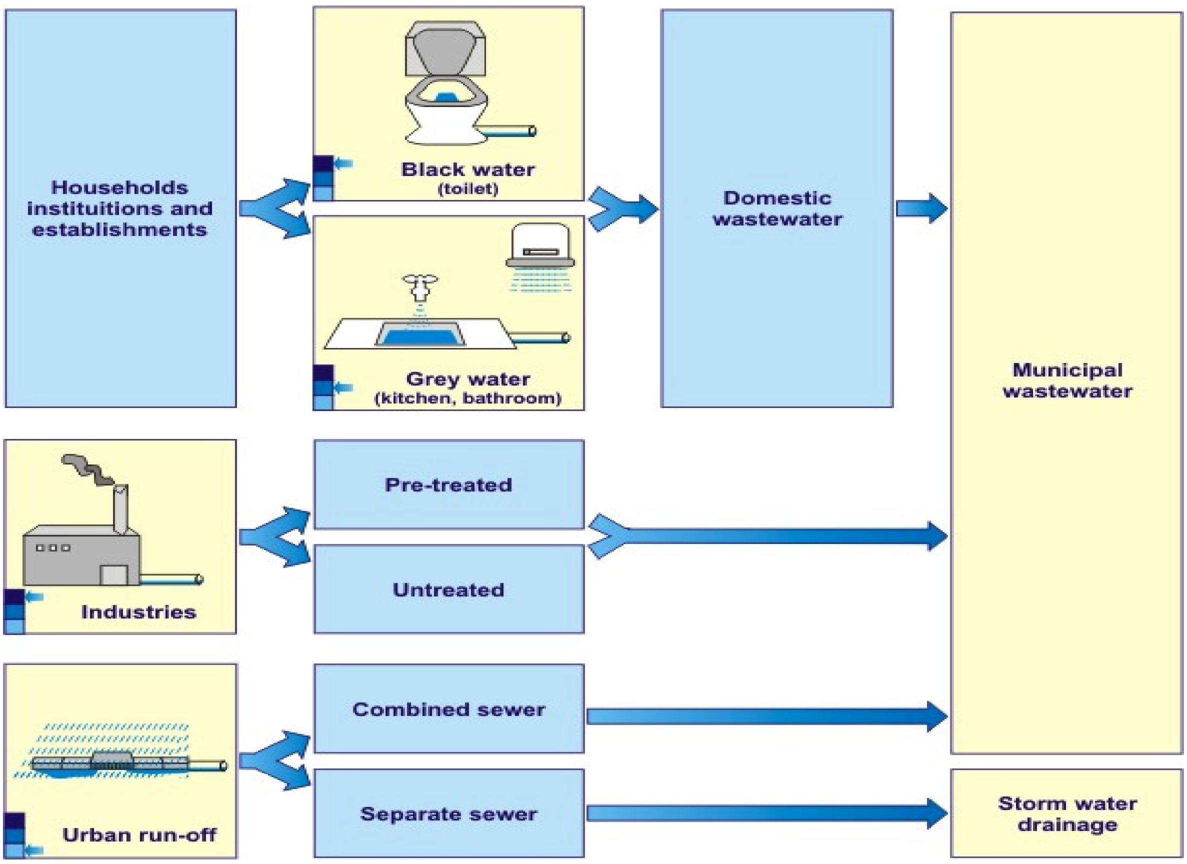

Figure 2- Municipal wastewater components.

Table 1- Variation in domestic wastewater composition (Source: Veenstra et al. 1997).

Parameter	**Specific production ($g\ c^{-1}\ d^{-1}$)[2]**	**Concentration[1] ($mg\ l^{-1}$)[2]**
TDS (total dissolved solids)	100-150	400 – 2,500 mg/l
TSS (total suspended solids)	40-80	160 – 1,350 mg/l
BOD (biochemical oxygen demand)	30-60	120 – 1,000 mg/l
COD (chemical oxygen demand)	70-150	280 – 2,500 mg/l
Kjeldahl-N	8-12	30 – 200 mg/l
Total-P	1-3	4 – 50 mg/l
Faecal coliforms (N^o per 100 mL)	$10^8 – 10^9$	$10^4 - 10^6$/100 ml

[1] assuming water consumption rate of 60 and 250 L $c^{-1}\ d^{-1}$, respectively

[2] except for faecal coliforms

Industrial wastewater

Industrial wastewater composition depends on the type of industry and whether on-site pollution measures have been taken. If toxic compounds are present, industrial wastewater discharged into a municipal sewer system can have a negative impact on the performance of a wastewater treatment plant.

Urban run-off

Urban runoff can be collected combined with sewerage in one system or in a separate storm water drain. Separate systems allow for collection and treatment of smaller, more regular and concentrated wastewater flows. Combined systems have to be designed to handle large fluctuations in flow, and therefore composition and concentration of the wastewater. Extreme peak flows might lead to overflows containing wastewater that are discharged into surface waters untreated.

2. Impacts of municipal wastewater

An overview of the potential impacts of wastewater components on the environment is summarised in Table 2.

Table 2- Major contaminants of municipal sewage, their impact on the environment and the gross parameters to quantify the degree of contamination (Adapted from: Veenstra 2000).

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

To better understand the potential impacts of municipal wastewater on aquatic ecosystems, it is useful to have a closer look at some relevant environmental processes. Figure 3 shows an example of a simplified aquatic food web, including men. Primary producers (plants, in this example phytoplankton-algae and water plants) use the energy of the sun to synthesize organic matter out of inorganic carbon (CO_2), water and nutrients. The small phytoplankton are consumed by zooplankton, which in turn are eaten by fish and animals that live on the bottom of water bodies. Water plants (including sea grasses) can be eaten by fish or, in the ocean, by sea urchins. Fish and shellfish are eaten by men. All dead organic matter, or detritus, is finally mineralised by bacteria, making the inorganic nutrients available again to the plants, thus closing the loop.

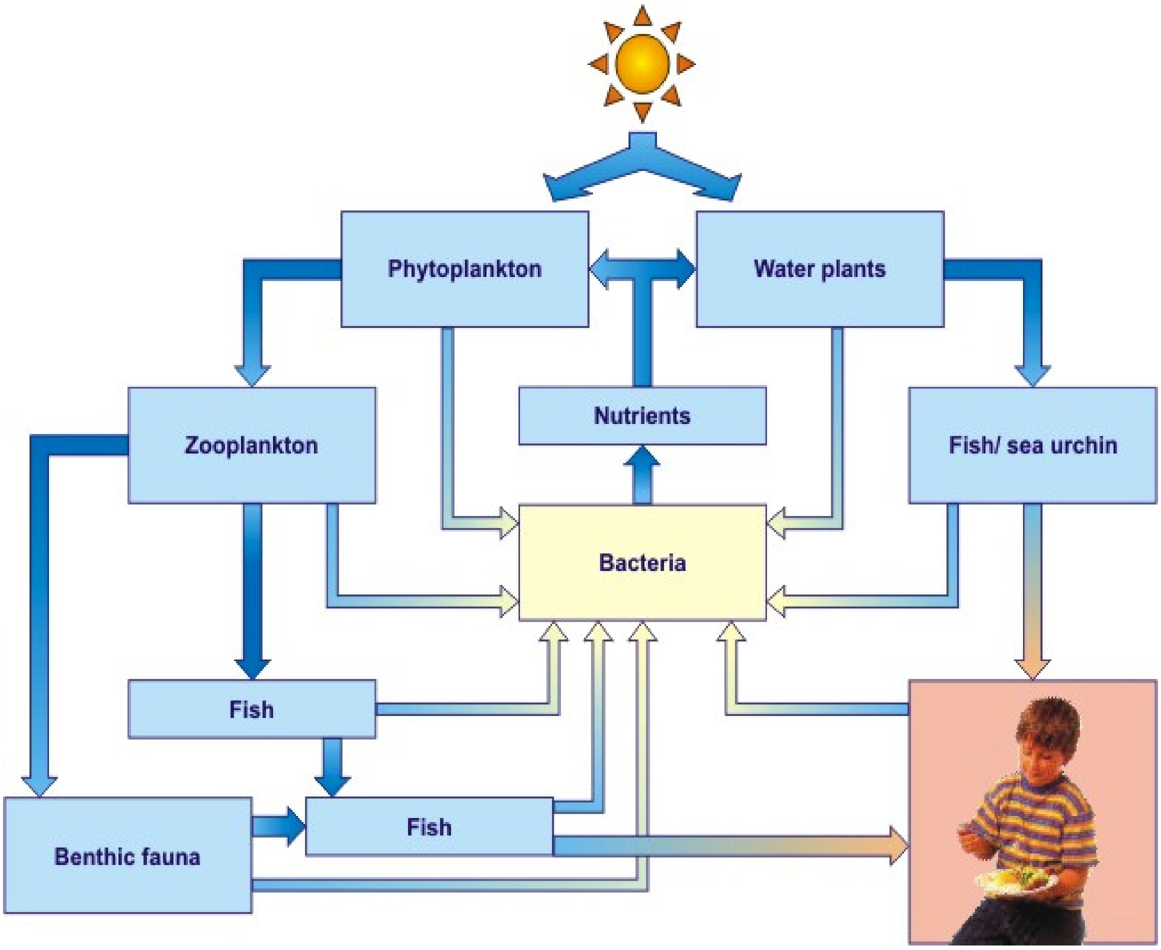

Figure 3- Simplified aquatic foodweb.

Except for the (industrial) toxic components, most constituents of municipal wastewater are natural compounds, being essential parts of the foodweb.

☞ The problem with wastewater is mainly related to the **quantities of wastewater** and the **characteristics of receiving water bodies**. Small amounts of municipal wastewater that are discharged in large bodies of water, in general, will not cause harm. Organic matter will be mineralised by bacteria and the released nutrients will sustain the foodweb. When the amounts of wastewater exceed the capacity of the receiving water body, as presently is often the case, a cascade of effects may start, which eventually could lead to serious environmental degradation.

Impacts on rivers

Chemical and biological changes that occur in a river downstream of a sewage discharge point are illustrated in Figure 4. Microbial processes in the river are responsible for the degradation of the organic components. As this is an oxygen consuming process, the oxygen level drops over a certain distance (the 'oxygen sac') until it increases again due to re-aeration. The decrease in oxygen is followed by an increase in nutrients, which result from the mineralisation of the organic matter. Uptake of these nutrients by algae and water plants is responsible for the subsequent decrease further downstream.

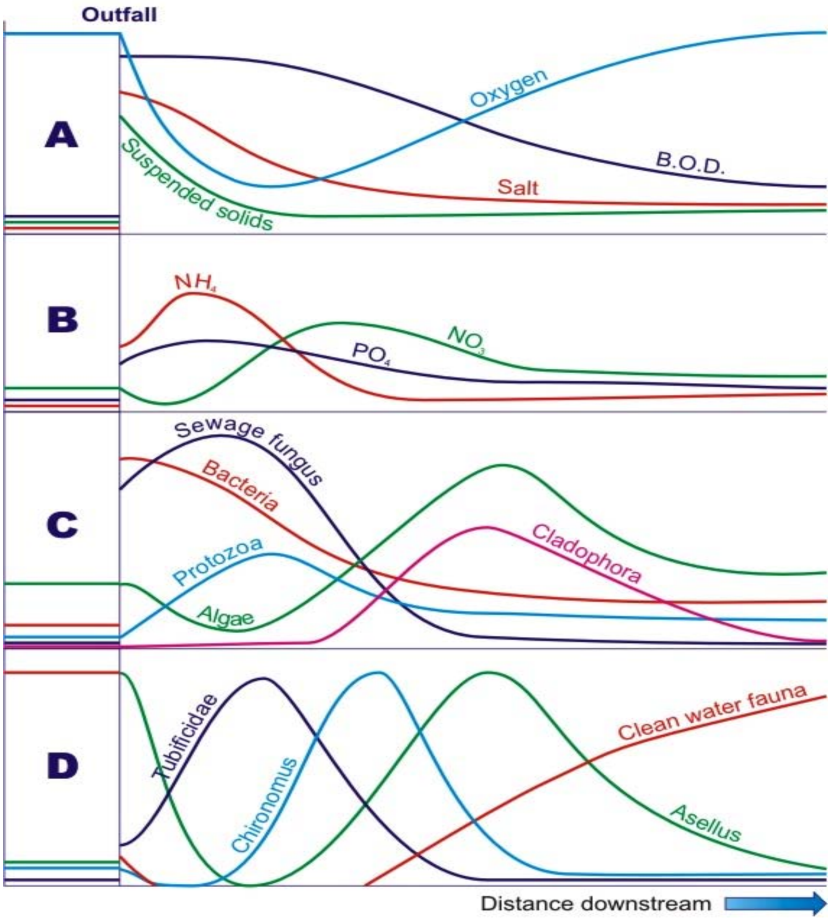

Figure 4- Changes in a river downstream of a sewage outfall (Source: Hynes 1960).

These changes in water chemistry, or water quality, have a strong impact on the organisms that live in the affected river. Animals need oxygen, and significant inputs of organic waste can reduce the ambient oxygen concentration to levels which prohibit survival of these organisms. Only the most 'resistant' animals will survive. Depending on boundary conditions (temperature, flow velocity), a river can handle a certain amount of organic waste without problems. However, often this **self purification capacity** is largely overstretched by too large amounts of waste. In other aquatic systems, like for example estuaries, the same processes can be observed.

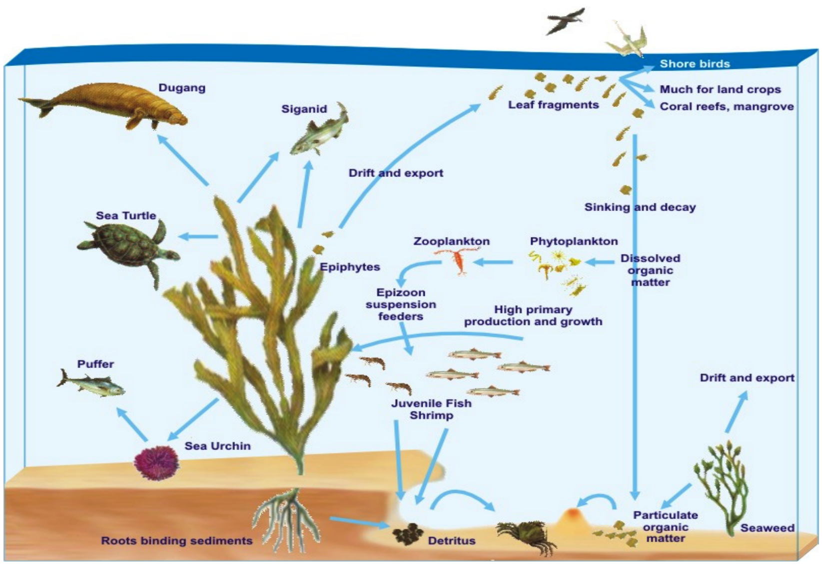

Figure 5- Food web relations in a tropical sea grass meadow (modified from: Fortes 1989).

Impacts on sea grass meadows

Some functional relationships in a sea grass community are shown in Figure 5 to illustrate possible impacts of sewage in sea grass communities. One of the major risks is the decreasing amount of light that reaches the plants. This decrease results directly from the increase of suspended solids in the water (increased turbidity), and indirectly through the growth of epiphytic algae on the leaves of the sea grasses and by phytoplankton, both of them stimulated by the input of nutrients. Thus, sea grass meadows might deteriorate or even disappear, with serious environmental consequences like increased sedimentation on coral reefs, and loss of nursery areas for fish and shellfish species (Figure 6).

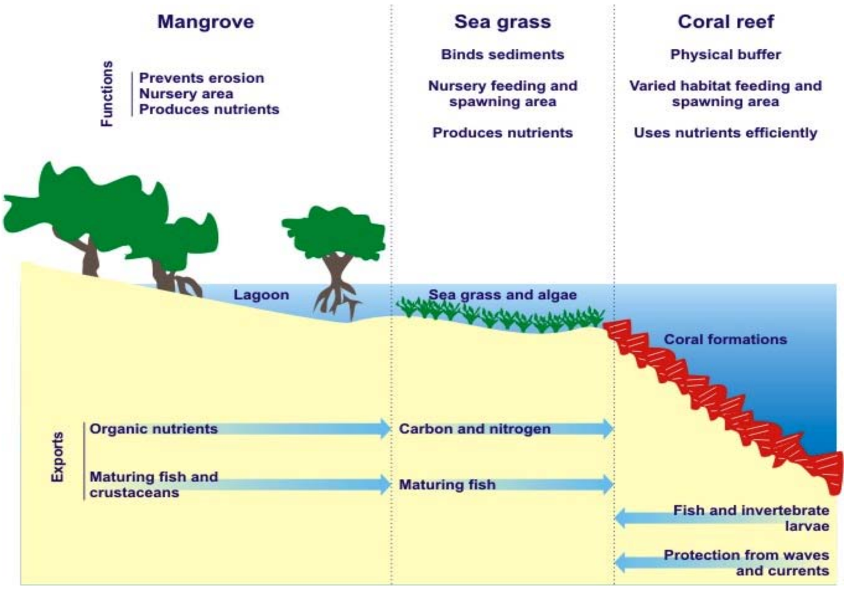

Figure 6- Interdependency of mangroves, sea grass meadows and coral reefs.

Impacts on human health

A vicious cycle of health impacts is established when human waste is not treated properly (Figure 7). Bacteria, viruses and parasites that are present in human excreta enter the environment, where they might remain for some time in water or soil. By drinking contaminated water, or eating food that has been irrigated with untreated water, these micro-organisms infect people, who in turn will contaminate the environment via their faeces and/or urine.

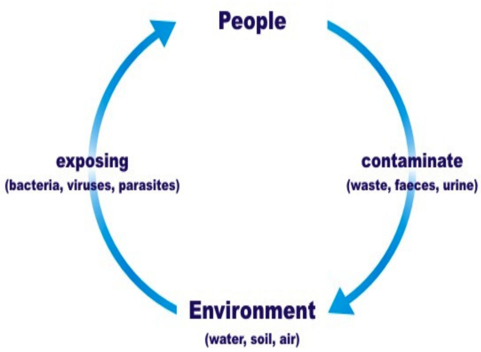

Figure 7- The vicious cycle between infection of people and contamination of the environment (Source: Esrey et al. 2000).

Economic impacts

Economic losses result from increased health care costs, additional treatment costs for drinking water, loss of income because of loss of productive days, drop in fish production, tourism etc. Some estimates of economic impacts can be found in Box 1.

Box 1- Some economic impacts related to inadequate wastewater treatment

❖ In 1992 cholera spread in Peru due to poor sanitation and inadequate disinfection of drinking water. Peru's income from fish exports and tourism, which accounted for 34% of the gross national product before the epidemic, tumbled. Lost income and additional health costs were estimated at US$1 billion, which was ten times the annual national budget on water supply and sanitation.
❖ Spain's tourism industry, which employs 10% of the country's work force, depends on its coasts, where water quality is regularly threatened.
❖ The Caribbean Island Bonaire depends almost entirely on tourism related to its coral reef, which is threatened by the island's wastewater discharges.

3. Out of sight-out of mind?

If municipal wastewater is not handled properly it will directly affect the local living environment where the waste is produced, including the groundwater. Therefore, discharge via a sewer or drain to a river is often chosen as an easy solution: the **´out of sight-out of mind´-** approach. However, this will directly affect communities living downstream. In the end, the marine environment, including the communities that depend on marine and coastal resources, will suffer, being the ultimate recipients (Figure 8). Locally produced waste can thus cause effects 100 km's downstream, while accumulated effects sometimes are only observed after many years: cause-effect relations often are obscured, which makes proper management more cumbersome.

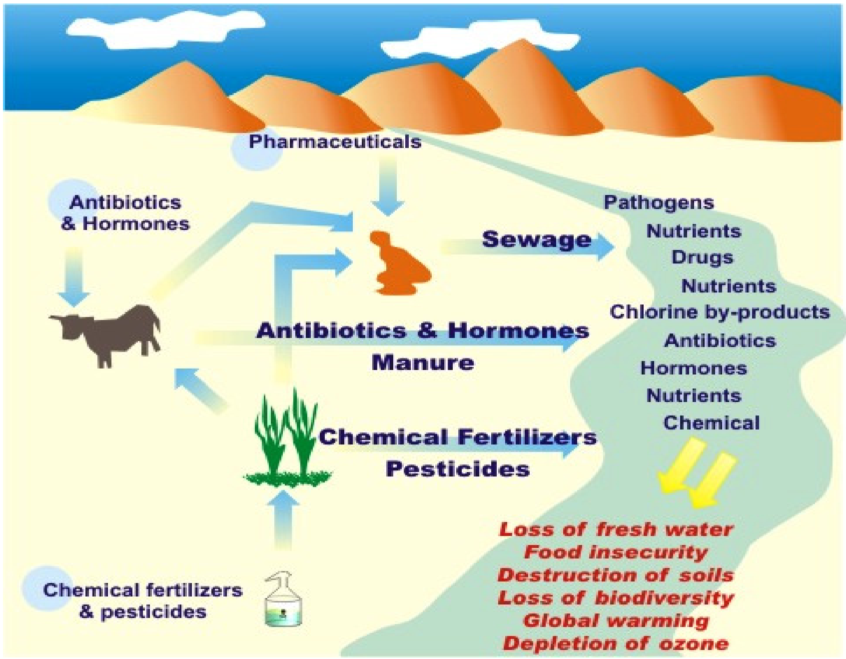

Figure 8- Linear sanitation solutions cause multiple problems (modified from: Esrey et al. 2000).

☞ Inaction will have its cost: public health impacts, environmental degradation and finally economic damage. There is a need for a vision in which to integrate water and wastewater management. The '**out of sight-out of mind'** approach has to be replaced by the principle of '**river solidarity'**.

II. Coverage of Water Supply and Sanitation

Over the past decades, the water supply and sanitation sector has been both an example of remarkable progress and a source of continued frustration. Progress, in the sense that over the past 20 years an additional 2.4 billion people have gained access to water and 600 million more people obtained access to sanitation services. There is, however, continued frustration, because some 1.1 billion people still do not have access to safe water and 2.4 billion lack access to improved sanitation services (Improved sanitation is defined in Box 2). The existing frustration is worsened by the fact that much of the gains in service coverage have been offset by population growth and rapid urbanisation. In 2000, 47% of the world's population were urban dwellers, as opposed to 43.5% in 1990 (WHO/UNICEF/WSSCC, 2000). The majority of these people live in Asia and Africa (Figure 9), but also within countries services are distributed unevenly, with service provisions in rural areas generally lacking far behind those in urban areas (WHO, 2000). Globally, the coverage of water supply is estimated at 82%, while global sanitation coverage is estimated to be 60%. A UNEP Regional Seas presentation of the data on water supply and sanitation coverage is provided in UNEP/WHO/UNICEF/WSSCC (2002).

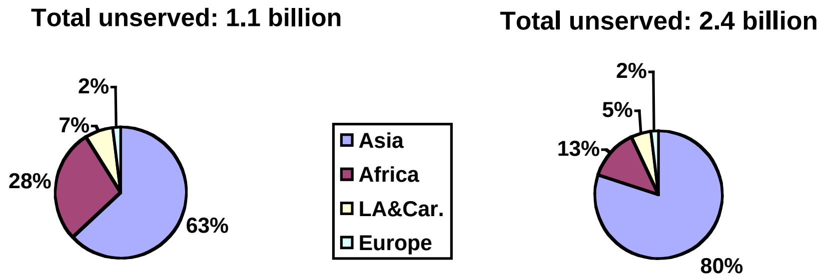

Figure 9- Distribution of the global population not served with improved water supply (left) and improved sanitation (right, after WHO/UNICEF/WSSCC 2000).

Box 2 Defining sanitation (from Bos et al. 2004)

The term sanitation is used in numerous recent sector policy documents, where improvements in coverage of both water supply and sanitation services are addressed. Vision 21, the water supply and sanitation paragraph of the recently formulated World Water Vision has defined a target to achieve full coverage of these services by the year 2025 (Cosgrove and Rijsberman, 2000). More recently, the Millennium Development Goals, agreed during the 2002 World Summit on Sustainable Development in Johannesburg, defined intermediate targets for the year 2015, aiming at a 50% reduction of the number of people without (safe water supply and) improved sanitation. In order to understand the implications of these goals for sanitation, one needs to develop a very clear understanding of what is to be considered as ‘improved sanitation’. Below, technologies to be considered improved are summarised (WHO/UNICEF/WSSCC, 2000):

Water supply	Sanitation
Household connection	Connection to a public sewer
Public standpipe	Connection to septic system
Borehole	Pour-flush latrine
Protected dug well	Simple pit latrine
Protected spring	Ventilated improved pit latrine
Rainwater collection	

In general, the term ‘sanitation’ is understood as the services and facilities required ensuring a healthy, user friendly and convenient management of human waste at the personal level, i.e. in and around the household. This definition specifically focuses at the household level, since sanitation does not necessarily involve the off-site management of this waste afterwards. Clearly, almost all on-site sanitation facilities fit under this definition (some may not be considered appropriate), but also the installation of flush toilets with sewer connection presents a form of appropriate sanitation. What is usually not covered in the term sanitation is the collection and treatment of wastewater.

Wastewater management
In general wastewater management is understood as all services, activities and facilities required to ensure the effective collection and treatment to agreed standards of sewage. This definition includes basically all point source discharges, including wastewater from industrial, commercial and household sources. Also storm water, if collected, is covered under this general definition. What is not included are non-point sources, such as agricultural run-off, or other diffuse pollution sources. The term wastewater management is addressed usually in the context of water quality protection and standards for effluents discharge, to protect water resources, are in place in most countries. Although legislation is often times in place, most developing countries do not have effective measures to ensure compliance.

To estimate the number of people world wide without wastewater management services, it is important to define the expected treatment levels. It is estimated that world wide only some 15% of all people are connected to a wastewater treatment facility that is built to provide primary or secondary level of treatment (usually some 60-80% reduction of SS and COD). The number of people connected to modern wastewater treatment facilities that include nutrient removal comprises only an estimated 2% of the world population. It will be clear that the large majority of the indicated coverage’s for wastewater treatment are found in developed regions.

III. Targets on Water and Sanitation and Guidelines on Municipal Wastewater Management

The last decades, water has become intrinsically related to sustainable development issues. The importance of sustainable use and provision of water and sanitation services was endorsed by Agenda21 in Rio, 1991. Such concerns have helped push the international community to ensure that the targets of the 2000 Millennium Development Goals (MDG) and the 2002 World Summit on Sustainable Development (WSSD) address improved access to safe drinking water and adequate sanitation.

The WSSD agreed target on water and sanitation:

To halve, by the year 2015, the proportion of people who are unable to reach or to afford safe drinking water and the proportion of people who do not have access to basic sanitation.

An immediate consequence of any success on the water supply front will mean that the volume of sewage produced will proportionally increase. Today sewage already presents the main point source water pollutant on a global scale.

A 50% reduction of the number of people without appropriate sanitation may have very positive consequences for the public health situation of these people, but it does not immediately provide benefits for the environment as such. In fact, considering that probably a substantial part of the (appropriate) sanitation solutions will involve flush toilets and sewer connections, the water quality situation of both surface and groundwater resources may further deteriorate.

Therefore, true environmental sustainability can only be achieved if the mentioned targets are accompanied by a specific programme, which considers (the increased volumes of) wastewater to be managed appropriately.

The *Global Programme of Action for the protection of the Marine Environment from Land-based Activities* provides recommendations for action and criteria for their development at various levels. To assist governments in implementing concrete actions at local and national levels, a *Strategic Action Plan on Municipal Wastewater* was developed which identified the following reasons for inefficient and inadequate wastewater management:

- low prestige and recognition (compared to, for example, water treatment),
- weak policies and institutional frameworks
- neglect of stakeholder interests
- lack of adequate funding and political will
- inappropriate technologies, and
- low public awareness and lack of solidarity.

To improve the existing situation with respect to wastewater management, UNEP/GPA proposed to initiate actions that focus on:

- promoting the use of alternative solutions
- including low-cost and environmentally sound sanitation and wastewater treatment technologies
- innovative financial mechanisms
- appropriate partnerships, and
- the creation of an enabling environment for action.

In line with this, UNEP/GPA, in co-operation with WHO, HABITAT, WSSCC and UNESCO-IHE has developed the '*Guidelines on Municipal Wastewater Management'*, including 10 KEYS for Policy and Decision Makers, focussing on policy issues, financing mechanisms, technologies and management processes.

These guidelines serve as a practical guide for decision-makers and professionals on how to plan, design, and finance appropriate and environmentally sound municipal wastewater discharge systems following an integrated, holistic approach. To support implementation of these guidelines in municipal wastewater programmes a course has been developed through the partnership of UNEP/GPA, UNESCO-IHE and the UN/DOALOS TRAIN-SEA-COAST training network. This course specifically targets professionals responsible for planning and implementation of sewage treatment works in coastal cities in low income countries.

10 KEYS

For Local and National Action on Municipal Wastewater

1 Secure political commitment and domestic financial resources.

2 Create an enabling environment at national AND local levels.

3 Water supply and sanitation is not restricted to taps and toilets.

4 Develop integrated urban water supply and sanitation management systems also addressing environmental impacts.

5 Adopt a long-term perspective, taking action step-by-step, starting now.

6 Use well-defined time-lines, and time-bound targets and indicators.

7 Select appropriate technologies for efficient and cost-effective use of water resources and consider eco-technology alternatives.

8 Apply demand-driven approaches.

9 Involve all stakeholders from the beginning and ensure transparency in management and decision-making processes.

10 Ensure financial stability and sustainability.

10.1 Link the municipal wastewater sector to other economic sectors.

10.2 Introduce innovative financial mechanisms, including private sector involvement and public-public partnerships.

10.3Consider social equity and solidarity to reach cost-recovery.

IV. Objectives and Outline of the Course

The overall objective of the course ***'Improving Municipal Wastewater Management in Coastal Cities'*** is to support low income countries in developing and implementing sustained actions to prevent, reduce, control and/or eliminate coastal and marine degradation from municipal wastewater. More specifically, the course aims at strengthening the capacities of wastewater managers at the municipal level to implement the UNEP/WHO/UN-Habitat/WSSCC *Guidelines on Municipal Wastewater Management*. A logical approach for wastewater management will be introduced. Following this process, participants will learn how to proceed from the identification of a problem towards developing a proposal that addresses and tries to solve this problem. The proposal will be in a format that can be submitted to potential funding agencies. During the course the following issues will be addressed:

- The role of stakeholders and how to involve them in the decision-making process
- Conventional and innovative approaches, both technological and financial
- Methodologies how to select the most appropriate approach; and
- Presentation techniques

Each subject will be introduced briefly, before it will be illustrated in a case study. Subsequently, participants have to apply the theories in a real case selected from their own experience, which they have to present at various steps during the course (Figure 10).

ANALYTICAL TOOLS **MODULE 1.** **OBJECTIVE ORIENTED PLANNING**	SUBSTANTIVE INFORMATION **MODULE 2.** **CONVENTIONAL AND INNOVATIVE APPROACHES TO MUNICIPAL WASTEWATER MANAGEMENT**	SKILLS **MODULE 3.** **PRESENTATION TECHNIQUES**
I. Problem analysis II.Objectives analysis	**INTRODUCTION**	I. Oral presentations
	I. Conventional approaches & alternative technologies II. The way forward: the 3-Step Strategic Approach III. Financial sustainability IV. Water management in the city of tomorrow	
III. Stakeholder analysis & interviews	**FIELD TRIP**	
IV. Options analysis		II. Writing the feasibility report
	SYNTHESIS Proposal presentation	

Figure 10- Course structure.

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MODULE 1

OBJECTIVE ORIENTED PLANNING

Addressing municipal wastewater issues in an efficient way and developing lasting solutions, is only possible when the major problems are known and when the project focuses on mitigating the identified problems. The objective of this module, based largely on NORAD (1992), is to guide participants through the different steps of objective oriented planning. In this module the participants will be familiarised with problem analysis, objectives analysis, options analysis and stakeholder analysis. In each of these topics the participant will first be introduced to into the methodology of undertaking the analyses. Following this introduction a case study will be used to illustrate the approach for undertaking the analyses. The participants are then asked to apply the different analyses that constitute objective oriented planning to their own working environment.

At the end of this module the participants will be able to:

1. Describe the various steps involved in establishing a problem tree.
2. Identify cause and effect relationships.
3. Analyse a (simple) problem in their own professional environment by making use of a problem tree.
4. Identify the project objectives that derive from a problem analysis.
5. Analyse the objectives for a project in their own professional environment by making use of an objectives tree.
6. Evaluate the strengths and weaknesses of various project options.
7. Select a set of measures that is most suitable to effectively address the identified problems.
8. Analyse the specific roles stakeholders play in the professional environment of the participants.
9. Discriminate between the roles of different stakeholders.

The module consists of the following parts:

I. The Problem Analysis
II. Objectives Analysis
III. Stakeholder Analysis
IV. Options Analysis

MODULE 1

OBJECTIVE ORIENTED PLANNING

I. PROBLEM ANALYSIS

II. OBJECTIVES ANALYSIS

III. STAKEHOLDER ANALYSIS

1. PRIMARY AND SECONDARY STAKEHOLDERS
2. STEPS OF STAKEHOLDER ANALYSIS
3. APPROACHES FOR INVOLVING STAKEHOLDERS
4. STAKEHOLDER ANALYSIS MATRICES
5. METHODS OF STAKEHOLDER PARTICIPATION

IV. OPTIONS ANALYSIS

REFERENCES

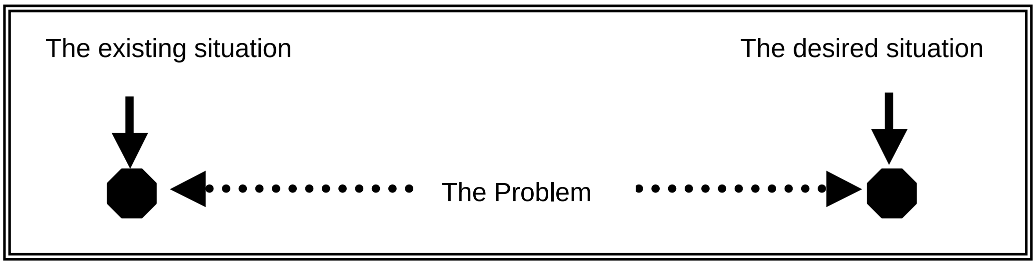
MODULE 1

OBJECTIVE ORIENTED PLANNING

I. Problem Analysis

Before any action for improvement of municipal wastewater services can be decided upon, there is a need to analyse the existing situation of municipal wastewater management. On the basis of available information, the existing situation, in particular the major problems facing municipal wastewater management, should be analysed and the main cause-effect relationships between the major problems should be visualized in a problem tree. This exercise of analysing the existing situation is referred to as a **problem analysis**.

A problem is the discrepancy (or difference) between the desired situation and the existing situation. Graphically, this can be presented as follows:



The problem as identified by the problem analysis becomes the main focus of the project that you propose. In other words, the goal of your project is to mitigate the problem you have analysed in the problem analysis.

A good problem analysis consists of a number of steps. At least five steps can be distinguished:

Identify major existing problems, based upon available information.
Select one main problem for the analysis.
Identify important and direct causes of the focal problem and construct a tree showing these relationships.
Identify important and direct effects of the focal problem and construct a tree showing these relationships.
Review the entire problem tree, verify its validity and completeness, and make necessary adjustments.

Step 1: Identifying the major existing problems

At the start of a problem analysis all the problems that are encountered in the provision of municipal wastewater services should be identified. Important in this step is that all possible problems that you can think of are identified. This can, for example, be done by way of a brainstorming exercise.

In identifying problems it is important that you identify existing problems, not possible, potential or future problems.

Step 2: Select one main problem for the analysis

After having identified all the existing problems, you select one problem that becomes the main problem that the project that you seek to develop will address. This main problem, which is sometimes called the focal problem, is the existing problem that you will try to remedy by implementing a project. This main problem becomes the starting point for your further analysis.

Below the case of water supply provision in Lembang, Indonesia is explained. We will use this case to walk through the steps of the problem analysis.

❖ **Water Supply in Lembang, Indonesia**

The water supply company in the town of Lembang wishes to sell more water to potential customers. Currently, in Lembang, there is an idle capacity for production of drinking water that they are not using. At the same time, the coverage rates are very low. If the water company could expand the service coverage, they could sell the water by using the full capacity of their systems. Potential new customers seem unwilling to connect to the network, however. See below an overview of water service condition in Lembang:

Indicator	**Lembang**
Total population	128,175
Number of connections	1823
Service coverage	10 %
Installed capacity of system	$32\ l\ s^{-1}$
Idle capacity	$6\ l\ s^{-1}$
Unaccounted-for-water	29 %

Source: Endra Saleh Atm 2000

A survey was conducted to investigate why the different households were unwilling or unable to obtain household connections. One of the main reasons for not connecting to the network was simply the unaffordability of the connection fees. A substantial portion of the respondents, however, had other reasons for not connecting to the network. Statements made by respondents illustrate these reasons:

- "We feel that water is simply a public good and should be provided either by government or the water supply company for free" (Endra Saleh Atm. 2000)
- "We think that quality of water provided by the water supply company is only good for cattle but not for drinking, cooking, washing, and other human activities. What we have now is […] better than piped water" (Endra Saleh Atm. 2000)

After identifying all the existing problems, a main problem is identified for the Lembang case, namely that the company has an idle capacity for the production of drinking water.

Step 3: Identify the direct causes of the main problem

Having identified the starting point of the problem analysis (the main problem), we now focus our attention to developing a problem tree. The problem tree will allow us to give a clear overview of the different causes and effects of the main problem. The first step we take in the construction of the problem tree is to identify all the direct causes of the focal problem.

Identifying the causes of the problem can be done by asking the question: 'Why?'. In other words, by asking the question why problems exist you establish what the causes of the problem are.

The next step is to make sure that the identified causes are direct causes of the problem. In other words, it is important that you make sure that you do not skip any steps in the relationship between the problem and its causes. The following example concerning the main problem that John failed his examination illustrates the importance of not skipping any steps. In the first case, no steps are skipped and there is a logical sequence from causes to the main problem. In the second case, where a number of steps are skipped the logical sequence is missing.

• **No skipped steps**
Peter was bored yesterday → Peter asked John to play outside with him → John played outside with Peter→ John did not study for his exam → John was not prepared for his exam → John failed his examination
• **Skipped steps**
Peter was bored yesterday → John failed his examination

❖ Water Supply in Lembang, Indonesia (2)

For the case of Lembang we have started identifying the direct causes of the problem by asking the question: why does the company have an idle capacity? The answer to that question is that there is a low service coverage (only 10%). The next step is to ask the question why there is low service coverage. The answer to this question is that customers are either unwilling or unable to connect. By continuing this method of questions and answers we arrive at a series of logical cause and effect relationships, which identify the direct causes of the problem (Figure 11):

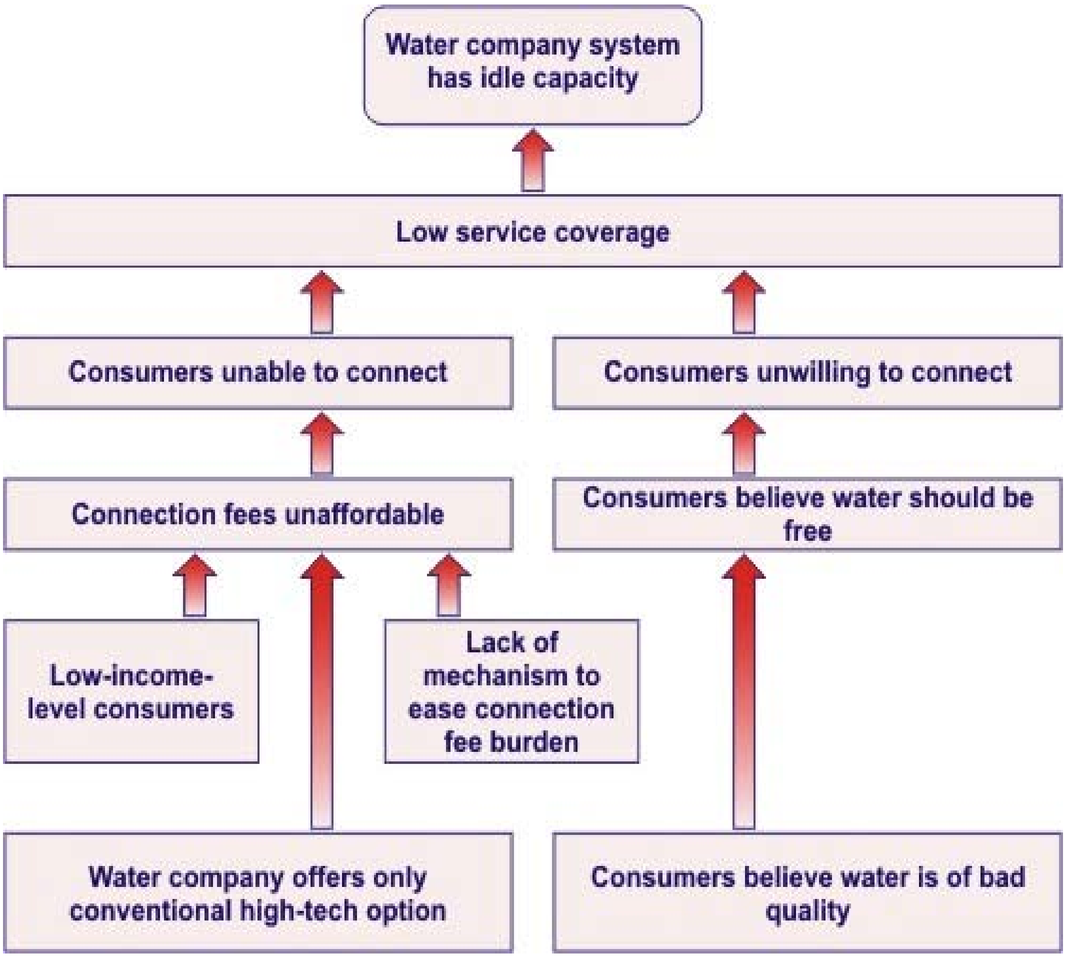


Figure 11- Series of logical cause and effect relationships applied to the Lembang example.

Step 4: Identify direct effects of the focal problem and construct a tree showing these relationships

This step is similar to the previous step. However, instead of looking at the causes of the problem, you look at the effects of the problem (Figure 12). Instead of asking the question why this problem exists, you ask the question what this problem leads to.

Similar to identifying the causes of the problem, when identifying the effects of the problem it is also necessary to make sure that no steps are skipped.

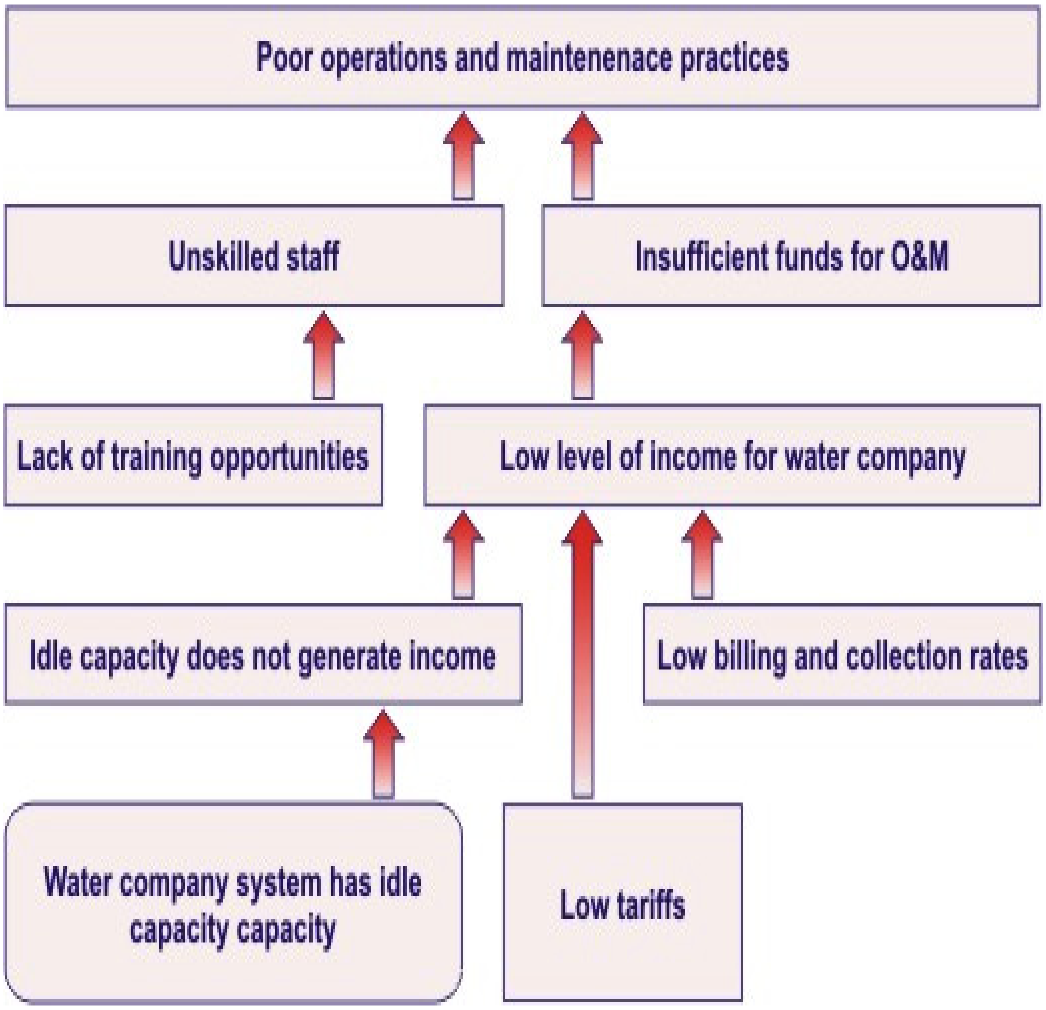


Figure 12- Series of logical cause and effects relationships applied to the Lembang example.

Step 5: Review the entire problem tree, verify its validity and completeness, and make necessary adjustments

In the final step the entire problem tree should be reviewed to make sure that it is valid and complete. The tree should 'read' like a logical sequence of cause and effect (or if-then) relationships (Figure 13).

Once the problem analysis has been completed it is possible to quickly identify what factors cause the main problem and how these factors are related. On the basis of the problem analysis you can identify what problems you will try to address with your project and how this will influence the main problem that you have identified.

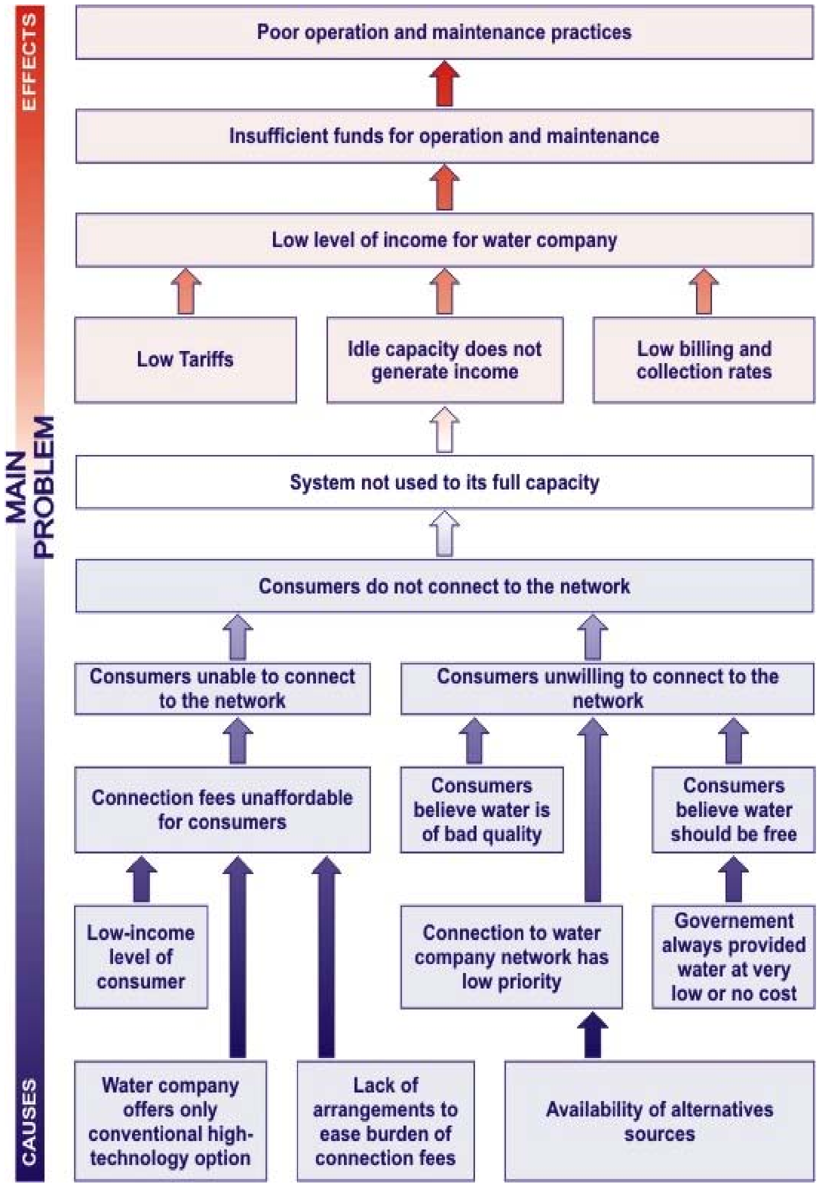


Figure 13- Problem tree: Case Study - Lembang, Indonesia.

II. Objectives analysis

The problem analysis forms the starting point for the objectives analysis. In the first step of the objectives analysis **the problems** that you identified during the problem analysis have to be translated into **objectives**. In fact, **the problem tree** can be transformed into **a tree of objectives**, where the problems can be translated into objectives.

The following steps have to be taken:

1. Reformulate all elements in the problem tree into positive, desirable conditions.
For example, a problem such as "the customers are unwilling to connect to the network" will become reformulated into a positive condition: "the customers are willing to connect to the network.

2. Changing the undesirable conditions (the problems) into desirable conditions (the objectives) implies that the relationship between the different factors changes from a cause-effect relationship to a means-ends relationship. The second step of an objecives analysis is to assure the validity and completeness of the objectives-tree. In other words, it is necessary to ensure that the relationships between the different objectives make sense.

3. If necessary, revise statements, delete objectives that appear unrealistic or unnecessary and add new objectives where deemed necessary.
For example, if one of the problems that were identified was that "the income of the consumers is too low to afford the connection fee", the positive reformulation of this problem would be "the income of the consumers is sufficient to afford the connection fee". However, increasing the income of the consumers is not a very realistic objective for a (waste)water project. As such, it may have to be deleted from the objectives tree.

4. Draw connection lines between the objectives to indicate means-ends relationships; As mentioned before, the relationship between the different objectives is one of a means-ends relationship. This relationship is indicated by a line between these objectives.
For example the objective "the consumers believe that water is of a good quality" is a means of achieving an end, namely that "consumers are willing to connect to the network".

5. Formulate the project purpose. Once all the objectives have been placed in the objective tree it is necessary to decide upon the objectives, which the project will seek to achieve. In the objective tree a large number of objectives is shown. In this step, you have to decide which objective (or objectives) will be the main focus of the project.

A complete objectives-tree provides a comprehensive picture of the desired, future situation. This is illustrated in Figure 14 for the Lembang case. As the availability of alternative sources cannot be manipulated easily, this, together with the low priority for connecting to the PDAM network has been left out (both are considered unrealistic objectives). Likewise, increasing the income of consumers is out of the scope of this project. An information and education campaign to convince unconnected consumers to connect to the network has been added.

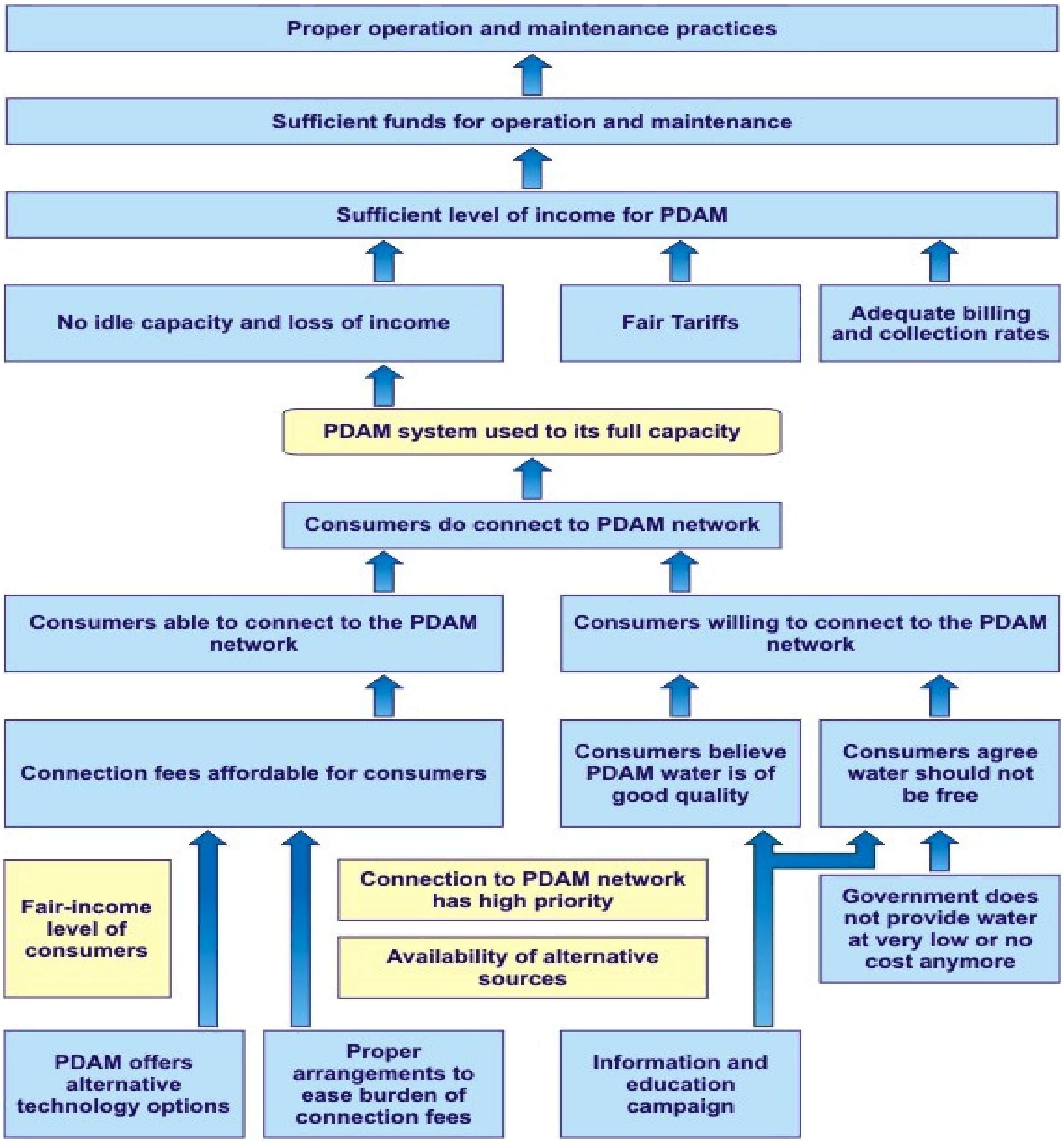


Figure 14- Objectives tree: Case Study - Lembang, Indonesia.

III. Stakeholder Analysis

Stakeholders are people, groups, or institutions, which are likely to be affected by a proposed project (either negatively or positively), or those which can affect the outcome of the project. Increasingly it has been recognized that **any project requires the active involvement of civil society to be truly sustainable**. Public participation of the different stakeholders in the decision-making process (be it active involvement or passive involvement) introduces a range of ideas, experiences and expertise that motivate the development of alternative solutions. This in turn enhances the knowledge of the actors involved in decision-making and implementation of the project. Moreover, if involvement of stakeholders can lead to reaching consensus at an early stage in the project, the potential for serious conflict, which is detrimental to the project, decreases and the likelihood of lasting and improved solutions increases.

For the success of a project it is important to know what the views and interests are of the stakeholders to a proposed project or proposed project alternatives. The importance of stakeholder participation should be recognized in a number of aspects of project preparation and implementation. These aspects include:

1. The identification of stakeholders' interests in, importance to, and influence over the proposed project;
2. The identification of local institutions or processes upon which to build support for the project; and
3. The provision of a foundation and strategy for involving the stakeholders in the various stages of preparing and implementing the project.

Benefits of Stakeholder Involvement (OAS 2001)

- It can lead to informed decision-making as stakeholders often possess a wealth of information which can benefit the project;
- Consensus at early stages of the project can reduce the likelihood of conflicts which can harm the implementation and success of the project;
- Stakeholder involvement contributes to the transparency of public and private actions, as these actions are monitored by the different stakeholders that are involved;
- The involvement of stakeholders can build trust between the government and civil society, which can possibly lead to lead to long-term collaborative relationships

1. Primary and Secondary Stakeholders

Generally a distinction is made between two kinds of stakeholders, the primary and secondary stakeholders. The **primary stakeholders** are the stakeholders who **are directly affected**, either positively or negatively by the project. As such, the primary stakeholders include the intended users of the improved facilities; in other words the intended beneficiaries of the project. Secondary stakeholders are government and donors but also include local NGO's, private sector entrepreneurs, local government, water and sanitation utilities, river management boards, consumer groups, clergy, etc. The **secondary stakeholders** are stakeholders, which **play some intermediary role and may have an important effect on the project outcome**.

In the past stakeholder participation was mainly limited to involving the secondary stakeholders. Many of these projects, however, proved unsustainable and since then a general consensus has emerged about the general need of involving primary as well as secondary stakeholders at an early stage.

❖ **Cultural considerations for the location of toilets in Andhra Pradesh, India**

A slum area in Vijayawada, Andhra Pradesh, India, had been upgraded but the community were not using the new toilets provided on their house plots. This was not immediately apparent to outsiders, but when a local resident was asked by a speaker of the language if there were any problems with the recent development, the resident explained that most of the residents had not been using the new toilets. The reason was that the toilets are located on the north-east corner of the house plots, and according to Hindu astrology this is a bad place to locate the toilet. The north-east corner is preferential for items such as the water source, the prayer room or the main door. Toilets should be located at the south of the plot. As a result, many residents do not use the toilets provided, and go to the edge of the upgraded area to defecate in the open areas.

Source: House et al. (1997) as cited in WEDC 1998.

2. Steps of Stakeholder Analysis

Stakeholder analysis essentially involves four steps:

1. Identify the key stakeholders from the large array of groups and individuals that could potentially affect or be affected by the proposed intervention.
2. Assess stakeholder interests and the potential impact of the project on these interests.
3. Assess the influence and importance of the identified stakeholders.
4. Outline a stakeholder participation strategy (a plan to involve the stakeholders in different stages of the project preparation and implementation process).

Step 1: Identification of key stakeholders

In identifying the key stakeholders, you should consider the following questions:

- Who are the potential beneficiaries?

- Who might be adversely impacted?
- Have vulnerable groups who may be impacted by the project been identified?
- Have supporters and opponents of the project been identified?
- What are the relationships among the stakeholders?

Answering these questions will lead to a simple list, which forms the basis of the stakeholder analysis.

Step 2: Assess stakeholder interests and the potential impact of the project on these interests

Once the key stakeholders have been identified, the possible interest that these groups or individuals may have in the project can be considered. Questions that you should try to answer in order to assess the interests of different stakeholders include:

- What are the stakeholder's expectations of the project?
- What benefits are likely to result from the project for the stakeholders?
- What resources might the stakeholders be able and willing to mobilize?
- What stakeholder interests conflict with project goals?

Important to realize when assessing the interests of the different stakeholders is that some stakeholders may have hidden, multiple or contradictory aims and interests.

In order to be sure that you are as accurate as possible about your assessment, 'on-the-ground' consultations with different stakeholders would be recommended.

Step 3: Assessing stakeholder influence and importance

In the third step the task is to assess the influence and importance of the stakeholders that you identified in earlier steps. Influence refers to the power that the stakeholders have over a project. This power may be in the form of stakeholders that have formal control over the decision-making process of it can be informal in the sense of hindering or facilitating the project's implementation. Importance relates to the question how important the active involvement of the stakeholder is for achievement of the project objectives. Stakeholders who are important are often stakeholders who are to benefit from the project or whose objectives converge with the objectives of the project. You should realize that some stakeholders who are very important might have very little influence and vice versa.

In order to assess the importance and influence of the stakeholder you should be able to assess:

- The power and status (political, social and economic) of the stakeholder.
- The degree of organization of the stakeholder.
- The control the stakeholder has over strategic resources.
- The informal influence of the stakeholder (personal connections, etc.).
- The importance of these stakeholders to the success of the project.

Both the influence and importance of the different stakeholders can be ranked along simple scales and mapped against each other. This exercise is an initial step in determining the appropriate strategy for the involvement of these stakeholders. As with the second step, in order to make sure the assessment is as accurate as possible it would be preferable to have 'on-the-ground' consultations.

Especially when assessing dimensions like informal influence over the project, personal communication with stakeholders is likely to be essential.

Step 4: Outline a participation strategy

On the basis of the previous three steps in the stakeholder analysis process, some preliminary planning can be done in relation to the question of how to best involve the different stakeholders. The involvement of stakeholders should be planned according to:

- Interests, importance, and influence of each stakeholder.
- Particular efforts needed to involve important stakeholders who lack influence.
- Appropriate forms of participation throughout the project cycle.

3. Approaches for involving stakeholders

As a rule of thumb, the appropriate approaches for involving stakeholders of differing levels of influence and importance can be as follows:

- **Stakeholders of high influence and high importance** should be closely involved throughout the preparation and implementation of the project to ensure their support for the project.
- **Stakeholders of high influence but low importance** are not the target of the project but could possibly oppose the project that you propose. Therefore, you would want to keep them informed and

acknowledge their views on the project in order to avoid disruption or hindrance of the project's preparation and implementation.

- **Stakeholders of low influence and high importance** require special efforts to ensure that their needs are met and that their participation is meaningful.
- **Stakeholders of low influence and low importance** are unlikely to be closely involved in the project and require no special participation strategies (beyond information-sharing to the general public).

❖ **Design for the needs of the users**

In 1992, DFIF evaluated a water supply project in Nepal. The project has been primarily engineering-led and project-staff had liased with communities through the leaders of the formal local political structures. Links with the communities were therefore only through a small group of local leaders who might not have broadly represented the interests and views of all sections of the community. When the project was finally evaluated it was discovered that some of the tap stand locations were unduly public, especially for women. Tap stands are also used for bathing purposes in Nepal and some of the tap stands were located next to roads where there was little or no privacy.

The design itself was also considered unsatisfactory by users, especially women, as the construction did not provide enough room for washing clothes, leading to crowded situations.

Source: House et al. (1997) as cited in WEDC 1998.

4. Stakeholder Analysis Matrices

In order to get a clear overview of the stakeholders and their interests, influence and importance it is useful to use so-called stakeholder analysis matrices.

The first matrix gives an overview of the different stakeholders, their interests and their importance and influence. In this matrix the stakeholders that you have identified are entered in the left column. In the second column the interests of the stakeholders to the project are identified. In the third column, the effect that the project will have on the interests of the stakeholders is identified. For this identification a three-point scale can be used (negative, neutral, positive). The fourth column provides information about the importance of the stakeholders for the success of the project. The importance can be indicated by using a 6-point scale (unknown, little/no importance, some importance, moderate importance, very important, critical player). The last column concerns information about the influence of the stakeholder over the project. Here too, a 6-point scale can be used to display the relative influence that each of the identified stakeholders has over the project (unknown, little/no influence, some influence, moderate influence, significant influence, very influential).

Matrix: Step 1, 2 and 3 of the Stakeholder Analysis.

Stakeholder groups	Interests	Effect of project on interests	Importance of stakeholder for success of project	Degree of Influence of Stakeholder

In the second matrix, the focus is on the third step of the stakeholder analysis. In this matrix the relative influence and importance of the stakeholders are mapped in relation to other stakeholders. The left column consists of the different degrees of influence the stakeholders have, whilst the top row concerns the different degrees of importance of the stakeholder for the success of the project. The different stakeholders that have been identified in the first step are now placed in the box, which most accurately displays their relative influence and importance.

Matrix Step 3: Mapping the relative influence and importance of the stakeholder to the project

INFLUENCE	***IMPORTANCE***					
	Unknown	**Little or no**	**Some**	**Moderate**	**High**	**Critical player**
Unknown						
Little or no						
Some						
Moderate						
High						
Very influential						

The third matrix that we will discuss in this module concerns the fourth step of the stakeholder analysis, namely the initial formulation of a strategy for stakeholder participation. The column consists of different stages in the project cycle. The top row presents the type of participation that you should adhere to, moving from a limited form of participation (one-way information sharing) to more far-reaching form of participation (including transfer of decision-making powers).

Information sharing – This relates to informing the stakeholders of a project, the project goals and project objectives. The stakeholders are not involved in determining the goals and objectives Informing stakeholders can be done by a variety of ways. News and information about the project can be transmitted through radio, TV or newspapers if access to mass media in the particular area is good. Otherwise, posters or leaflets may be prepared and distributed in areas where the stakeholders are likely to be. Also presentations may be given to the stakeholder stakeholders.

Consultation – This involves involving the stakeholders in discussions on the goals and objectives of the project and on the design and implementation of the project. These stakeholders may experience impacts from decisions relating to the project and as such need to be consulted. The stakeholder representatives consulted in the project should be given the opportunity to voice their concerns and should be regularly informed of the progress of the project. This can be done by sending progress reports or by inviting stakeholder representatives to project meetings.

Collaboration or Partnership – Collaboration implies full involvement of the identified stakeholder. This means that the stakeholders are involved in decision-making relating to the project’s goals, objectives and design. Possibly representatives from the stakeholders are included in the project team in order to strengthen the partnership.

Empowerment or Ownership – The most far-reaching form of stakeholder participation involves transferring control of decision-making powers and resources to the stakeholders.

The matrix for the strategy of stakeholder participation provides you with an overview of the participation strategy that you have to follow in each of the stages of the project. This matrix provides an overview of the way you will involve what stakeholder, in what way and during which stage of the project.

Matrix Step 4: Formulation of Stakeholder Participation Strategy

STAGE IN PROJECT PROCESS	*TYPE OF PARTICIPATION*			
	Information sharing (on-way flow)	**Consultation (two-way flow)**	**Collaboration (increasing control over decision-making)**	**Empowerment (transfer of control of decisions and resources)**
Identification				
Preparation and Appraisal				
Implementation, Supervision and Monitoring				
Evaluation				

❖ **Design of groundwater wells in Letang, Nepal**

In the town of Letang, some hand-dug wells were in use. These wells have head walls built above ground level. The head walls were tall and wide, so it was difficult and exhausting to lift the water from the wells, because the head walls came up to the armpits of a tall man. This made it difficult to lift the water as this had to be done with extended arms. The difficulty is even greater for Nepali women, who are generally significantly shorter.

Source: House et al. (1997) as cited in WEDC 1998.

5. Methods for Stakeholder Participation

In principle, different methods can be employed to gather the information required for a stakeholder analysis. Although it I possible to do an entire analysis on the basis of a desk study, it is strongly recommended that other methods of gathering information be employed. Among the possible forms that you could think of are:

- Stakeholder workshops, in which selected stakeholders are invited to discuss the project.
- Local consultations 'on the ground'.
- Surveys.
- Consultations with collaborating organizations (such as NGOs, academic institutions, etc.).

Using multiple sources of information not only has the advantage that the information obtained is likely to be more accurate, but especially the participatory methods of information gathering (stakeholder workshops, local consultations, etc.) can also contribute to creating a sense of local ownership of the project and consensus about the project objectives. Stakeholder participation techniques range from a low level of involvement to a high level of involvement (Figure 15).

The Dynamic Nature of Stakeholder Analysis and Involvement

It is important to recognise that a stakeholder analysis is not just a one-time activity, after which you return to the normal 'order of the day'. As the society in which the project will be implemented is not static but continuously evolving, so will the views, interests and importance of the different stakeholders. As such, it is important to keep analysing the different stakeholders during the different stages of the project.

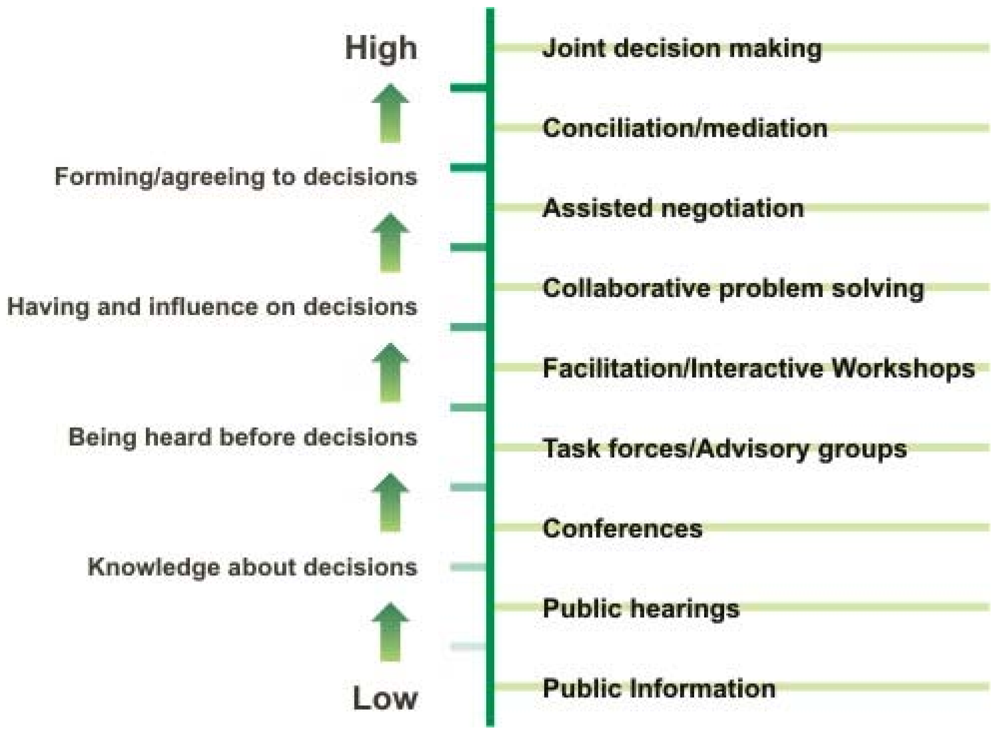


Figure 15- The degree of stakeholder involvement and methods for involvement.

IV. Options Analysis

Once the objectives, which the project aims to achieve, have been identified, it is necessary to decide upon the way in which these objectives will be achieved. For this purpose an **alternatives analysis** or **options analysis** has to be undertaken. The purpose of the alternatives analysis is **to identify alternative options, assess their feasibility and agree upon one project strategy**. The alternative options are based on the means-ends relationships of the objectives-tree (Figure 3).

> It is crucial to discuss the alternative options together with the stakeholders and to come to an agreement which will be the most favoured option.

Below a list of criteria is provided that can be considered when selecting the most viable alternative. Depending on the nature and scope of the project some of these criteria may be more important than others:

- Social: distribution of costs/benefits, gender issues, socio-cultural constraints, local involvement, motivation etc.
- Health: mortality rates, diseases etc.
- Technological: appropriateness, use of local resources, market suitability etc.
- Economic: economic return, cost effectiveness etc.
- Financial: costs, financial sustainability, foreign exchange needs etc.
- Institutional: capacity, capability, technical assistant inputs etc.
- Environmental: environmental impacts, environmental costs *vs.* benefits etc.

The planning team should consider the different criteria in relation to the alternative options and make rough assessments as to how an alternative scores for each of the selected criteria (e.g. high/low, +/-, extensive/limited, a scale of 1-5, etc.). Based on these criteria one project strategy should be selected.

The following activities are generally undertaken in this step:

1. Identify differing ‘means-ends’ branches as possible alternative options or project components;

2. Discuss the implications for affected groups;
3. Make an assessment of the feasibility of the different alternatives;
4. Select one of the alternatives as the project strategy;
5. If agreement cannot be reached directly, then:

a. Introduce additional criteria, or
b. Alter the most promising option by including or subtracting elements from the objectives-tree.

In order to make sure that the proposed project strategy is widely supported it is beneficial to include the various stakeholders in the selection of the preferred project strategy.

❖ **Water Supply in Lembang, Indonesia (3)**

If we apply this analysis to the Lembang case, let us assume that we have the following alternative options:

1. **Water company provides alternative technological approaches**, by offering cheaper technology options will make connecting financially attractive for a larger group of consumers. However, if consumers still do not trust the quality of the water provided by PDAM, the chances that they indeed will connect to the network are small. Thus, investments in alternative technologies by PDAM will not be returned.
2. **Water company provides proper arrangements to ease the burden of the connection fee.** This option makes connecting to the network more attractive for the consumers by offering arrangements, which reduce the burden of the connection fee. However, the problem remains that if the consumers do not believe that the water is of good quality, they will still not connect regardless the burden of the connection fee
3. **Water company starts an information and education campaign to convince the consumers** that the water is of good quality. Increase the willingness of consumers to connect, as they believe to get high quality water and attractive services. For many of them, however, the price for connecting to the network will be too high, and therefore most consumers will depend on alternative, cheaper sources of drinking water, e.g. water from shallow wells, etc.

A fourth option, i.e. the combination of options, seems to be more attractive. In this case, either option 1 or 2 is combined with option 3. Although the costs will be higher, this option has the highest probability of success as it addresses both the costs of connecting to the network as well as changing the attitudes of the consumers.

The results of this analysis are summarised in Table 3. It has to be stressed here, that all stakeholders should first agree on the criteria that should be used to assess the viability of the different options. On the basis of these results, option 3 is chosen as the most favourable one.

Table 3- Alternative options - Lembang case study.

Criteria Selection	Alternative technology	Measures to reduce connection fee	Information & education campaign	Alternative technology & Information and education campaign
Willingness to pay	Low	Low	High	High
Ability to pay	High	High	Low	High
Cost	High	High	Low	High
Cost/benefit	High	High	Medium	Low
Social risk	Low	Low	Low	Low
Sustainability	Low	Low	Low	High

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MODULE 2

CONVENTIONAL AND INNOVATIVE APPROACHES TO MUNICIPAL WASTEWATER MANAGEMENT

This module is the core of the course. The participants will get an overview of conventional and innovative technological solutions as well as financing options. A general overview of possibilities and limitations of various approaches is presented that will give sufficient background to develop new approaches to wastewater management in each municipality. The participants will be asked to develop a number of alternative approaches to address major wastewater problems under your responsibility. These will be presented and discussed during the course.

At the end of this module the participants will be able to:

1. Recognise the changing principles underlying (waste)water services (technological and financial).
2. Adapt to a more consumer-based financing approach.
3. Classify various alternatives to address wastewater problems.
4. Describe their strengths and weaknesses in a specific situation.

This module has two focal areas, technological and financial and is divided into the following parts:

I. Conventional approaches & alternative technologies

II. The way forward: the 3-Step Strategic Approach

III. Financial approaches to municipal wastewater management

IV. Water management in the city of tomorrow

MODULE 2

CONVENTIONAL AND INNOVATIVE APPROACHES TO MUNICIPAL WASTEWATER MANAGEMENT

I. CONVENTIONAL APPROACHES AND ALTERNATIVE TECHNOLOGIES

1. CONVENTIONAL APPROACHES
2. CONSTRAINTS TO CONVENTIONAL APPROACHES
3. THE NEED FOR ALTERNATIVE APPROACHES

II. THE WAY FORWARD: THE 3-STEP STRATEGIC APPROACH

III. FINANCIAL APPROACHES TO MUNICIPAL WASTEWATER MANAGEMENT

1. THE CASE FOR COST-RECOVERY
2. THE COST OF WASTEWATER SERVICE PROVISION

IV. WATER MANAGEMENT IN THE CITY OF TOMORROW

REFERENCES

MODULE 2

CONVENTIONAL AND INNOVATIVE APPROACHES TO MUNICIPAL WASTEWATER MANAGEMENT

I. Conventional Approaches and Alternative Technologies

1. Conventional approaches

The collection and disposal of waste and wastewater is essential in order to control the transmission of waterborne diseases and to prevent degradation of the environment, including groundwater and surface waters. The standard 'Western' service level of water supply comprises high quality piped water with multiple connections per household.

This concept results in high water consumption and produces large volumes of rather dilute wastewater that needs to be collected via an extensive sewer system and is finally treated in modern centralised treatment works.

The major features of water infrastructure in the industrialised world are listed below (Table 4). The trend in the industrialised world is towards further development and improvement of these conventional systems. This requires highly skilled labour, large amounts of capital and steady socio-economic conditions with regard to finance and chemical supplies, etc. Although this conventional approach is the standard in the industrialised countries, its application as standard solution for developing countries is not realistic.

Industrial countries

The development of the 'Western' sanitation concept originates from the 19th century with the prime objective to prevent water borne diseases. This has been realised by selecting clean water resources and effective potable water treatment and distribution systems for a wide range of domestic purposes. As a consequence, 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 sewerage infrastructure (Figure 15), cities in countries with a high gross national product (GNP) have been essentially free of water borne diseases.

Figure 15- Modern wastewater treatment plant

Despite this evident success, the present day concept of urban water management needs to be seriously reconsidered from a sustainability point of view.

Table 4- Major features and disadvantages of water infrastructure in the industrialised world (after van Lier and Lettinga 1999; Varis and Somlyody 1997).

Feature	Disadvantages
Water supply	High coverage required, safety is a major concern, part of living standard, willingness to pay is there, inherited systems from past decades: no separation (high quality water is used for all the purposes) Limited flexibility, infrastructure is given, a change would need 15-20 years (reconstruction period).
Sewerage	The concept originates from 19th century; Public health and waterborne/transmitted diseases original driving force; Long planning horizon and life time - difficult planning due to uncertainties in future flow estimates; Very expensive, investment and money driven; Functions: transport of pollutants (liquids), originally domestic wastewaters; industrial ones at a later stage; stormwater, linkage to road construction; Requirement of relatively high tap water consumption to prevent sewer clogging resulting in large volumes of contaminated water; High dependency on supply of power for pumping stations.
Treatment	Central plants dominate; activated sludge mostly and its advanced versions; increasing sophistication (operation); sludge management; High dependency on supply of power and chemicals, and skilled O&M and management staff.

Developing countries

There is at present hardly any infrastructure for the effective treatment of sewage in developing countries. Municipal sewerage and the extent of domestic and industrial wastewater treatment are inadequate in most urban situations. When there is a municipal sewerage network in place, the coverage is usually incomplete and the treatment level is insufficient. Even when treatment facilities exist, poor maintenance and operation often results in failing treatment processes, causing pollution of the effluent receiving surface waters. The risk of water borne diseases may actually increase in developing countries as a result of the introduction of a conventional sewerage scheme, since it is usually not accompanied by effective end-of-pipe treatment.

2. Constraints to conventional approaches

Water availability and quality

The national plans of all developing nations address the importance of increasing the coverage of safe water supply to the population. Donor agencies and development banks obviously stimulate this objective and provide (credit) support to reach that goal. However, current information on water resources indicates that there will be many regions where such service level cannot be sustained, simply because of unavailability of the required quantity of water at the right quality. Moreover, one may question many of the industrial and domestic uses of water, other than drinking, which has been purified to drinking water standards. In 1958 the United Nations Economic and Social Council stated that *no higher quality of water, unless there is a surplus of it, should be used for a purpose that can tolerate a lower grade*. Yet we use drinking water to flush, wash cars etc.

Financial resources

Lowest coverage of drinking water services is found in the low-income countries as well as in the poorer areas in middle-income countries. If these countries indeed would succeed to provide their entire population with safe centralised drinking water services, it is not likely that sufficient additional financial resources will remain for the proper collection and treatment of the generated sewage before discharge into nearby water bodies. As a result, the sanitary waste (excreta) which previously was contained and treated via on-site technology (pits, composting toilets) will now appear as sewage pollution in nearby water resources, threatening the environment and the users and communities downstream. From a public health point of view, one may wonder whether it is wise to strongly dilute pathogens, which originally are produced in compact (manageable) form. This concern relates to communities and regions where the effective treatment and disinfections at the end of the pipe will not be feasible and a risk of water borne diseases will continue to exist.

The cost of conventional wastewater infrastructure is prohibitive in the majority of the developing countries.

According to the World Bank, up to 3% of a country's GNP can realistically be spent on environmental protection (including wastewater treatment). Grau (1994) and Gijzen (1997) estimated the period of time needed to meet the European effluent standards by a number of low and middle income countries, assuming that 1.5% of the GNP could be invested in sewers and treatment facilities (Table 5). This period exceeds by far the economic life-time of the treatment plant (20–30 years) and in many cases even that of sewers (50-60 years). The implementation of conventional wastewater collection and treatment in developing countries to reach EU standards is therefore unrealistic, except maybe in densely populated urban centres where the average income is much higher.

Table 5- Estimated period of time needed to meet EU effluent standards at an investment level of 1.5% of the GNP (Gijzen 1997).

Country	Population (MILLION)	GNP c^{-1} (US $ C)	Cost to meet EU standards (US $ c^{-1})	Time needed at 1.5% GNP y^{-1})
Bulgaria	8.5	2210	3755	113
Egypt	60	1030	4000	259
India	935	335	3750	746
Kenya	29.2	290	4500	1034
Mexico	92.1	2705	3750	92
Poland	38.3	1700	1230	48
Romania	23.2	1640	1422	58

It should also be realised that in industrialised countries, the current treatment capacity has been installed over a rather long period in a staged approach, with high investments (Figure 16):

- **Primary treatment systems** were installed to remove a large portion of the suspended solids and associated BOD.
- **Secondary treatment systems** were added to achieve high removal efficiencies for TSS and BOD.
- Currently many **activated sludge systems are being upgraded to include also nitrogen and phosphorus removal.**

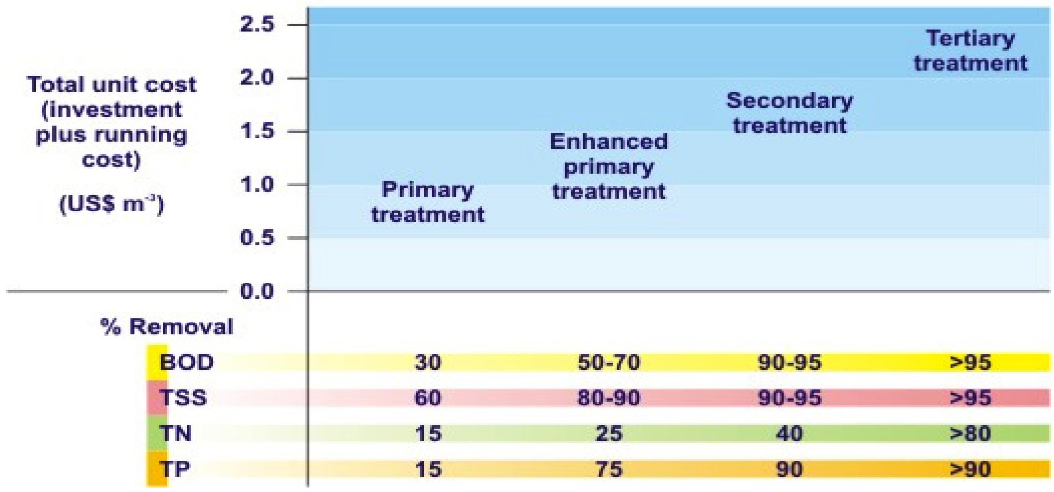


Figure 16- Typical total unit costs for wastewater treatment (data from Western Europe and the United States, Veenstra *et al*. 1997).

Loss of valuable resources

Modern sewage treatment systems apply tertiary treatment for the removal of nitrogen and phosphorus via physical-chemical or biological processes. This practice does not seem rational when analysed as part of the overall food production and consumption cycle. Intensive agriculture and animal production systems have been developed to sustain a secure food supply to an ever-growing population. Intensive agriculture requires the use of substantial amounts of inorganic fertiliser, which is obtained via energy intensive industrial fixation of atmospheric nitrogen. When fixed nitrogen has been incorporated into high quality plant protein, it will serve as human food or animal feed, and a major part of the nitrogen will be released again into the environment through wastewater or animal waste. When applying costly biological nitrogen removal (nitrification/denitrification), the potentially useful nitrogen will be re-circulated to the atmosphere. This approach seems inefficient from both an energy and resource utilisation point of view.

3. The need for alternative approaches

These issues suggest that the current 'Western' conventional approach to water supply and sanitation should be reconsidered. Changes in the industrialised world will be slow due to the phenomenal investments contained in the existing infrastructure for water supply, collection and treatment in these countries, together with the considerable commercial interests of established companies on the technology supply side. Nevertheless, it might prove rewarding to develop long-term strategic approaches leading to sustainable urban water services within two to four generations from now. Most low- and middle-income countries have not yet invested heavily in the physical infrastructure for urban water supply and sanitation, and may benefit on a short term from such new approaches to sanitation.

Below follows an overview of alternative approaches to address wastewater problems. In Chapter II, a combination of these alternatives will be used to formulate a new strategic approach to sewage management.

On-site v.s. off-site treatment

On-site sanitation is effective when little or no piped water is available. It consists of on-site wastewater collection and treatment systems at the level of a household or an apartment block. On-site systems, such as septic tanks and pit latrines, comprise low-cost technology, allow construction, repair and operation by the local community or house owner and effectively reduce public health problems related to wastewater. With on-site sanitation systems, black toilet water is disposed in pit latrines, soak-aways or septic tanks. Where little or no piped water is available, excreta and other household waste can be disposed off in on-site household systems such as (ventilated) pit latrines or dry (composting) toilets.

The solids (septage) that accumulate in the pit or tank (some 40 litres per person per year) have to be removed periodically. In case of the single or dual-pit latrine, a new pit must be dug. The septage should be treated in a sewage treatment plant or in a separate waste stabilisation lagoon. A septic tank will remove 30 to 50% of BOD and 40 to 60% of suspended solids. In properly designed septic tanks with soil absorption, the soil will remove the remaining BOD, and suspended solids, bacteria and viruses from the effluent.

The main selection criteria for on-site or off-site sanitation are the population density (number of people per hectare) and produced wastewater volume (in cubic meters per hectare per day). The presence of shallow water wells susceptible to sewage pollution, soil permeability and unit cost of sewerage are also major factors. Social considerations play an important role in the choice of the sanitation system, especially for on-site systems. Cultural and local differences (cultural conceptions about excreta) can result in a specific on-site system being effective in one place but not acceptable in another.

Pollution prevention

A good example of pollution prevention by source reduction is the banning of phosphate detergents in washing powders. In many countries this has significantly reduced the phosphorus level of domestic sewage and consequently of receiving water bodies.

Once a pollutant is discharged into the sewer, it is diluted by several orders of magnitude and mixed with other contaminants. This dilution makes treatment more difficult, while the perspectives for recovery and re-use are significantly reduced.

Reducing domestic water consumption is a very effective way to reduce sewage volume and makes treatment cheaper. Demand management, water saving technologies in households and, for example, re-using grey wastewater for toilet flushing may yield significant reductions in required sanitation capacity (Figure 17).

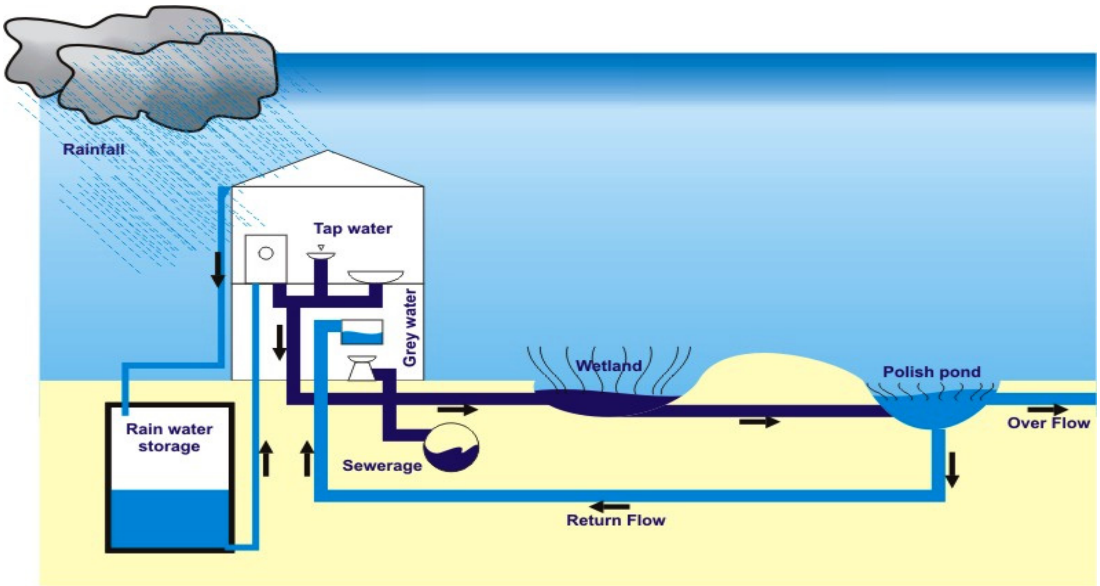


Figure 17- The use of grey water to flush the toilet (from Veenstra 2000).

Water conservation reduces the volume of sewage requiring collection and treatment. It does, however, not change the total mass of wastewater pollutants. The benefits of water conservation include reduced cost of facilities for water supply and wastewater treatment, and reduced impacts in the region from which surface or ground water supplies are abstracted.

❖ **Water savings in Seoul and Pusan, South Korea**

In South Korea an expansion of the sewage treatment capacity for Seoul and Pusan was proposed, based on the projected growth of tap water consumption from 120 to beyond 250 l c^{-1} d^{-1} 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 down by half (Veenstra et al. 1997).

A significant step further would therefore be the development of (advanced) dry sanitation concepts, or sanitation technologies that use very small volumes of water (Figure 18). Larsen and Gujer (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.

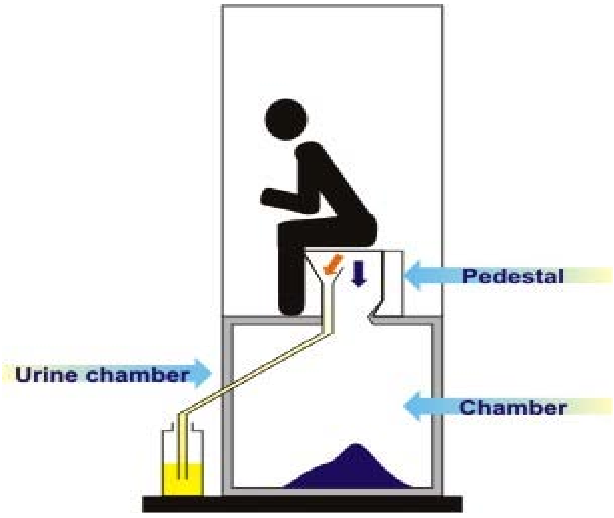


Figure 18- Ecological toilet: separating wet (urine) and dry (faeces) components (Source: Esrey et al. 2000).

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 developing countries

Letson et al. (1998) present a number of case studies on pollution prevention in the coastal zone, among which the Boston Harbour cleanup project and the Chesapeake Bay nutrient reduction project.

❖ **Boston Harbour Cleanup Project, USA**

The Boston Harbour cleanup project consisted of the construction of a municipal wastewater treatment plant with an ocean outfall. The pollution prevention component consisted of the construction of a sludge processing plant to recycle the nutrients from the sludge into fertiliser pellets.

Some potential benefits of the incorporation of pollution prevention principles in municipal wastewater management are summarized below:

- Significant reduction of household water consumption and generation of high strength and better treatable domestic wastewater.
- Low cost water supply and wastewater systems for the smaller volumes of water to be treated.
- The recovery and re-use of waste components, e.g. the separate collection and transportation of urine with industrial recovery of nitrogen fertiliser (Larsen and Gujer 1996).
- Development of dry sanitation systems, connected to (high pressure or vacuum) centralised energy and nutrient recovery.
- The effective (re-) use of water with different quality ranges for different purposes

Water consumption rates are almost directly correlated with development status. In light of this perception of water consumption as a development indicator it might be difficult to suggest that 'new' connections to water services should use a different sanitation approach. Therefore, alternative concepts of non-water borne sanitation or low-water consuming alternatives need to be developed and introduced both in industrialised and developing nations alike.

Natural treatment systems

A natural system for wastewater treatment is 'any type of wastewater treatment system in which the process of biological degradation of organic compounds is not aided by the input of significant amounts of energy or chemicals'. A natural treatment system may include pumps and piping for waste conveyance but does not depend exclusively on external energy sources to maintain the major treatment responses (Reed et al. 1995). A brief overview of the characteristics of a number of natural wastewater treatment systems is given in Annex 1: 1) anaerobic (pre-)treatment in septic tanks, 2) anaerobic ponds or high rate anaerobic reactors, 3) waste stabilization ponds, 4) macrophyte ponds, 5) fish aquaculture, 6) constructed wetlands, and 7) land treatment systems.

Natural systems follow 'the logic of nature'. In nature, resources are recycled and it may, therefore, be beneficial to replace the 'linear' view on sanitation i.e. collection, transport, centralized treatment and final disposal, with a 'loop approach'. In a loop approach, one views waste as a resource.

> Though sewage may be a 'resource in the wrong place', it has economic value and, therefore, could beneficially be recovered or recycled (King 2000).

The general features of natural systems include:

- Natural systems are aimed at recycling of nutrients, water and energy.
- Natural systems use aerobic and/or anaerobic microbiological processes to remove COD without the need for energy input.
- The oxygen for aerobic microbiological processes in natural systems is supplied by photosynthesis (algae, plants) or natural re-aeration.

In areas of higher population density, it is feasible to develop a local collection system and use a single facility to treat the community's waste. Lagoons, stabilisation ponds and aerobic package plants are for example common treatment options that are being used in mid-size communities in the wider Caribbean region (UNEP 1998). Package plants are used mostly for resort communities, hotels and other public buildings. Many package plants are however working improperly, because of improper design and/or inadequate maintenance. Many conventional treatment facilities in developing countries do not provide adequate treatment because of improper maintenance and lack of skilled operators.

Such problems specifically in coastal zones are for example reported in the Caribbean (UNEP 1998), in Barbados (Herbert *et al.* 1992), in the Indian Ocean Islands (Parr and Horan 1994), in Greek islands (Katsiris and Kouzeli-Katsiri 1989) and in Cyprus (Vaananen and Gavrielides 1989).

Lagoons are the most cost effective and efficient wastewater treatment systems for domestic sewage when inexpensive land is available. Lagoons are non-mechanised biological treatment systems. Typical examples are simple anaerobic reactors, stabilisation ponds, deep reservoirs and macrophyte based systems (ponds and wetlands). The design of these 'natural' systems is based on the stimulation of self-purification of natural eco-systems and water bodies. Marine sewage outfalls are another example of the application of self-purification. The examples of the use of natural ecosystems in Uganda and China (see below) are simple systems in operation and maintenance, but are generally only feasible when land prices are sufficiently low (Viessman and Hammer 1993). The use of 'natural systems' has attractive economic benefits, because of the relatively low construction and operation costs and the potential generation of utilisable resources.

❖ **Ecological engineering: Wetland system in Uganda**

The Nakivubu swamp, a natural wetland located on the northern fringes of Lake Victoria, Uganda has been used for over 30 years for the (partial) treatment of sewage from the Ugandan capital Kampala. Kansiime and Nalubega (1999a, b) have made an extensive study of the functioning of the swamp as a natural component in a wider wastewater strategy. The average water discharge into the swamp was estimated at over 100,000 m^3 per day, yielding an annual nutrient loading of about 770 gN m^{-2} and 66 gP m^{-2}. The overall removal of N, P and pathogens from the wastewater, before it enters into Lake Victoria, is estimated at 56%, 40% and 91%, respectively.

Improved distribution of the wastewater and the construction of a supplementary forest wetland are suggested as measures to improve the treatment capacity of this natural system.

Natural wastewater treatment systems, such as wetlands, waste stabilisation ponds and macrophyte ponds, are now well-established processes, but they all have the disadvantage that they have substantially greater land area requirements than conventional processes such as activated sludge, biofilters and aerated lagoons. The hydraulic retention times in ‘natural systems’ can probably be further optimised by stimulating the natural conversion processes and/or by including an anaerobic pre-treatment step. Attention should be given to the development of high-performance low-maintenance natural systems, which produce energy, high-quality plant protein and high-quality effluents for agricultural re-use at low cost and with lower land area requirements.

Most natural wastewater treatment technologies provide adequate treatment in terms of removal of organic matter, but some fail in the removal of nutrients. For low-income, rural communities, nutrient removal and advanced treatment are generally not required; the low wastewater volumes result in sufficient dilution by the receiving surface water. The disposal of large wastewater effluents from densely populated areas into eutrophication-sensititive estuaries would require nutrient removal. For urbanised areas with effective management control and access to skilled labour, conventional mechanised, energy-intensive technologies may be appropriate, especially when land is too expensive for natural systems.

❖ **Ecological engineering: Fumen River, China**

Water hyacinth has been introduced in a section of the Fumen river, in an eastern suburb of Suzhou, China. A mixture of municipal sewage and urban run-off is discharged into the river at a rate of about 10,000 m^3 y^{-1} upstream of the water hyacinth covered section. The total area covered by water hyacinth amounts to 2.8 ha and the retention time of the water in the covered section ranged from 8 to 32 h. Via the production of water hyacinth the annual per ha removal of N and P amounts to 1580 and 358 kg, respectively. The water hyacinth with attached micro-organisms and organic pollutants is regularly harvested from this ecosystem to serve as feed in fish culture ponds, duck farms and pig farms.

Although the system described above is small in scale, it provides a good example of sewage pollution control via ecological engineering, where pollution is converted into green fodder.

Re-use options and waste valorisation

The final result obtained after wastewater treatment is not easily recognised as a valuable product (contrary to, for example, the water treated for the provision of drinking water). This may explain that many ‘low cost’ wastewater treatment systems are poorly maintained and eventually become inactive. If the treatment process itself, in addition to purified effluent, could generate valuable ‘products’, this would be an important incentive to stimulate optimal operation and maintenance of the treatment plant.

An example of re-use is found in so-called integrated systems, where optimum use of resources is achieved via waste recycling aimed at the recovery and re-use of energy, nutrients and possibly other components. The conversion processes for different sources of waste are arranged in such a way that a minimum input of external energy and raw materials is required and maximum self-sufficiency is achieved. The re-use of wastewater and excreta in aquaculture is a traditional practice in certain countries, particularly in China, India, Indonesia and Vietnam. In China there are huge farms that are almost completely self sufficient in terms of energy and nutrients because of effective recycling of their waste streams. Effluent irrigation has been practised for centuries throughout the world. It provides farmers with a steady supply of cheap nutrients and water.

The application of integrated concepts provides a good balance between resource utilisation, re-use and environmental protection.

Several examples of large scale re-use of wastewater, yielding important economic returns, exist, notably for aquaculture and crop production. Below, a brief description is given of the world largest examples of wastewater fed agriculture (Valle Mezquital, Mexico) and of wastewater fed aquaculture (Calcutta wetlands, India). An example is given of duckweed-based sewage treatment and resource recovery in Bangladesh and the recovery of energy from wastewater is discussed.

Wastewater-fed agriculture: the Valle Mezquital, Mexico

The Valle Mezquital represents the world largest area of wastewater irrigated agriculture. The valley is located in the Mexican high plateau, at an altitude of between 1700 and 2100 m above sea level, and about 60 km north of Mexico City. The entire valley has an estimated population of about 500,000 inhabitants, most of which are involved in agricultural activities.

The standard of living of the population is reported to be higher than that of similar populations in Mexico, which do not apply wastewater-fed agriculture. The valley presents a unique example of wastewater irrigation, because of its immense cultivated area (83,000 ha) and its long history (almost 100 years). The area is irrigated using raw wastewater from the metropolitan area of Mexico City (about 1900 million m^3 y^{-1}). This wastewater has received no conventional treatment and is channelled to the area by gravity via a large drainage canal. The principal crops grown are alfalfa, maize, beans, oats, tomatoes, chillies and beetroot. Although prohibited by law, there is some production of restricted crops as well, including lettuce, cabbage, carrot, spinach and radish.

The wastewater is highly valued by farmers because of its soil improvement qualities and its nutrient load. The economic importance of wastewater-fed agriculture in the area is demonstrated in Table 6. The total production value for 1994 was estimated at about US$ 100 million. The importance of wastewater-fed agriculture in this region can also be demonstrated by comparing production data with those of other regions in Mexico (Table 7).

Table 6- Irrigation data for Valle Mezquital for the period 1993-1994 (Source: Romero, 1997).

Irrigation area	Area covered (ha)	Area cultivated[1] (ha)	N°. of users	Water volume (10^6 m^3 y^{-1})	Production value (10^6 N$)[2]
District 03	45,2	55,3	27,9	1,1	255
District 100	32,1	22,40	17,0	651	85
Private units	5,4	5,5	4,0	96	-
Total	82,7	83,18	48,9	1,9	340

1) includes areas with more than one crop per year
2) exchange rate: 1 US$ is about 3.5 N$

Via irrigation, the wastewater from Mexico City receives a natural land treatment, which is estimated to be equivalent or even superior to conventional secondary wastewater treatment. The environmental benefits include a reduction of 1,150 t per day of BOD load, which would otherwise end up in the Panuco river basin and could affect large coastal areas of the Gulf of Mexico.

Table 7- Agricultural productivity (t ha^{-1} y^{-1}) of Valle Mezquital compared to non-wastewater irrigation areas (Romero, 1997).

Crop type	Valle Mezquital	National average	Hidalgo State	Rain-fed area
Sweet corn	5.2	3.7	3.6	1.1
Kidney bean	1.8	1.4	1.3	0.5
Oat	3.7	4.7	3.6	1.7
Barley	22.0	10.8	15.5	13.5
Lucerne	95.5	66.3	78.8	0.0

In spite of all these benefits, the wastewater-fed irrigation practise of Valle Mezquital receives criticism from a public health point of view.

The wastewater is produced from domestic and industrials sources and therefore contains pathogens and toxic chemicals that constitute a health risk for both farmers and consumers. Reliable data on pathogen counts and on the presence and fate of toxic chemicals are scarce. Analyses of faecal coliforms in reservoirs in the valley indicate values which are 10^2 to 10^4 higher than the WHO guidelines for re-use. Due to the spread of cholera, the National Water Authority (CNA) has enforced restriction on crops irrigated with wastewater. The incidence of infection by *Ascaris lumbricoides* in children aged between 1 to 14 years appeared to be 10 to 20 times higher compared to areas with rain-fed irrigation (Romero 1997).

These data underscore the importance of effective treatment of wastewater before land application.

❖ **Wastewater-fed aquaculture: the Calcutta wetlands, India**

Fish raised in (pre-treated) wastewater-fed ponds represents an important source of high quality animal protein for many millions of people, especially in South East Asia. Also the direct re-use of excreta in aquaculture is traditionally practised in a number of Asian countries, including China, India, Indonesia, and Vietnam. The largest example of wastewater fed aquaculture in the world is the Calcutta wetland system (see below), immediately to the East of the city (Edwards and Pullin 1990).

The Calcutta wetland system has developed over the past 100 years due to uncontrolled discharge of wastewater and urban run-off from Calcutta. Over time, fish farmers have segmented parts of the wetlands into small-scale aquaculture enterprises. The aquaculture practise in Calcutta creates employment and provides low-cost protein to the local population. However, public health aspects of both producers and consumers must be considered. The wetland receives about 550,000 $m^3\ d^{-1}$ of untreated wastewater, flowing through about 3,000 ha of constructed fish ponds within the wetland. The annual fish production amounts to 13,000 tons (mainly Indian Major Carp and Tilapia), which is supplied to fish markets of central Calcutta and consumed in the wider region.

Obviously these practises will not be able to comply with current WHO guidelines for microbiological quality in aquaculture (i.e. zero nematodes; less than 1000 feacal coliforms per 100 ml). Total coliform counts of 10^5 to 10^6 100 ml^{-1} have been reported in the influent of the wetland (Pescod 1992). Mara et al. (1993) suggested that WHO guidelines for such aquaculture systems could be easily achieved by applying a minimal treatment of the wastewater prior to the Calcuta aquaculture ponds, using 1-day retention anaerobic ponds followed by 5-day retention facultative stabilisation ponds. Although this approach may improve the microbiological quality of the water, industrial pollution may still pose a threat to public health.

The Calcutta sewage is a mixture of domestic and industrial wastewater. One wastewater-fed fishpond system in Calcutta receives as much as 70% industrial wastewater. Hardly any data are available on the content of metals, pesticides and other toxic chemicals in the wastewater. No information is available on the fate of such toxic compounds in the current aquaculture system in Calcutta.

The public health aspects of wastewater-fed aquaculture requires further study and safe approaches need to be developed.

❖ **Ecological engineering: duckweed based sewage treatment and resource recovery, Bangladesh**

Stabilisation ponds for the treatment of wastewater can be modified by the use of aquatic macrophytes such as *Pistia* (Lemnaceae = water hyacinth or duckweed). Duckweed based wastewater treatment has been successfully introduced in a number of countries. In Bangladesh a local NGO, PRISM-Bangladesh, is operating a small scale duckweed based pond for the treatment of domestic sewage (Gijzen and Ikramullah 1999). The protein-rich duckweed biomass is harvested daily and fed to adjacent fish ponds which yield an annual fish production of 12 to 16 tons per ha. The results over the last 5 years of operation demonstrate that the system generates a net profit of almost US$ 2000 per ha/y. For comparison, the maximum net profit for rice production in Bangladesh can be estimated at $ 1000 to 1400/ha.y. Detailed financial evaluation of the wastewater treatment and aquaculture facility operated by PRISM suggests that this is probably the first system that is able to generate a net profit from the treatment of domestic sewage. This is possible because the cost intensive treatment is combined with revenue generating aquaculture.

Recovery of energy from wastewater

The above examples deal with the effective recovery and re-use of water and nutrients from wastewater effluents. Effective re-use schemes should also consider the energy component of wastewater and that of wastewater treatment systems. Modern wastewater treatment such as activated sludge requires substantial inputs of external energy, usually coming from non-renewable sources. Theoretically 0.8 and 3.0 m^3 of oxygen are required for the oxidation of one kg of organic matter or ammonia, respectively. In aerated systems several times this volume must be forced into the water phase at the expense of valuable energy. The treatment of wastewater in a high-rate anaerobic reactor does not require oxygen input and, in addition will yield some 375 L of methane per kg of BOD digested. In fact some 90% of the energy contained in organic matter will end up as methane gas. This is not only positive for the overall energy balance of the system, but also replaces an equivalent amount of non-renewable energy and greenhouse gas emissions.

From the composition of human excreta (Table 8), and assuming about 70% biodegradation of organic matter, a daily production of between 18 and 30 L of methane can be expected per capita. This suggests excellent possibilities for energy recovery from human excreta. Due to the high water consumption, however, the energy recovery per unit of volume of wastewater is relatively small; 200 mg BOD L^{-1} at 70% biodegradation will yield some 50 ml of methane gas, of which a substantial part will leave the reactor via the effluent in suspended form.

Table 8- Production and composition of human faeces and urine (Polprasert 1996).

Production and composition	Faeces	Urine
Quantity (wet) per person per day	100-400 g	1.0-1.31 kg
Quantity (dry solids) per person per day	30-60 g	50-70 g
Moisture content	70-85%	93-96%
Approximate composition (% dry weight)	-	-
Organic matter	88-97	65-85
Nitrogen (N)	5.0-7.0	15-19
Phosphorus (as P_2O_5)	3.0-5.4	2.5-5.0
Potassium (as K_2O)	1.0-2.5	3.0-4.5
Carbon (C)	44-55	11-17
Calcium (as CaO)	4.5	4.5-6.0
C/N ratio	~6-10	1

Integrated approaches

Duckweed ponds could play an important role in recycling and re-use schemes in both rural and urban areas. The process steps and products of an integrated duckweed based treatment system for rural and urban recycling of waste streams are presented in Figure 19. Anaerobic technology is advocated to reduce the bulk of organic and suspended matter. The energy produced in rural biogas digesters or urban high-rate reactors (e.g. UASB or AF) can be used by the community (rural context) or for the operation of subsequent treatment steps (urban application), thereby reducing treatment costs.

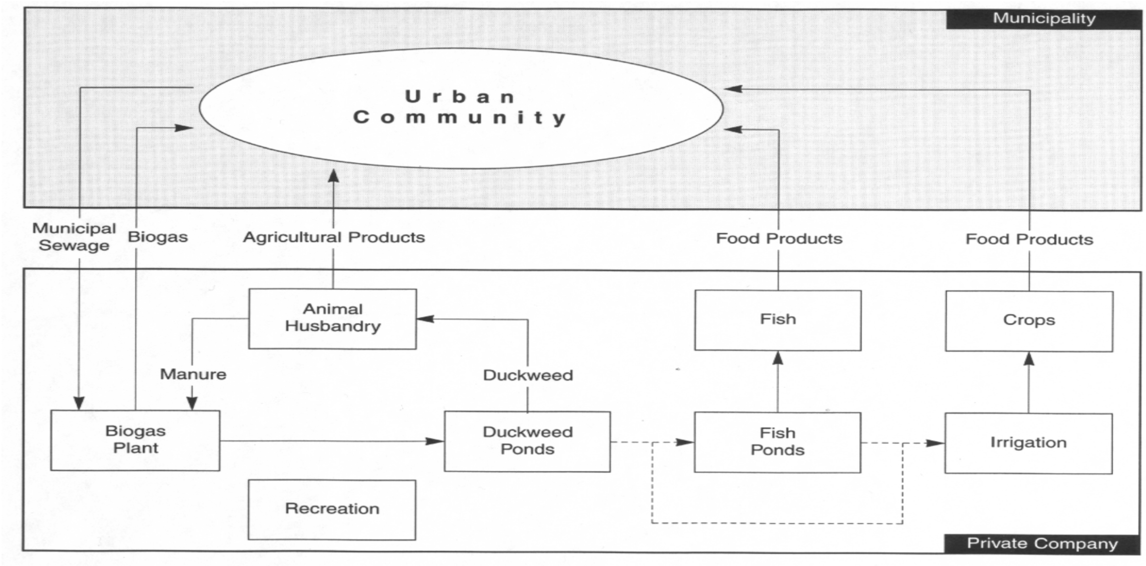


Fig. 19- Urban integrated waste recycling system using duckweed ponds (from Gijzen and Veenstra 2000).

Anaerobic treatment facilities, requiring only limited space, may be planned at convenient locations in or near the city. The effluent of the anaerobic reactors can be channelled outside the city to duckweed pond facilities. The duckweed harvested at regular intervals can be used to cultivate fish in adjacent ponds, while the effluent can be made available for irrigation. With the income from the products generated (energy, fish, irrigation water), the proposed integrated system has the potential to become a commercial enterprise generating substantial revenues.

The Way Forward: the 3-Step Strategic Approach

Considering the low level of treatment of wastewater, and the rapid increase in water resource contamination world-wide, it is clear that urgent actions are required. The problems are of such proportions, especially for cities in developing nations, that we can not expect that the sewage problem will be solved within a short time. Also it is not realistic to expect that exclusively an 'end of pipe' approach via the installation of expensive collection and treatment infrastructure will provide the magic solution. The wastewater problem is extremely complex and solutions need to be tailored to the specific characteristics encountered in each country, province and municipality. The above tasks call for the development of a strategic action plan for the sustainable management of sewage in (urban) coastal zones, and their inland catchment areas.

Applying 'Cleaner Production Principles' to the water and sanitation sector has resulted in a new approach to sustainable municipal (or 'urban')water management (Fig. 20) (Gijzen in press). This approach strongly focuses on sewage management, but also considers water supply, nutrient uses and other material flows associated with the urban water cycle. This approach includes three steps: 1) prevention, 2) treatment for re-use, and 3) planned discharge with stimulation of self-purification capacity. The steps should be implemented in chronological order, and possible interventions under each step should be fully exhausted before moving on to the next step.

Examples of possible interventions under each step will be presented below and largely follow from the alternative approaches presented in Chapter I.

Step 1: Pollution prevention or waste minimisation

The central question under this step is 'to use or not?' The basic principle is that interventions should start by controlling consumption. The recent past has shown various good examples of the 'no use' approach. In many countries the use of P-containing detergents has been prohibited now and washing powder manufacturers have responded by substituting phosphorus, important in the cleaning process, by other less harmful chemicals. As a result, sewage P-levels are lower and surface waters will be protected from rapid eutrophication. The same question applies to the use of high quality drinking water; e.g. is it wise to use 50 to 80 litres of high quality drinking water to transport daily 1 – 1.5 kg of human waste to a water treatment facility or, as is often the case, to a water resource? High water consumption has serious implications on the sizing of water and wastewater facilities and their efficiency. Reduction in wastewater generation is therefore necessary in view of the importance of conserving resources, investments and energy. This can be achieved via reduction of domestic water consumption, which will reduce sewage volume and treatment costs. Any level of reduction can theoretically be achieved. On the far end of the scale we find dry sanitation, but significant reductions can also be achieved via demand management and water saving technologies in the household (water saving flush toilets, water efficient shower caps and taps, efficient dishwashers, laundry machines etc.). In addition demand management schemes should be aimed at educating families in efficient water use. These interventions have shown to produce excellent results.

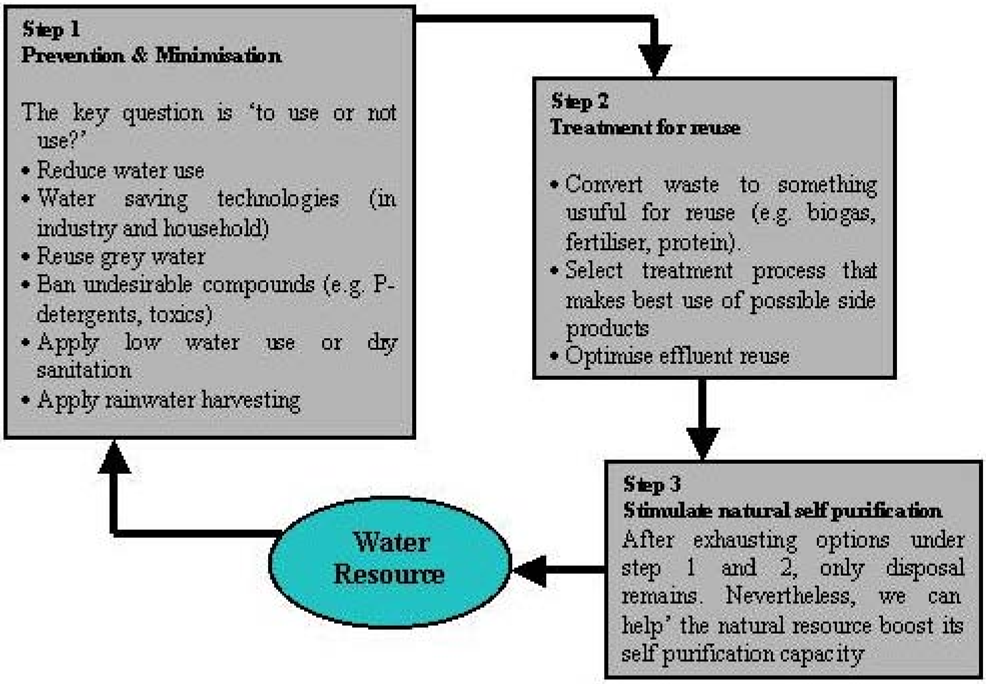


Figure 20– The three-step strategic approach for Urban Water Management (from Gijzen in press).

The other question is whether people should really consume at current levels of inefficiency, *e.g.*, use water, nitrogen and phosphorus only once? Waste minimisation involves not only technology, but also planning, good housekeeping, and implementation of environmentally sound management practices (cleaner production). It also involves a special attitude of the users (education, demand management). The 'polluter pays' concept and discharge limitations are some of the instruments used to control user practices. Industries can also be compelled by legislation to strictly treat or pre-treat and re-use wastewater within their properties, wherever possible, and thus limit discharges to public sewers and streams.

The successful implementation of a wide range of options under Step 1 will lead to smaller volumes of more concentrated wastewater reaching wastewater treatment facilities. This makes effective wastewater treatment aimed at resource recovery possible.

Step 2: Treat for re-use

Municipal wastewater contains valuable resources and therefore it is irrational to treat it the conventional way with subsequent river discharge. Its components of water, organic matter (energy), and nutrients should be re-used. Systems such as grey water separation offer opportunities for direct re-use of wastewater at the point of generation for purposes such as car washing, toilet flushing, and on-plot irrigation (Fig. 12). In some cases, urine could also be separated and re-used directly (Fig. 13, Larsen and Gujer 1996). In this step, technologies are selected aimed at treating in the direction of re-use. Anaerobic treatment of the more concentrated wastewater will generate biogas as a form of renewable energy. Post-treatment of the effluent can be combined with effective recovery of nutrients via aquatic plants (*e.g.*, duckweed) and/or by irrigation of crops in agriculture. In some parts of the world, water itself is a scarce commodity and recycling wastewater would enhance water availability. Examples of large scale re-use systems of sewage have been presented in Chapter I (e.g. Valle Mezquital, Mexico and Calcutta wetlands, India). A main limitation of these re-use practices is that sewage is generally not (sufficiently) treated before re-use, which introduces public health risks. The combination of anaerobic treatment, for energy recovery, and duckweed-based lagoons for pathogen removal and nutrient recovery was proposed as an example of possible re-use strategies (Gijzen and Veenstra 2000). By selecting optimal applications of the duckweed biomass and lagoon effluent, nutrients will end up as fish protein (via duckweed feeding) and crop protein (via irrigation). The focus on duckweed as a key step in waste recycling is due to the fact that it forms the central unit of a recycling engine, driven by photosynthesis and therefore the process is energy efficient, cost effective and applicable under a wide variety of rural and urban conditions.

Step 3: Dispose and stimulate natural self-purification

All options under Step 1 and Step 2 should be exhausted before resorting to Step 3. In some cases the application of above steps might still leave some residual wastes and effluents and the last option remaining is discharge, usually into surface waters (river, lake, coastal sea). The conventional approach is to connect the effluent pipe to the nearest water resource via the shortest route. We seem, therefore, to rely fully

❖ **'La Cienaga de la Virgen' Cartagena, Colombia**

The coastal city of Cartagena in Colombia discharges some 60% of its wastewater into an adjacent natural inland lagoon, which was connected with the sea via a narrow opening. Due to the narrow opening the 'cleaning' effect of the tidal differences in sea level were minimal. Via an engineered inlet and outlet system, and a separator extending some 3.2 km into the shallow lagoon, an effective dilution of the polluted lagoon water by fresh sea water was achieved. Via the tidal pressures, sea water is 'pumped' trough the lagoon, and algal biomass develops and contributes to the aeration of the water body. The high oxygen levels achieved trigger the growth of heterotrophic bacteria, which boost the self -purification activities in the lagoon.

on the self-purification capacities of receiving water bodies. In reality, however, often this capacity is exceeded substantially, rendering water bodies anaerobic, eutrophic or with high concentrations of toxic compounds. Under the 3-Step Strategic Approach proposed here, we suggest to consider options to boost the natural purification capacity of receiving water bodies. This could for instance be achieved by allowing rivers to flow outside their oftentimes artificial embankments. The so generated wetland surface area will contribute in terms of self purification of the water body, mainly due to prolonged retention time and improved aeration by algae and wetland plants. Other options include the construction of small dams to cause rapids and turbulence in streams for improved aeration of the river water. This will boost the aerobic heterotrophic activity of bacteria in the water. Also the introduction or stimulation of controlled algal development to stimulate oxygenation could be considered. An interesting case study of this last option is found in Cartagena, Colombia, where a recently finalised civil work causes channelling of seawater trough a natural inland lagoon receiving wastewater. This case study shows that interventions can sometimes be very simple with excellent results.

Substantial improvements in coverage of wastewater treatment, especially in developing regions will take decades. The 3-Step Strategic Approach provides options for interventions that can be planned on the short, medium and long term. This means that with good planning and prioritisation of options, substantial reduction of water resources pollution can be achieved on the short term.

II. Financial Approaches to Municipal Wastewater Management

Current structures for financing of wastewater services have evolved from historical patterns of infrastructure financing in water management. Traditionally, investments for water supply and sanitation infrastructure have been met by government grants, development agencies or international lending agencies. The source of funding for the provision of wastewater infrastructure has often led the agency responsible for wastewater management to be more oriented to the agencies providing funding than to the customers that the agency was designed to serve (Figure 21). Generally, an agency responsible for water services will orient itself and be accountable to the source where its funding comes from. In the case of the traditional financing of wastewater management, this has meant that these agencies have been accountable to the government for the services that they provided.

The government, for reasons of principle, often insisted that the level of water services should not be differentiated and all users should have access to the same service. As a result, the water and sanitation agencies usually offered only one level of service, usually a capital-intensive conventional technology, which required high investments.

> As a result of this traditional approach, a mismatch often occurred between the services offered by the water and sanitation agencies, at the demand of the government, and the needs of the customers.

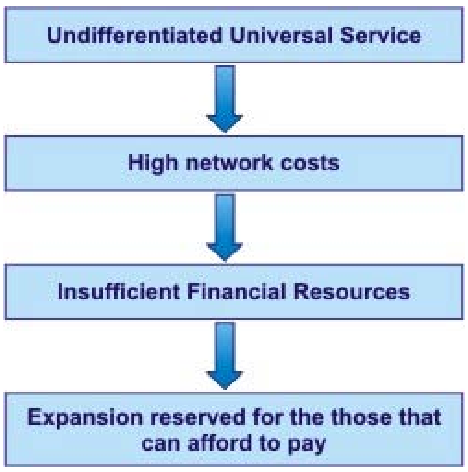


Figure 21- Problems with the centralised “technical” approach.

These high investments could often not be met by the government. The result was that wastewater services were often limited to the privileged few. Moreover, the financial resources for maintaining the existing wastewater infrastructure were often inadequate, resulting in a deteriorating service provision to the limited number of people that were actually connected, as the necessary maintenance of the system could not be undertaken.

In recent years, however, the thinking about financing wastewater service has started to change. Following the Water Supply and Sanitation Decade, which lasted from 1980 to 1990, a consensus emerged in the early 1990s about the way the urban water supply and sanitation sector should be managed. This consensus is based on two main principles drawn up in 1992, during the International Conference on Water and the Environment in Dublin.

1. The first of these principles states that water should be recognized and treated as a scarce and therefore economic good.
2. The second principle is that decisions should be taken at the lowest appropriate level, with full public consultation and involvement of users in the planning and implementation of water projects.

The result of this shift in thinking has meant that instead of depending on the government for funds, the agency responsible for wastewater management has become dependent on the consumers of its services for the necessary income. As a result, the wastewater agency has had to adopt a more customer-oriented focus (Figure 22).

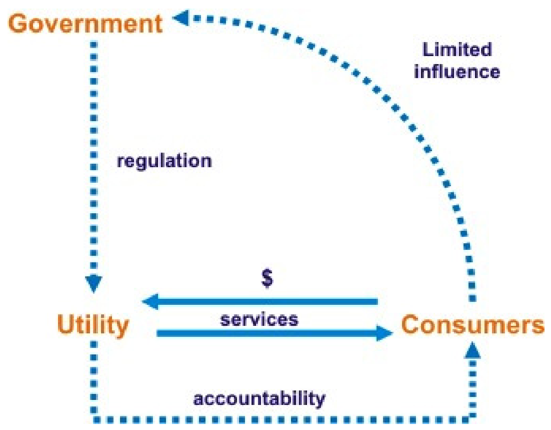


Figure 22- New approach to financing water services.

In this new approach, the role of the government shifts from being a financier of services to a regulator of services.

The utility becomes accountable to the customers of the utility who provide most of the income for the utility. Neglecting the wishes and desires of the customers will result in non-payment of the wastewater bills, which in turn means a decline in the income of the utility. As such, in order to recover the costs of service provision the utility is required to orient itself to the desires of the consumers of the utility in order to ensure sufficient income.

The Changing Financing Regime
One reason for the changing regime in infrastructure finance is that many governments are finding the burden of public finance increasingly difficult to bear. In developing countries, infrastructure is usually very costly, the public sector is almost always the provider of financing for it – and the costs of these investments can be staggering. About $250 billion a year is spent by developing countries on new and rehabilitated infrastructure. Ninety-percent of this amount is taken from government tax revenues or intermediated by governments through foreign financing (both concessional and non-concessional funds from multilateral and bilateral sources). Of the $250 billion, about 30% or $65 billion is spent each year on water sector infrastructure such as: hydropower ($15 B); water and sanitation ($25 B); and irrigation and drainage ($25 B).
Source: Gentry and Abuyuan, 2000.

1. The Case for Cost-Recovery

Since the early 1990s, it has increasingly been recognised that recovering the costs of service provision is a requirement for the sustainable delivery of water services. A number of arguments have been raised why increasing cost-recovery for the provisions of wastewater services should be promoted. The arguments include:

- Available capital funds are inadequate to achieve full coverage and increasing cost-recovery would increase available funds.
- State intervention and control has proven to be inefficient and ineffective. With increasing cost-recovery comes an increase in customer orientation. The increase in customer orientation is likely to lead to more efficient and effective service provision.
- Subsidies disempower users by denying them choice. The traditional subsidy-based approach generally promoted only one service level. Increasing cost-recovery and the accompanying increase in customer orientation is likely to lead the agency responsible for wastewater services to a variety of services for its customers.
- Payments increase sense of value and commitment among users.
- User payments are likely to improve the quality and standards of service. With users paying for services, they will also demand that the utility delivers services

of good quality. As such, user payments are likely to stimulate improvements in the quality of service delivery.

In the wastewater sector, increasing cost-recovery is not as easy as it is in the water supply sector. A number of mechanisms exist, however, to recover costs from the users of wastewater services. These are (UNEP/WHO/ HABITAT/WSSCC 2003):

Consumption-based charges

User charges are levied upon discharge of wastewater into the sewerage based on volume and/or characteristics of the effluent. The volume of discharged wastewater is directly related to consumption of potable water. Consequently, the tariff is usually collected as a surcharge on the water consumption bill.

Effluent charges

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 about the industry (production, number of employees, etc.). Effluent charges are mainly applied in Western Europe, in some developing countries (such as Indonesia and Mexico) and in a few Eastern countries

Discharge permits

A responsible authority sets maximum limits on total allowable emissions of a pollutant to a sewer or to surface water. In discharge permits, charges or levies can be incorporated for cost-recovery purposes. A permit system requires elaborate monitoring of effluent flows and quality

Designing and enforcing cost-recovery mechanisms in the wastewater sector is a complex process. It requires arrangements (technical, institutional, legal, and financial) for a good monitoring system, including regulations and legislation on receiving water quality levels and emission standards. An efficient revenue collection system should be in place, including the capacity to determine the right tariffs, to implement appropriate billing systems, and to enforce fines if needed. Moreover, polluters need to be willing and able to change their behaviour. For efficient revenue collection it is much better to convince users that they should pay for wastewater services than to impose a penalty for disposing waste.

2. The Cost of Wastewater Service Provision

In examining the financial resources required for the provision of wastewater services it is useful to distinguish between the financial resources required for investment in the infrastructure necessary for wastewater management (the capital costs) and the financial resources required for the operation and maintenance of the system (the recurrent costs).

In the mid-1990s the breakdown of financial sources for investment in water supply and sanitation services was estimated to be as follows (Winpenny 2003):

- domestic public sector 65–70%;
- domestic private sector 5%;
- international donors 10–15%; and
- international private companies 10–15%.

The capital costs can be subdivided into infrastructure costs (main sewerage network, treatment plants, etc.) and connection costs (the costs involved in connecting a house or company to the existing network).

Investment Options

A range of investment options exists for the development of wastewater infrastructure (Table 9). In the top-part of the table the ‘traditional’ investment approached are presented. In the bottom part of the table, the more innovative (but relatively complex) approaches are presented.

Table 9- Various sources of investment funds (Source: UNEP/WHO/HABITAT/WSSCC 2003).

Type of Financing	Characteristics	Constraints
Grant Finance : most existing wastewater infrastructure has been financed through allocations from national or local governments	Helps overcome lack of household or community willingness to pay. Systems fully cover costs at lower tariff rates than would otherwise be feasible	Lower tariffs reduce incentive for households or industries to abate pollution. Reduces pressure to identify most efficient solution.
Loans from Government or Multilateral Agencies: 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 repayments periods (in comparison with commercial loans). Matches expected facility life to loan period. Fewer incentive risks than grants as they must be repaid.	
Loans International Financial Institutions (IFI): provide low-cost project financing. Includes loan conditions designed to maximize incentives for efficient service (tariff structures, financial performance measures)	Same characteristics as for government or multilateral institution loans	IFI loans often require a sovereign guarantee. Denomination in foreign currency exposes projects to foreign exchange risks
Market Financing *a) Commercial bank loans:* are secured by contracts and documents to assure funds will be used to support projects in the way intended.		Commercial banks typically require a public sector guarantee which may not always be available
b) Bonds (municipal, international)	Traditional, as in the US, such bonds have a tax-exempt status that makes then attractive to creditors and are in fact a form of subsidized finance).	
Revolving funds: various sources to finance project costs. Subsequent repayments from projects are then used to replenish the fund, permitting funding of other investments	Debt payment risk spread out over a large, diversified pool of borrowers. Households, communities and property investors can also apply revolving funds to finance on-site and local sewerage systems In sanitation sector, revolving funds usually created with large government or donor involvement.	

Connection fee

The connection fee for a sewerage connection to the main network can present a significant problem in many countries. This is especially true for people living in low-income areas. In Buenos Aires, Argentina, for example, the connection fee for a sewerage connection used to be almost US$1,000. For many of the low-income residents in Buenos Aires, who have annual incomes in the range of US$500 per year, this high connection fee forms an impossible hurdle to overcome.

A number of financial mechanisms exist that can ease the burden of a high connection fee for a sewerage connection (Table 10).

Table 10- Possible 'solutions' for high connection fees (Source: Suez-Lyonnaisse des Eaux, 1999).

Solution	Description
Amortisation	The payment of the connection fee is spread out over a number of (usually monthly) instalments.
Labour Participation	The people who will receive the new connection do part or all of the work involved in installing a new connection themselves. In return the connection fee is lowered
Grants or subsidies	Part or all of the connection fee is subsidised by an agency (for example municipal or provincial government)
Cross-subsidisation mechanisms	The connection fee for a particular population category is subsidised by other users.
Micro-credit schemes	People from a particular population category can loan money at favourable rates for the connection fee from a fund or institution.

❖ **Reducing the Burden of the Connection Fee in La Paz-El Alto, Bolivia**

In an agreement signed by the Water Company Aguas del Illimani and the Municipality of El Alto, a number of measures were agreed upon to reduce the likelihood that high connection fees will hinder service expansion to low-income communities. First of all, new customers have the option of supplying labour during the connection process. The connection fee will be reduced in accordance with the amount of labour supplied. This scheme has proved very popular, as only 20% of households on El Alto have opted to pay the full connection fee.

Variable connection fees In El Alto La Paz

Households……………………………………..Sanitation connection fee
Does not supply labour…………………………$180
Digs trench for household connection………….$150
Digs trenc for connection and network line…..…$130

Secondly, 'the population most in need' can pay the connection fee over a period of 3 to 5 years. Moreover, Aguas del Illimani also offers low-income households in the outlying areas the opportunity to pay for connection fees at a subsidised interest rate. In most of the metropolitan area households are charged a 12% interest rate, whilst on the outskirts of El Alto, households pay 8% interest.

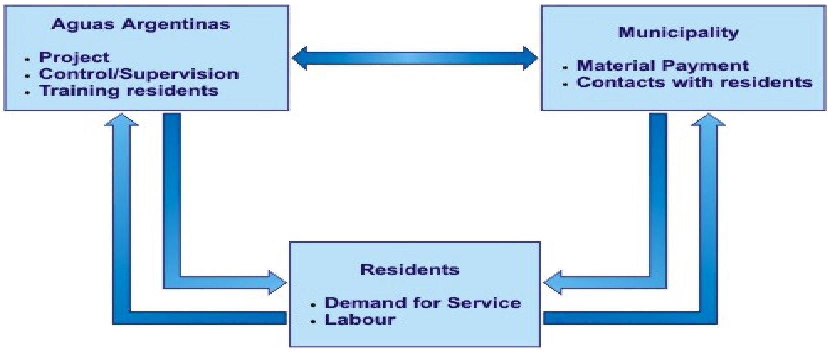
Source: Komives 1999

❖ **Reducing the Burden of the Connection fee in Buenos Aires, Argentina**

In the late 1990's the water utility in Buenos Aires, Argentina, Aguas Argentinas undertook a series of projects together with the municipalities of Buenos Aires and local residents to expand service coverage of water supply and sanitation to low-income areas. The projects they undertook were so-called 'participative water service' projects that are based on direct links between residents in the area where the project is undertaken, the water utility and the municipalities in which the project area is located.

The residents, who have voiced a demand for services, provide labour that is required for the construction of the connection.

The water utility, Aguas Argentinas, provides training to the residents and controls and supervises the project. The municipality provides materials that are required for the construction of the connections. Graphically, the 'participative water service' projects can be portrayed as follows:



Source: Suez-Lyonnaisse des Eaux 1999

Tariffs

In general, the structure of the tariff for wastewater services should be geared towards achieving a number of principal objectives.

1. It should influence the amount of wastewater that is produced in the sense that consumers try to limit the amount of wastewater that is produced. The less wastewater the consumers produce, the less they are charged.
2. The tariff should cover operations and maintenance costs and at least part of the investment cost of sewer trunk lines. In the case of a privatised utility, the water tariff should also cover an acceptable rate of return for the shareholders.
3. Furthermore, the tariff structure must be fair and equitable and have particular regard to the needs of the poorer members of the community.

It is important to realise that the tariffs that are charged should be simple to administer and enforce and easy for consumers to understand. A consumer is likely to be hesitant to pay a bill that he or she does not understand.

Whereas the investment in the infrastructure and the connection fee are one-time costs, the utility must continuously generate sufficient income to operate and maintain the systems for collecting and treating wastewater. For this purpose it must continuously charge the users of its services for the provision of those services. As mentioned earlier, charging users for the wastewater services can be done in a number of ways such as consumption-based charges, effluent charges and discharge permits.

Perhaps the most common form of charging users for wastewater services is by way of charging a percentage of the water supply bill that they consumers have to pay. The thought is that the amount of wastewater produced will depend on the amount of water consumed.

❖ **Wastewater Management in Guanajuato, Mexico – charging the water supply**

In 1996, Regulation NOM-001-ECOL established quality standards that (treated) wastewater must meet prior to being discharged in public water bodies. A fine of US $0.25 is charged for every cubic meter of wastewater that does not meet these standards. In response to this regulation, the local water supply and sanitation company (SIMAPAG) constructed a wastewater treatment plant. The funds for building this plant came from a grant from the federal government (24%) and the local government (40%). The remaining 36% of the costs for construction of the plant were paid for by SIMAPAG, which implemented a charge of 10% of the water supply bill for sanitation services. So all consumers of potable water in Guanajuato pay 10% extra to cover the costs of the wastewater treatment plant.
In addition, SIMPAG has started to explore the possibility of selling treated wastewater for reuse. The cost of treating 1 cubic meter of wastewater is US$0.11. Industrial customers who do not require water to be of potable water standards for their production process have indicated that they would be willing to pay up to US$0.50 per cubic meter of treated wastewater.

Source: Dutch Association of Water Boards 2003

The system of effluent charges is more difficult and is exemplified by the system used in Netherlands (see below).

It should be noted, however, that not all users of wastewater services might be able to pay cost-recovering user charges. For these purposes the design of the tariff structure can allow for a cross-subsidy mechanism that aims to make tariffs affordable for low-income groups. A cross-subsidy requires that one category of customers pay more for a good or service than it would otherwise cost so that others can pay less. The category of customers that pay more subsidise the category of customers that pay less than the cost-price. Cross-subsidies can take on various forms depending on the categories of customers that are selected. One form of cross-subsidy concerns the subsidisation by one sector (for example the commercial sector) of another sector (for example domestic consumption). Another frequently used cross-subsidy mechanism is the increasing block tariff (IBT). IBTs provide two or more prices for the services used, where each price applies to a customer's use with a defined block. Prices within IBTs rise with each successive block. Some tariff structures have as many as ten blocks, each with a different price. The common characteristic of IBTs, as they are applied in developing countries, is that the first block price is deliberately set below cost. As such, IBTs ensure that a basic level of consumption is affordable to all consumers. However, under some conditions IBTs can, in fact, work against low-income consumers.

❖ **Charges for wastewater treatment in the Netherlands**

In the Netherlands the waterboards are, among other things, responsible for the managing treatment of urban wastewater. In order to finance the activities required for the treatment of wastewater, the waterboards charge a 'water pollution levy'. The pollution levy is imposed to users of water in the service area of the water board. These users include:

- Households;
- Industry discharging wastewater into surface water or the sewer system.

Every household or industrial discharger of wastewater pays this levy in accordance with the amount of wastewater that they discharge to the sewerage.

For households there is a fixed rate, for industries the levy that is charged is dependent on the scale in which they pollute the water. In a strict sense, there is no question of a direct, individual service (wastewater treatment) performed in return for the pollution levy. However, there is a clear relationship between the users of the wastewater treatment services and the people that are charged a levy.

The pollution levy is calculated on the basis of the oxygen consumption of the discharged materials (and to a very limited extent, the quantity of certain heavy metals and salts). The pollution levy is based on a so-called 'pollution equivalent', which is equivalent to the amount of wastewater one person produces per year. In 2002, the average pollution levy was US$50 per 'pollution unit'. A family on average pays for three pollution, or US$150 per year.

The production of pollution units (million) by industry and households and the total discharge on surface waters in the Netherlands are:

	1970	1980	1990	1995
Industry	333	13,7	9,8	10,2
Household	12,5	14,3	14,9	15,3
Dissolved in treatment plant	5,5	12,6	17,0	18,6
Discharge or surface	40,0	15,4	7,7	6,9

Source: Dutch Association of Water Boards 2003

Over the past decade a significant shift has occurred in the way people think about financing wastewater services. Whereas historically the utility requested funds from the government to meet its investment and O&M costs, in recent years the utility has been forced to orient itself to the consumers of the wastewater services for the financial resources to cover its costs. With the increasing need to secure revenue from its consumers, the utility has to develop a strong consumer-orientation, which means that the utility has to increase the involvement of stakeholders in the provision of wastewater services.

Without involving stakeholders in the provision of wastewater services, the utility will be unable to recover the costs for wastewater management.

❖ **The Strategic Sanitation Programme in Ouagadougou, Burkina Faso**

The Strategic Sanitation Programme in Ouagadougou is an example of an innovative experience the aim of which is to put into practice an innovative view of urban sanitation and to spread the concept of this innovative view among the population of this city. The approach used in this programme is an integrated approach, which considers the development of sanitation to involve economics, town planning, hygiene, culture, education and policy, just as much as technology.

The techniques used in this programme are not necessarily innovative: what is different is the form of participatory management, which alone can lead beneficiaries to understand and support the project.

Local participation must, however, fit with the whole range of legal, fiscal, institutional and organizational mechanisms on which urban life and city management are based.

Rather than capacity to pay, the Strategic Sanitation Programme in Ouagadougou considers willingness to pay primordial – or, rather, the type and form of user contribution: services paid through tariff structures, physical participation in laying installations, financial participation in investments, etc. The contribution depends on users' satisfaction with existing situation, their understanding of the improvements that projects can bring, and the way each households chooses to adapt its budget to effect the changes it would like to see in its immediate surroundings.

Source: Suez-Lyonaisse des Eaux, 1999

III. Water Management in the City of Tomorrow

The approach towards UWM of the city of tomorrow should be based on sustainability in all its depth. In Table 11 various aspects of water management in the city of today are compared with that in the city of tomorrow.

Table 11- Comparison of water management of the city of today and that in the city of tomorrow.

Aspect		City of today	City of tomorrow
UVM Organization	Organizational structure	Separate entities for different types of water,	One entity for 'water' covering entire urban area
		Covering entire urban area	City subdivided in water management units (WMU) with high level of responsibility
			Water is a tradable good between units
	Units	Depending on preference of water entities	Determined by possibilities to manage water within a unit
	Philosophy	Various types of water have no relationship	Various types of water are part of the same cycle and serve various purposes at different times
Drinking water	Quality	One quality for all uses	One quality for drinking, a second quality for other uses
	Distribution	Underground piping system, vendors	Drinking water through shops, second quality through piping system
	Origin	From wherever available	From nearby
Wastewater	Quality	Any quality wastewater is accepted	Only 'clean' wastewater is accepted, dischargers responsible for quality of wastewater submitted
	Collection	Collection from domestic and industrial origin to point of discharge or (central) treatment	Collection of 'clean' wastewater within the WMU to point of further processing
			Specific waste flows kept separate
	Treatment	Predominantly of the activated sludge type	Further processing determined by the reuse/recovery options and the specific use of the water within the WMU
			Indirect reuse is objective
	Discharge	Into nearest surface water	Depending on possibilities within WMU, *e.g.*: irrigation, groundwater recharge, surface water discharge
Rainwater	Approach	Removal as quick as possible so as not to have flooding problems	Make best possible use of this resource
	Processing	Removal into sewer	Collection, temporary storage, followed by some type of treatment
	Usage	None	Various options, *e.g.*: street cleaning, green areas, ground water recharge, or drinking/process water

The above described comparison is illustrated in Figure 23 (Otterpohl et al., 1998), which compares two communities. The community A with a 'once-through' water management system, and the community B with a system where water is managed as a more or less closed-loop. The community A does not assume responsibility for water management, i.e. water is taken from elsewhere and, by discharging into a river, is sent elsewhere. Therefore, whether the wastewater gets proper treatment, groundwater is recharged or rainwater is harvested, is not an urgent matter to the community as long as there is no shortage of water. The community B accepts the full responsibility for the quality of the water since this water will, at some point in the future, be again its drinking water. Therefore, consumption determined by resource conservation, generation of clean wastes, proper treatment, maintaining groundwater resources, etc. is in the clear interest of the community.

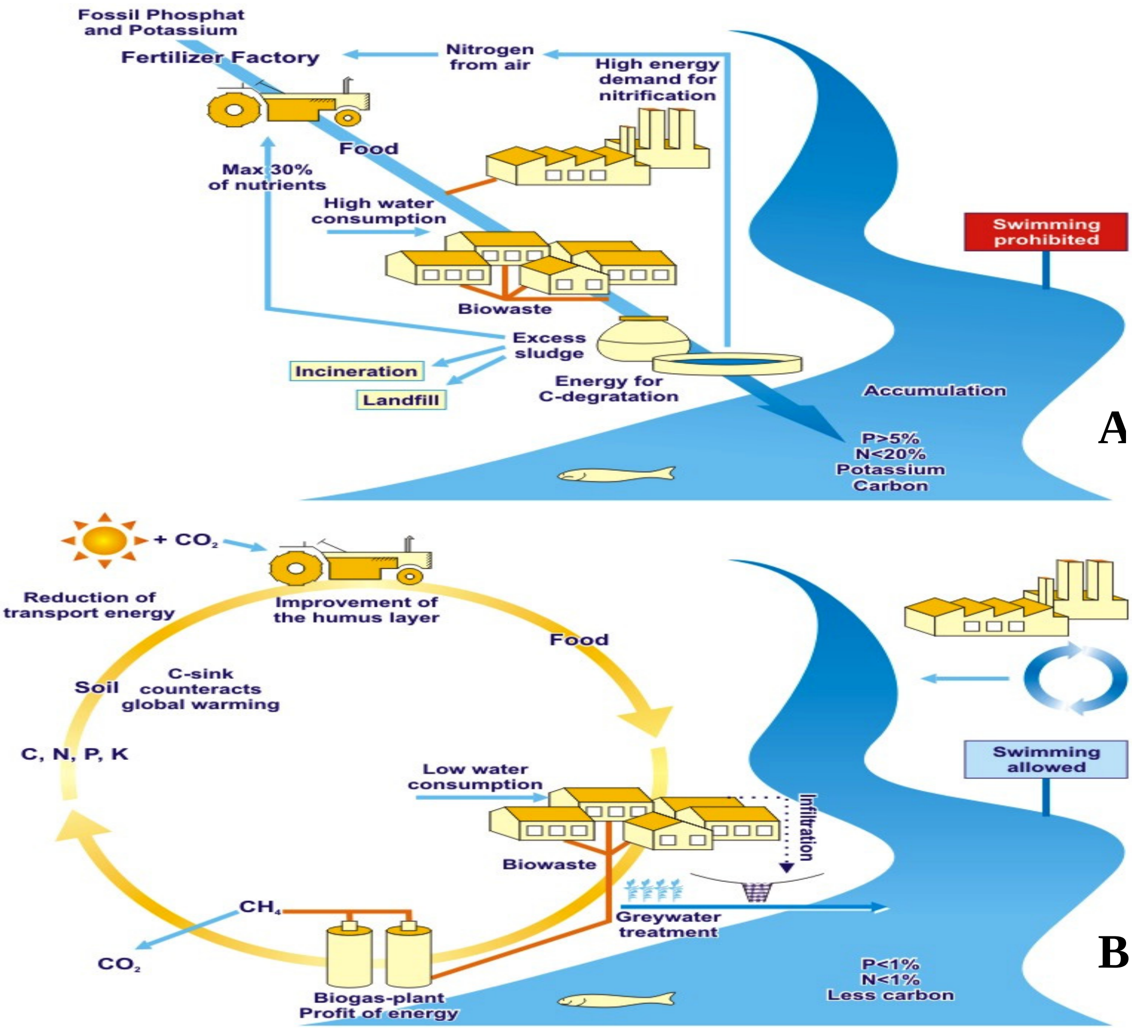


Figure 23- Linear Mass Fluxes in the traditional approach (A) and Mass Fluxes in a possibly sustainable urban sanitation approach (B) (Otterpohl *et al.*, 1998).

Continuing the urban water practice in a 'business-as-usual' manner is unsustainable and has lead to significant problems related to public health, environment and, thus, economy. However, urban water management is not an issue that requires one and the same approach for all cities. In fact, a differentiated, approach is needed, per city and within cities, depending on a wide variety of factors and resulting in a tailored approach for different parts (center, suburbs, industrial zones, etc.).

It is high time that urban managers recognize these needs and take the lead for an UWM approach based on real responsibility for water quantity and quality.

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MODULE 3

PRESENTATION TECHNIQUES

Developing proper solutions is one thing, but getting moral and financial support for the ideas is as important. Thus, a proper presentation to organisations, to stakeholders, or to potential donors for getting support for the ideas is vital. Therefore one has to pay some attention to presentation techniques: each module ends with a presentation by some of the participants. To facilitate these presentations, a short introduction into the basic skills for giving oral presentations is provided.

Moreover, after a brief introduction of the distinct stages of a project (project cycle) this module will acquaint the participants with the contents of a feasibility study and explain how to structure the presentation of projects in a written document.

At the end of this module the participants will be able to:

1. Compose a presentation within a set time frame.
2. Realise an oral presentation within a set time frame, using basic presentation skills (e.g. visual aids, time management, delivery performance).
3. Prepare and present a project proposal to address the problem that requires mitigation.

This module is divided into the following parts:

I. Presentations Skills

II. Writing the Feasibility Report

MODULE 3

PRESENTATION TECHNIQUES

I. PRESENTATION SKILLS

1. PREPARATION OF PRESENTATIONS
2. CONTENT OF PRESENTATIONS

II. WRITING THE FEASIBILITY REPORT

1. THE PROJECT CYCLE
2. PLANNING AND PREPARATION STAGE

REFERENCES

MODULE 3

PRESENTATION TECHNIQUES

I. ORAL PRESENTATIONS[1]

In many fields, the ability to communicate orally is just as important as the ability to write well. Studies show that people in management positions rely more on oral communication than on written communication.

A survey done among engineers showed that of 30 specific job-related tasks, 10 of the most important were oral tasks, such as: project proposal presentations, project progress report presentations, etc. The purpose of this section is to provide some guidelines on how to give formal and informal presentations.

Keys points for an successful presentation:

1. Prepare properly.
2. Practice sufficiently.
3. Deliver your presentation with energy and enthusiasm.

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1. Preparation of Presentations

Begin by checking all the details you need to plan your presentation, this includes:

- The duration of the talk.
- Whether time for questions is included.
- The size and location of the room.
- The projection/lighting facilities provided.

Projection and lighting facilities are particularly important to check. Does the room have the equipment you need? E.g., slide projector, overhead projector. Is it working? Is it in the right position?

Have a look around the room and try out the equipment not later than the day before your presentation, so you are able to use it with confidence.

[1] The section on presentation skills is taken from Sturrock (2001).

The most important thing to remember is that people have a limited attention span, and that you must therefore organize your talk very clearly so that the main points stand out. This is how you do it:

- Analyse your audience and *limit your topic accordingly*. What do your listeners already know? What do they need to know? How much information can they absorb?
- *Determine your primary purpose*. What is the main point you wish to communicate? Build your presentation around that.
- *Select effective supporting information*. Remember, your listeners will only remember at most three or four supporting points and only two or three supporting details for these points. So choose the information that will sell your case to your particular audience.
- *Choose an appropriate pattern of organization*. Often your supporting information can be ordered according to one dominant pattern of organization: problem-solution, criteria, chain of reasoning, process of elimination, experimental research, chronological description, or comparison and contrast, to mention a few. Whatever pattern you choose, stick to it.
- *Prepare an outline*. Main points and main supporting points only. Only write out the whole text if you feel the information is too technical for you to be able to just explain it.
- *Select appropriate visual aids*. These are indispensable, firstly as prompts to help you and secondly as attention-getters. People remember visuals much more than they do words. The following options are available for technical oral presentations:
    - Overhead transparencies
    - Slides
    - Flip charts
    - Chalkboard
    - Handouts
    - Computer screen projection (PowerPoint)

2. Content of Presentations

The content of the presentation has three main elements: the introduction, the body of the presentation and the conclusion. Ideally the time spent is:

- Introduction: What you will do (content), how you will do it (structure) – 10% - 20%.
- Body – 65%-80%.
- Conclusion –10%-15%.

Introduction

Capture the interest of your audience from the beginning – make your opening comments strong. Never begin with an apology.

Remember that it takes a few minutes for an audience to establish a relationship with a new speaker: do not begin with key information. You might say what your talk is about and show a transparency with the title on it. This allows the audience to settle in. After these preliminaries, you should introduce your topic.

Make sure your listeners are clear about whatever the basic problem or issue is. If necessary, provide background information and define essential terms. In the introduction you should:

1. Explain the structure of your talk.
2. Set out the aims and objectives of the presentation.
3. Explain your approach to the topic.

Body of the Presentation

This section should include the bulk of your experimental results or literature findings, depending on the type of presentation. Keep details of methods to a minimum (just enough to explain your data). Results should be presented in an easy format.

Present summary statistics rather than individual results. Graphs and diagrams are usually better than tables. The audience will be able to see the trends and relationships in your data. Each diagram should have a short title and the symbols and trend lines should be clearly labelled. Take the audience through your story step-by-step at a reasonable pace. Try not to rush your story because you may be nervous. Avoid complex story lines and have your visuals well organized.

Consider the structure of your 'main message'. Keep it as simple as possible and announce each sub-division, so your audience is aware of the structure.

Do not overwhelm your audience with large amounts of data.

Conclusion

You must bring your talk to a conclusion. Listeners' attention typically decreases during a presentation, but perks up again towards the end, when they hope to catch a closing comment or recommendation.

Finish as strongly and as clearly as you started. Provide your audience with a clear 'take-home message' by returning to the key points in your presentation.

Signal the end of your talk by saying "Finally,…" of "In conclusion,…" and stop speaking after that sentence, as your audience will lose interest after that point.

Visual Material

Some things to remember about the visual material that you use during your presentation:

- Keep text to a minimum: present only the key points. Less than 10 lines per sheet is preferred.
- Do not use the lower 10 cm of the sheet. Some of the audience may not able to read it because of people in front of them.
- Start each point at the beginning of a new line. Sentences should be avoided and should not exceed 2 lines.
- Font size: choose a large font and do not use capital letters for all letters. For example Arial Bold 24 points is suitable.
- Make sure the text is readable: try out your material beforehand.
- Graphs: limit the number of trend lines and use different colours for different lines.
- Avoid using too much colour.
- Use simpler figures rather than one complex graph.
- You should speak for about 2 minutes for each overhead sheet. That means that for a presentation of 10 minutes, you should not use more than 5 overhead sheets.
- Make sure there are no spelling errors on the sheets.

Improving your delivery performance

The greatest obstacle to effective delivery is nervousness. The key is to convert your nervousness into the kind of energy that will inject liveliness into your speech. A number of ways exist to do this:

1. Be well prepared. Have all your notes and visual aids in order. Practice in the room and with the equipment you will actually use if possible.
2. Release tension. Exercise, listen to music, do whatever will help you to relax.
3. Establish contact with your audience beforehand. This will help you concentrate on them rather than yourself.

4. Be aware of your posture and facial expressions. Concentrate your full attention on what you have to say.

Practice makes perfect

Practicing your presentation in front of a friendly audience, or videoing or tape-recording it, will all help you spot and correct any flaws: awkward transitions, poor delivery, length of presentation, etc. In short it will help you give your presentation effectively. Here are some things to watch for:

1. Avoid monotony by devising interesting ways to reiterate your main points.
2. Avoid a breakdown in flow by creating smooth transitions to bridge the gap.
3. Rehearse your presentation. Ask a colleague or friend to listen and comment constructively on parts that were difficult to follow.
4. Use note cards with keywords and phrases. As you rehearse, your confidence will improve and you will find a set of cards much easier to handle than pages of notes.

Questions

Sometimes you will be asked questions after an oral presentation. The best approach is to prepare beforehand:

1. Consider what questions you may be asked: prepare brief answers. Have colleagues or friends throw every kind of difficult question they can think of at you.
2. Do not be afraid to say if you do not know the answer to the question.
3. Always be polite to questioners.

II. WRITING THE FEASIBILITY REPORT[2]

1. The Project Cycle

All projects go through a series of distinct stages, or project cycle, between the initial idea for the project and the time when the project is completed. In general, the following stages can be identified in the project cycle.

1. An **identification stage** - The problematic situation that needs to be adressed by the project is identified. The needs, goals and purpose of the project are broadly identified.
2. The **planning and preparation stage** - During this stage alternatives for the project are analysed that are to address or mitigate the identified problematic. A project alternative is selected and a feasibility report for this project alternative is produced which explains in detail the rationale of the project.
3. The **appraisal or approval** stage - The approval stage is the stage where decision-makers, including financiers, determine whether or not the project will be implemented.
4. The **implementation stage** - In this stage detailed designs are completed and the project facilities are built and commissioned. Supporting activities such as staff training are also under way.
5. The **operational stage** - During the operational stage the project facilities are integrated with the existing system to reach the specified objective or goal.
6. The **evaluation** stage - During this final stage, the project is evaluated and the lessons learnt are identified so that future projects can be improved accordingly.

In this section we will concern ourselves **solely with the planning and preparation stage of projects** in which the preferred project is selected, the feasibility of this project is assessed and the report detailing the feasibility of this project is written. The main focus will be on two reports, the **pre-feasibility** report and the **feasibility report**, that are generally written as part of this stage. These two reports form the basis of a bankable proposal.

[2] The section on writing a fesibility report is largely based on Grover (1983).

2. Planning and Preparation Stage

Key issues in the preparation of pre-feasibility and feasibility reports

The decision by an agency to finance and implement a project is generally based on findings of a comprehensive feasibility study which shows that the proposed project is the preferred solution and is technically and institutionally feasible, financially viable, socio-culturally acceptable and economically justified.

Both the pre-feasibility report and the feasibility report, form the basis on which the decision will be made to approve or reject the proposed project. Based on the pre-feasibility report, which includes the selection of the preferred project, a comprehensive feasibility report is drafted in which a more in-depth analysis is undertaken of the preferred project alternative.

The Pre-Feasibility report

Aim

The basic aim of the pre-feasibility report is to select a project alternative that can improve wastewater management at minimum cost in the near future.

Key issues

The pre-feasibility report analyses the past and present situation in which the project will intervene. Also included is a preliminary analysis of alternative projects, which can address this problem situation. Projects that are technically inferior or culturally unacceptable are eliminated. Ideally, the pre-feasibility report is based on limited fieldwork. Initial consideration is given to relevant institutional arrangements and financial considerations. The pre-feasibility report can be used to secure political commitment (at the municipal and/or national level), to identify stakeholders, and to involve the private sector and communities.

The Feasibility Report

Aim

The aim of the feasibility report is to confirm the rationale for selecting the chosen project.

Key issues

The feasibility report will be the basis on which decision–makers decide whether to support or reject the project. Eventually, project appraisal and investment decision are based on the feasibility report.

This report provides preliminary designs and cost estimates for the selected project, based on considerable data gathering and analysis, with input from ultimate users (e.g. all relevant stakeholders). This means that considerable information is required at the time the feasibility report is written. Feasibility studies are expensive and require intensive effort and, therefore, should not be done until a preliminary screening and ranking of alternatives is made to show the relative merits of the projects proposed for implementation.

The feasibility report also defines required supporting activities and provides a cost-estimate for them. Detailed consideration is also given to institutional arrangements (both at the agency and the community level), the subsequent operation and maintenance of facilities, and financial aspects. Very important are the investments, the need and costs for operation and maintenance, as well as the ways to secure cost-recovery. Finally, all probable impacts are considered and a conclusion is drawn whether the project is technically and institutionally feasible, financially viable, socio-culturally acceptable and economically justified.

Design Aspects

Structure and content of a pre-feasibility report

Summary
In the summary the main points of the pre-feasibility report are summarized for individuals without the time or need to read the entire report.

Introduction
This chapter briefly explains the reasons for the report and how it was prepared. Preferably, the introductory chapter will contain information about:

The *Project Origin* – a description of how the proposed project idea was developed.

The *Organization and Management of the Study* – an explanation how the pre-feasibility study was carried out.

Scope and Status of this Report – an explanation of how this pre-feasibility report fits in the overall process of project preparation.

The Water Sector
This chapter (although highly desirable) is not an absolutely essential part of a pre-feasibility study. It provides a general overview of the

water sector. The advantage of such an overview is that it provides the decision-maker with a general context in which it can place the proposed project. Ideally, this chapter should show how the proposed project supports national and sectoral development plans. In most countries this sectoral overview would have a national focus, but in some countries (where individual states are large or where the national government does not have the basic responsibility for sector services) the overview should be presented in the context of the individual state or particular region. This chapter can include aspects like:

Country Background – (topographic features, climate, population, urbanization, overview of government structure, etc.).

Economic and Health Indicators - summarize the main features and principal sectors of the national economy, including information on per capita income, levels of poverty, health indicators, etc.).

Water Resources and Control - Provide an overview of water resources and water use.

Sector Organization and Developments – briefly describe the government and non-government institutions, which have an impact on the sector.

Present Service and Coverage Standards - discuss the patterns of watsewater treatement by region and by season. Also discuss the service reliabilities.

Sector Goals - Describe the country's past record in setting and fulfilling sector goals.

Past Projects - List and describe briefly all projects undertaken within the past ten years (by region) and estimate the total expenditure for each project.

The Project Area and the Need for a Project

This chapter explains why a project is needed and tells the reader about:

- The project and its people.
- The present wastewater management services in the project area; the prospects for future development.
- The need to improve existing services.

The following sections should be dealt with in this chapter:
Project Area – description of the project area.

Population Patterns – discuss the population and its distribution in the project area.

Economic and Social Conditions - Give a general description of present living conditions for people of different socio-economic and ethnic groups.

Sector Institutions - Discus the role and responsibility of all institutions (government and non-government) involved in wastewater management in the project area.

Available Water Resources - summarize the quantity and quality of surface and groundwater resources, actual and potential, in the project area and vicinity. Comment on the quality and reliability of available data.

Existing Sanitation Systems and Population Served - this section should summarize and assess all existing sanitation and waste disposal systems in the project area and estimate the number of people each system serves.

Need for a Project - This is the key section of this chapter. In this section conclusions are drawn about the need for a project in light of population patterns and projections, existing service levels and standards, and prospects for improving and expanding existing systems. Basically in this section it is summarized why the existing systems cannot cope with present (and projected) demands for services.

Project Alternatives

In this chapter alternatives for improving wastewater management services are proposed and evaluated. The main aim is to recommend a feasible and affordable project aimed at mitigating the problem described earlier. The alternatives should be evaluated in terms of their social, economic, technical, financial, environmental and institutional feasibility.

Conclusions and Recommendations

This chapter informs decision-makers of the essential results of the pre-feasibility report, including the next steps necessary to develop a project. This chapter includes the following aspects:

Conclusions - a brief summary of the results of the pre-feasibility study.

Issues and Risks – a major objective of the pre-feasibility stage of project investment is to identify and resolve potential problems that could endanger the success of the project. Possible issues and risks should be identified.

Recommended Actions - all actions necessary to complete project preparation and implementation should be identified.

Structure and content of a feasibility report

The following report format is generally applicable, although it may vary depending on the specific project.

1. **Summary**
   The most important results of the feasibility study should be summarized for the convenience of the readers. The summary should be concisely written and should present the proposed project clearly.

2. **Background**
   This chapter should describe the history of the proposed project and explain how it fits into the national sector strategy and the long-term development program. Plus municipal responsibilities and roles of stakeholders involved.

3. **The Project Area and the Need for a Project**
   This chapter of the feasibility report is similar to the same chapter in the pre-feasibility report.

4. **The Proposed Project**
   This chapter describes the recommended project in detail. Information here is based on extensive analyses and preliminary design. Summary information in the report is supported in back-up documentation in annexes.
   Dimensions of the project that should be elaborated upon in this chapter include:

   Objectives - objectives that the project should achieve should be expressed both as general development objectives and operational objectives. General development objectives include aspects such as expected health improvements, improved living standards, institutional improvements etc. Operational objectives for the project concern improvements in coverage and treatment standards. Each objective should be quantified (to the extent possible), and a schedule for achieving these objectives should be presented.

   Project Users and their Perspectives - the expected beneficiaries and other stakeholders of the project should be defined. The benefits that the project will bring to the beneficiaries should be realistically estimated. This section should also contain an explanation about the involvement and input of potential users of the project.

   Project Description – Where the need for the project and the analysis of project alternatives is the most important part of the pre-feasibility report, the project description forms the backbone of the feasibility report. In this section the various components of the project are clearly described.

Integration of the Project with Existing Systems - explain how the various physical components of the project will be integrated into the existing systems.

Responsibilities for Project Implementation - This section describes how the project will be designed and built and how it will later be operated and maintained, including the role of other stakeholders.

Cost Estimates - provide an overview of the estimated cost of the entire project and detailed cost estimates for each project component for each year of the project period, as well as cost recovery.

Implementation Schedule - Provide a detailed and realistic implementation schedule for all project components.

Future Operation and Maintenance of the Project - describe all groups that will be involved in operation and maintenance after the project facilities are built, including donor innovative financial arrangements and an exit strategy.

Environmental Impacts - Briefly describe the various environmental impacts that are expected to result from the project, including those on public health and/or water resources. This could be done with a step-wise approach.

Institutional Aspects – Describe how the organization and management of the project during the operational stage of the project is arranged. This section should include an assessment of the organization responsible during the operational stage in terms of management and personnel.

Financing Plan - This section summarizes all sources of funds (e.g. user-pays principle, cross-subsidizing etc.) for the implementation of the project.

5. Conclusions and Recommendations

This chapter states whether the proposed project is feasible when judged from all perspectives and recommends actions to be taken for its implementation. It also discusses issues and risks associated with the implementation of the project.

Justification - Discuss in why the proposed project is justified and should proceed. This includes summarizing how the project will satisfy the desired objectives and confirming that the proposed project is the most cost-effective solution to meeting these objectives. The interest of the intended beneficiaries of the project should be highlighted and their role in project preparation. Specific reference can be made to the willingness and capability of the intended beneficiaries to support the project. In case the project benefits can be reasonably quantified and valued, compare them to project costs for each year in the future. Finally, the justification of the project also includes a brief discussion of the effect of not proceeding with the project.

Conclusions - the conclusions should be summarized that demonstrate that the project is feasible economically, technically, socially, financially, environmentally and institutionally.

Issues and Risks - Identify all issues that may pose a risk to project implementation and operation. Make a judgment as to the gravity of each risk and suggest ways of minimizing such risks.

Uncertainty and Sensitivities - Examine the consequences of small and large changes in the major assumptions on which the report is based. Test the sensitivity of the project to changes in basic parameters such as delay in project implementation, reduction in benefits, increases in costs, etc.

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Annex 1

Short description of natural systems for wastewater management

• Anaerobic treatment

All anaerobic systems are based on the degradation of organic material (both particulate and dissolved) by a consortium of anaerobic bacteria. The process results in the production of biogas, containing up to 80% of methane that can be re-used for electricity generation. The anaerobic process does not require oxygen and, therefore, no energy for aeration purposes.

Anaerobic treatment of wastewater is carried out either in:

- low-rate systems - anaerobic pond, septic tank or lined pit, (Figure 1)
- high-rate systems - anaerobic filter, up-flow anaerobic sludge blanket reactor, anaerobic contact process (Figure 2).

Fig. 1- Septic tank.

High-rate systems are characterized by higher loading rates and, therefore, smaller volumes, shorter retention times and less required area. High rate reactors are generally more complicated in construction, operation and maintenance than low rate systems.

Fig. 2-A high rate anaerobic reactor of the UASB type for 6000 population equivalents (research station, Ginebra, Colombia).

• Waste Stabilization Ponds

Water stabilization ponds are shallow basins, surrounded by an embankment of soil (Figure 3). Wastewater enters the pond at one or multiple inlet structures and is collected at one or several outlet structures. A pond system may consist of several ponds, either in series or parallel. Sometimes effluent of a pond is re-circulated to a previous pond.

Ponds are classified in three categories:

- Anaerobic ponds are devoid of oxygen; removal of waste compounds takes place by sedimentation and by degradation of organic material by anaerobic bacteria.
- Facultative ponds are characterized by an aerobic top layer and an anaerobic bottom layer; the depth of the aerobic layer depends (among others) on the oxygen production by algae and is fluctuating during the day.
- Maturation ponds are fully aerobic and characterized by solar radiation throughout the pond depth.

Fig. 3- Aerobic ponds in Ginebra, Colombia.

- ## Wetlands

Wetlands are plots of land where the water table is at (or above) the ground surface long enough each year to maintain saturated soil conditions and the growth of related vegetation (Reed *et al.*, 1995) (Figure 4).

Constructed wetlands are plots of land specifically designed to act as wetlands for the purification of wastewater (Figure 5). There are two types of constructed wetlands, free water surface constructed wetlands (FWS) and subsurface flow constructed wetlands (SF). The water table in the former is above the ground surface, whereas in the latter it is just below the ground surface.

Fig. 4- Natural wetland of water hyacinth.

Fig. 5- Constructed wetland.

- **Macrophyte ponds**

Macrophyte ponds are modified waste stabilization ponds. A cover of floating plants is floating on the water surface. The plants may be water hyacinth (*Eichornia crassipes*), (Figure 4), duckweed (*Lemnacaea*) (Figures 6 and 7) or others. The function of the plants is to take up nutrients from the wastewater and to provide a pond environment that is not disturbed by wind action so that sedimentation is optimal. The extended root system of the water hyacinth also serves as surface for attachment of bacteria, thus enhancing the removal of COD and nitrogen (nitrification).

Fig. 6- Duckweed in simulated treatment plants.

Wastewater based **fish-aquaculture** transforms the nutrients that are present in wastewater into proteins. The fish feed on algae or macrophytes that grow on the nutrients.

One can distinguish two kind of systems. In the first system the fish directly is grown in wastewater ponds, whereas in the second type of system the wastewater nutrients are first converted into macrophyte or algae biomass, which is subsequently taken from the wastewater pond and brought to separate fish ponds. The latter system has the advantage of a smaller risk of pathogen infection of the fish. Fish ponds improve the water quality by the same processes as in stabilization ponds.

Fig. 7 – Duckweed pond in Bangladesh for treatment of domestic wastewater and fish aquaculture; the fish are fed with wastewater grown biomass (Duckweed)

Terrestrial treatment methods can be divided in **slow rate** (or irrigation) processes (SR**), rapid infiltration** processes (RI) and **overland flow** processes (OF).

- SR is the controlled application of wastewater to a vegetated land at a rate of a few centimeters of liquid per week. Treatment occurs by physical, chemical and biological processes at the surface and as the wastewater flows through the plant-soil matrix.
- Rapid infiltration (RI) is a similar process, but using shallow basins with a rapidly permeable soil underneath. Application ranges from 2-35 centimeters per day.
- An overland flow process (OF) distributes the wastewater over a gently sloping piece of land. The water slowly flows downhill and is collected in a collection ditch. Treatment takes place in the upper few centimeters of the soil.

• Achievable effluent qualities in natural treatment systems

The effluent quality that can be achieved after treatment of domestic wastewater in the above mentioned natural systems is given in Table 1. Actually the effluent quality depends mainly on temperature, area available and pre-treatment. Any desired quality can be achieved, but a trade-off between effluent quality and required land area exists. The costs for natural systems depend mainly on land prices and costs for construction. For instance the soil type affects strongly the costs for stabilization ponds. Anaerobic high rate reactors are expensive but take relatively small area.

Table 1. Overview of achievalble effluent qualities for natural systems.

Natural system	HRT[1)] (days)	BOD (mg/l)	TSS (mg/l)	Total N (mg/l)	Total P (mg/l)	FC[2)] (#/100 ml)	Ref[4)]
High rate anaerobic reactors (pre-treatment)	0.25	50-200	20-350	25-90	5-30	10^5-10^7	1
Waste stabilisation pond (anaerobic + facultative type)	10-40	20-40	80-120				2
Waste stabilisation pond (anaerobic + facultative + maturation pond)	14-23			0-20		<100	3,4
Duckweed ponds	14-28	5-40	40-80	3-45	0.5-2.5	10^2-10^4	5,6
Water hyacinth pond	30-50	< 10	< 10	< 5	< 5		2
Constructed Wetland	3-15	5 - 40	5-20	5-10		10^2-10^5	2,7
Land treatment (slow rate)	n.a.[3)]	< 2	< 2	<3	< 0.1	0	2

1) HRT = hydraulic retention time. 2) FC = faecal coliforms. 3) n.a.=not applicable; 4) References: 1=Van Buuren, 1991; 2=Reed *et al*., 1995; 3=Silva *et al.*, 1995; 4=Arridge *et al.*, 1995; 5= Alaerts *et al.*, 1996; 6=Zimmo *et al.*, 2000; 7= Gerba *et al.*, 1999.

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Annex 2: Case Study

Managing wastewater in Santiago, Chile[3]

1. Background

(Non-Antarctic) Chile covers an area of 756,096 km^2. It is a 4,000-km long and on average 200-km wide strip of land bordered by the Andes Mountains in the East and the Pacific Ocean on the West (Figure 1). In 1996 Chile has a population of 14.5 million people of which 5 million live in the Santiago Metropolitan Area. Annually, the population grows by 1.5% in this highly urbanised country.

In 1996 per capita GNP was US$ 4,160, which makes Chile a middle-income country. In the 1990s, the economy expanded by almost 8% per year and inflation averaged close to 8.5% in 1994.

Figure 1- Case study area (Source: www.lonelyplanet.com/mapshells/south_america/ chile_and_easter_island/chile_and_easter_island.htm).

Historically, the Chilean economy depended heavily on copper exports[4], of which Chile is one of the world's largest producers. These

[3] This case study is based on a real situation but facts have been altered for purposes of this role-play
[4] Still approximately 42% of export earnings.

days, however, Chilean exports have diversified and include exports of fruits and vegetables, forest products, seafood and flowers.

2. Water Services in Santiago

In the 1970s sewerage in Santiago was collected by a public utility called Servicio de Alcantarillado de Santiago. As in other Chilean cities, coverage for sewerage was low. In 1970, coverage for sewerage was estimated at 31.1% (Alfaro 1997a). Moreover, the wastewater that was collected was discharged without any treatment. Tariff levels were kept extremely low during this period. As such, the public sewerage company needed to be financially supported by the government. In 1977, the Empresa Metropolitana de Obras Sanitarias Sociedad Anonima (EMOS) was created. EMOS became responsible for the entire water cycle, from the abstraction of water resources to the disposal of sewage in most of the 40 or so municipalities that together form the Santiago Metropolitan Area. By 1995, sewerage coverage had increased considerably and an estimated 97% of the population in EMOS' service area had connected to the sewerage network. Although coverage was increased considerable over this period, treatment of wastewater did not improve.

Table 1- Selected indicators of EMOS S.A. in 1995 (Source: Blokland, 1999).

Approximate population in service area	5 million
Coverage– water (%)	100
Coverage– sewerage (%)	97
Connections– water (*1000)	1,022
Connections– sewerage (*1000)	991

3. Sewerage in Santiago

The wastewater collection system of Greater Santiago is made up of a network with some 6,500 km of sewer mains that evacuate a current average flow of 13 m^3/s. This flow is expected to increase to 24 m^3/s by the year 2024.The waste water that is collected is discharged in more than 40 points along three major natural channels that drain the metropolitan area: the Mapocho River, the Maipo River, and the Zanjon de la Aguada. Most of the wastewater that is discharged in these natural channels is untreated prior to being discharged. The only treatment plant is a pilot plant, which was constructed in 1992. The experimental pilot plant is an unconventional installation of the deep settling pond type. The purpose of the two deep ponds was to meet the coliform concentration standard through natural biological processes without additional disinfection methods, and to hold the treated water through the winter before releasing it to irrigate summer crops (Valenzuela 1998). EMOS S.A., however, concluded that under Santiago's climatic conditions, this system couldn't meet the biological quality standards. Natural biological treatment processes may be a preferred choice for warmer areas, but future projects in the Santiago Metropolitan Area will most likely have to be of the traditional activated sludge type (Valenzuela 1998).

4. Wastewater Irrigation

The effect of the discharges of untreated wastewater is the pollution of the three natural watercourses and, in turn, of the entire network of irrigation canals that derive from them. Bacterial pollution levels in the irrigation canals range from moderately polluted (more than 10^3 faecal coliforms per 100 ml) in most areas irrigated principally by the Maipo River and the upper Mapocho River, to highly polluted (more than 10^5 faecal coliforms per 100 ml) in areas irrigated by the Zanjon de la Aguada and the central and lower Mapocho River.

Table 2- Irrigation water quality and distribution of affected areas (Source: SAG 1993 as cited in World Bank, 1994).

Water Quality	Faecal Coliforms (per 100 ml)	Affected Areas (%)
Safe	$<10^3$	8
Moderately polluted	10^3-10^4	27
Polluted	10^4-10^5	38
Highly polluted	$>10^5$	27

The total agricultural area irrigated with polluted water from the canals is in the order of 130,000 hectares. This area includes some 7,000 ha. which is used for growing vegetable crops for raw consumption in the immediate vicinity of the Santiago Metropolitan Area. The affected irrigated areas are high-producing agricultural lands that supply the vegetable market of the Santiago Metropolitan Area itself and also produce 40% of Chile's fruit exports, and to a lesser extent vegetable exports. Figure 2 provides an overview of the agricultural lands with contaminated water.

Irrigation with wastewater also provides benefits to the farmers of vegetables. The fertiliser value of the organic material in wastewater (high in nitrogen and phosphorus) is high. In other words, the untreated sewage acts as a free fertiliser for the crops of the farmers.

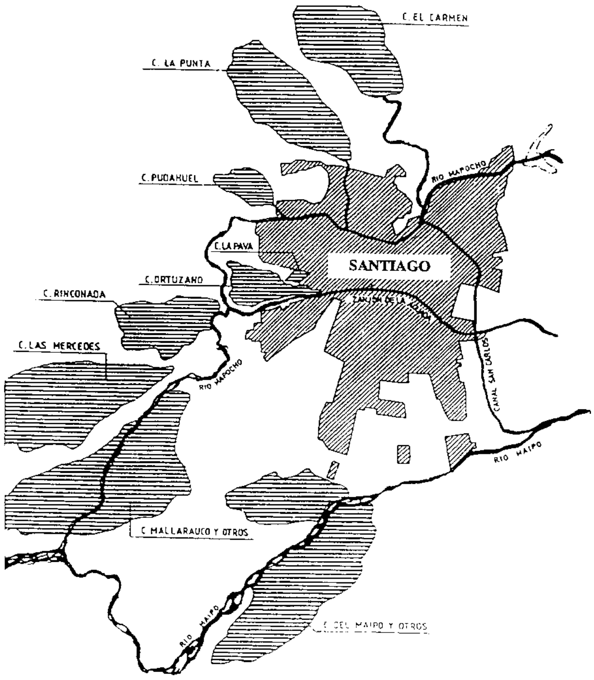

Figure 2- Areas irrigated with contaminated water (1990) (Source: World Bank 1994).

5. Irrigation of Crops and the Pattern of Enteric Diseases in Santiago, C hile

Irrigation of crops with untreated wastewater has not been without consequences. The pattern of enteric diseases in Santiago is unique. In the capital of a country with moderate income, high levels of education, nutrition and healthcare, ample coverage of good quality water supply and reasonable sewerage coverage (90% of the Santiago Metropolitan Area is connected to sewerage) one would expect the indicators for enteric diseases to be low. Although this is indeed the case for diseases such as infant diarrhoea, two enteric diseases have remained at high levels in Santiago. Whereas in the rest of the country typhoid rates fluctuate between 30-50 cases per 100,000 people, those in the Santiago Metropolitan Area vary between 100-200 cases per 100,000 people. In addition, the typhoid rates in Santiago show a seasonal variation, with higher rates in summer time, which coincides with the irrigation season. Moreover, typhoid rates among infants and children, who are normally more susceptible to this disease, were unusually low in Santiago, presumably because infants and children do not consume large quantities of raw salad crops. These higher rates of infection in the Santiago Metropolitan Area are largely attributed to infection by way of the "long cycle" (infected individual→ sewage→ water pollution → food → people).

Apart from the tragedy of human suffering that accompanies these high rates of enteric diseases also represent a high economic cost. The total costs associated with the occurrence of typhoid cases attributable to sewage irrigation of vegetables is estimated at US$ 1.4 million annually (World Bank 1994).

6. Wastewater Irrigation and the Possible Impact on Agricultural Exports

As mentioned before, agricultural exports for human consumption constitute an important export product for Chile, second only to the export earnings from copper. In fact, over the period 1988 to 1992, the export of agricultural products rose by almost 79% and the export of fruticulture by almost 70%.

Table 3- Chilean agriculture and fruticulture exports 1998-1992 (millions of US dollars) (Source: Source World Bank, 1994).

Sector	1988	1989	1990	1991	1992
Agriculture	84.0	124.2	118.1	123.7	150.3
Fruticulture	579.8	549.1	742.7	991.9	981.8
Subtotal	663.8	673.3	860.8	1,115.6	1,132.1
Percentage of total exports	9%	8%	10%	12%	11%

With 40% of the agricultural and fruticultural exports coming from the Santiago region, an outbreak of enteric diseases, such as cholera can be of tremendous impact on the export of agricultural products. A cholera outbreak in Peru in 1991, demonstrated that the export losses can run be in the order of many millions of dollars (World Bank 1994). Moreover, the lack of consumer confidence in the agricultural products following such an outbreak can have a damaging impact long after the actual outbreak of the disease has long subsided.

7. Efforts to Control Irrigation with Untreated Wastewater

The government of Chile has long recognised the dangers of irrigation with untreated wastewater. As far back as 1967 irrigation of vegetables with sewage has been prohibited by the 1967 Sanitary Code. A Ministry of Health Resolution (No. 350 of 1983) reiterated the prohibition of irrigation with wastewater following an outbreak of typhoid in Santiago. The 1983 Resolution included the prohibition of cultivating 10 crops with sewage-polluted water[5]. For many years however, the Sanitary Code and the Ministry of Health Resolution were not enforced[6]. In fact, it was not until an outbreak of cholera in

[5] These 10 crops were lettuce, chicory, coriander, parsley, carrots, two types of radishes and three types of berries (Gomez-Ibanez & Bok 1996)

[6] A 1994 World Bank Report attributed the lack of enforcement to the lack of political will to enforce these regulations and the fragmentation of pollution control responsibilities in the Chilean water sector (World Bank 1994).

the Santiago Metropolitan Area in 1991 that any credible action was taken.

8. The Cholera Outbreak of 1991

In the months of April and May of 1991, 41 cases of cholera were detected in the Santiago region. The appearance of cholera gave a new sense of urgency and purpose to attempts to enforce regulations that were on the books for many years. The outbreak of cholera was not only a concern to government officials because of the threat to health of the population of SMA, but also because the detection of cholera threatened agricultural exports.

To avoid the spread of cholera the authorities took a series of emergency measures to break the long cycle of infection: the prohibition and removal of vegetables grown with sewage irrigation and restrictions on transporting irrigated vegetables and fruits outside of SMA, intensification of water quality monitoring, the chlorination of irrigation water in channels, the prohibition of serving raw vegetables in restaurants, and an intensive campaign of social communication informing the population of the risks of vegetables and the need to wash them and cook them.

Table 4- Cost-benefit analysis of the emergency measures taken in 1991. (Source: World Bank, 1994).

Annual Benefits	US$ millions	Annual Costs	US$ millions
Reductions in typhoid mortality and morbidity	1.4	Public education campaigns	1.5
Avoided cholera mortality and morbidity	14.7	Inspection program	0.1
Avoided export losses	50.0	Farmer losses	4.9
		Consumer losses	7.2
Total benefits	66.1	Total costs	13.7
Total Benefits – Total Costs = US$ 52.4			

The emergency measures taken by the government of Chile greatly reduced the spread of cholera. The effectiveness of the measures is not only reflected in the fact that after May no more cholera cases were reported, but also in the dramatic drop in typhoid cases in Santiago. In fact the number of typhoid cases dropped to 9 per 1000,000 in 1992. The measures were estimated to have generated US$ 66.1 million in 1991 by bringing down the occurrence of typhoid (US$ 1.4 million) and by preventing a cholera epidemic which is estimated to have been accompanied by treatment costs (US$ 14.7 million) and lost exports (US$ 50 million).

9. The Development of a Strategy

The success of the measures introduced in 1991 to combat the spread of cholera, motivated the Government of Chile to search for a long-term solution for the problem. For this reason the Government of Chile approached the Superintendecia de Servicios Sanitarios (SISS). SISS is an independent regulator, established by the 1989 Regulatory Act. According to this Act SISS is charged with the supervision of the concessionaires, i.e. the proposal and control of norms and technical standards, the application and supervision of regulations on tariffs, and the interpretation of all relevant legislation.

The Chilean government has demanded that the SISS decide upon a strategy to mitigate the problems associated with the irrigation of untreated wastewater.

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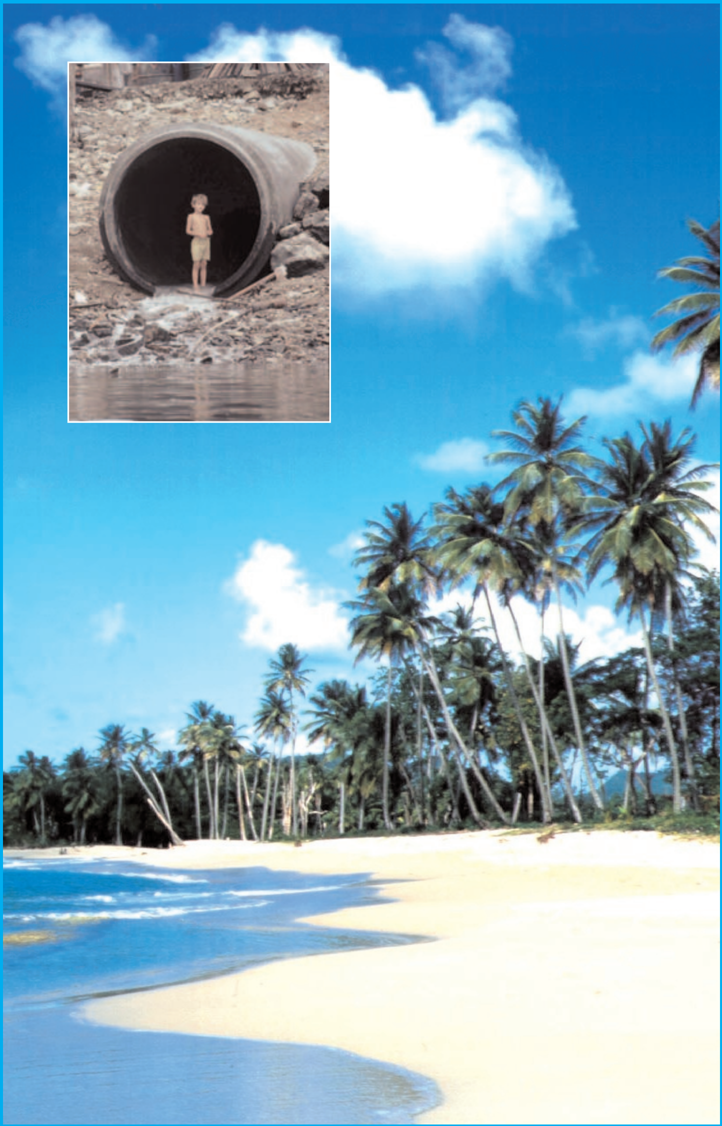

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